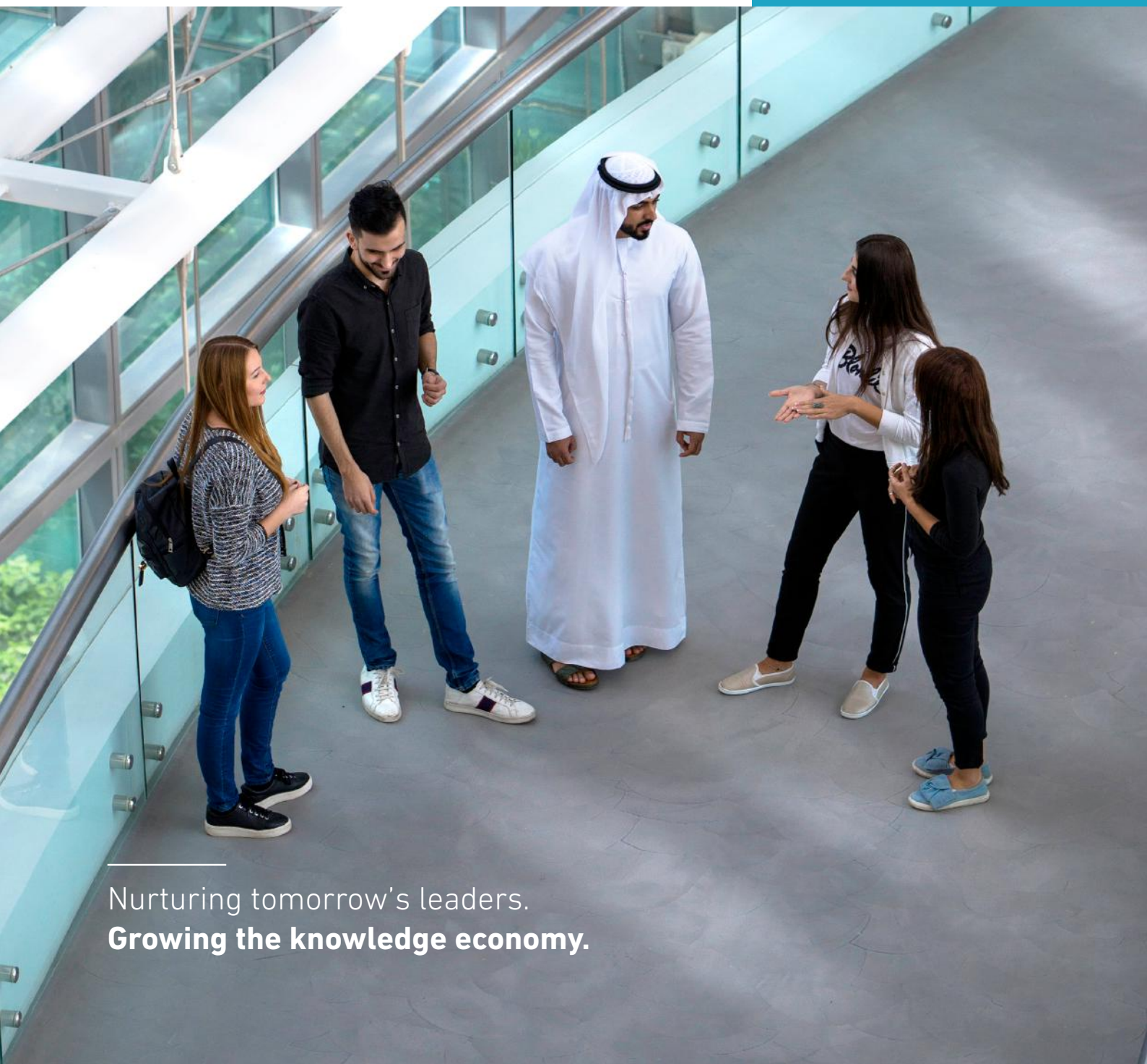
جامعة خليفة
Khalifa University

ku.ac.ae

GRADUATE CATALOG 2020 - 2021



Nurturing tomorrow's leaders.
Growing the knowledge economy.

DISCLAIMER

TABLE OF CONTENTS

PROVOST'S MESSAGE

Welcome to Khalifa University, where you will spend the next few years of your educational journey.

High-quality education is beneficial to you and an important prerequisite towards understanding and addressing societal challenges relating to energy, environment, healthcare, security, communications, transportation and civil infrastructure, amongst others.

The diverse community of scholars at Khalifa University will help prepare you to face these challenges and to make your unique contribution to the solutions demanded by them. Beyond a high-quality grounding in your chosen subject area, you will also need a variety of other attributes to succeed as a leader, including the ability to communicate and to work in teams, competence in working within economic and societal constraints, a sense of professional and personal ethics, managerial and business acumen and the interest and capacity to serve others. We are dedicated to helping you develop and refine all of these skills.

Our University is a dynamic institution offering high quality education and practical experience. We strive to create a learning culture that exemplifies excellence in teaching and scholarship, which promotes lifelong learning and prepares individuals for leadership and service in the global society. We have the responsibility to help you develop as complete and well-rounded individuals and maximize your potential to pursue careers with passion and purpose.

We offer a diverse range of degree programs that are designed to meet the criteria set by national and international accreditation bodies. Our faculty and staff are highly qualified, experienced and dedicated professionals, who are always willing to impart their knowledge and experience to our students. The University has world-class facilities which will make your learning experience productive and enjoyable.

This Catalog provides you with information to make your academic planning easier. Decisions about majors, specializations and courses require careful consideration, and the Catalog will help you plan your degree from your first year through to your final year. If you need more information or advice, please take advantage of the professional expertise of our faculty and administrative staff. Your academic advisor will be happy to give you the appropriate advice.

I look forward to meeting you and to sharing the great adventure of university life with you and the rest of our community. I believe you will find Khalifa University to be a stimulating and supportive environment in which to shape your future and wish you every success and happiness during your time here.

Professor Bayan Sharif
Office of the Provost,
Khalifa University

ACADEMIC CALENDAR 2020 - 2021

2020 AUG

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

16 Faculty Reporting

17-20 New Std Orientation

23 Hijiri New Year*

24 Classes Begin

27 End of add/drop for UG

2020 SEP

S	M	T	W	T	F	S
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27	28	29	30			

17 Run Census Report

2020 OCT

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17 Mid-Grade Due Date

29 Last Day to withdraw with "W"

2020 NOV

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29	30					

15-23 Advmt priod Spring 2021

24-26 Early Reg. Spring 2021

2020 DEC

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27	28	29	30			

1 Commemoration Day

2-3 National Day

10 Last day of classes

13 Final Examps, Begin Thesis Submission

22 Final Exams End

24 Final Grades Due

27 Winter Break

2021 JAN

S	M	T	W	T	F	S
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24	25	26	27	28	29	30
31						

10 Faculty Reporting

12-13 New Std Orientation

17 Classes Begin

21 End of add drop for UG

28 End of add drop for PG

2021 **FEB**

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28	29					

11 Run Census Report

2021 **MAR**

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21	22	23	24	25	26	27
28	29	30	31			

11 Mid-Grade Due Date

25 Last Day to withdraw with "W"

28-31 Spring Break

2021 **APR**

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1 Spring Break

11-15 Admt Priod Summer/fall 2021

19-22 Early Reg. Fall 2021

2021 **MAY**

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23	24	25	26	27	28	29
30	31					

9 FinalExams Begin; Thesis Submission

13-16 Eid El Fitr

20 Final Exams End

25 Final Grades Due

2021 **JUN**

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20	21	22	23	24	25	26
27	28	29	30			

6 Classes Begi, Internship Begin

24 Mid-Grade Due Date

2021 **JUL**

S	M	T	W	T	F	S
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11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

1 Last Day to withdraw with "W"; Run Census Report

15 Last day of classes

18 Final Exams Begin

20 Final Exams End

22 Final Grades Due

*Islamic Holidays are subject to change

This calendar does not apply for the College of Medicine and Health Sciences

EMAIL DIRECTORY

ALUMNI SERVICES
E-mail: kualumni@ku.ac.ae

CAREER SERVICES
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CENTER FOR TEACHING AND LEARNING
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COUNSELING
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EMERGENCY
Telephone: +971 2 401 8200

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FINANCE
E-mail: finance@ku.ac.ae

GOVERNMENT RELATIONS
E-mail: kugovernmentrelations@ku.ac.ae

GRADUATE ADMISSIONS
E-mail: pgadmission@ku.ac.ae

GRADUATE STUDENT ACCOMMODATION
E-mail: pgr.life@ku.ac.ae

GRADUATE STUDIES OFFICE
E-mail: gso@ku.ac.ae

HUMAN RESOURCES
E-mail: askhr@ku.ac.ae

INFORMATION TECHNOLOGY (IT)
E-mail: servicedesk@ku.ac.ae

MEDICAL CLINIC AND NURSE
Telephone: +971 2 401 8014
E-mail: nurse.auh@ku.ac.ae

REGISTRATION OFFICE
E-mail: registration.office@ku.ac.ae

SECURITY
Telephone: +971 2 401 8100

STUDENT SERVICES
E-mail: ss.helpdesk@ku.ac.ae

STUDENT TRANSPORTATION
E-mail: studenttransporation@ku.ac.ae

CATALOG OF RECORD

This Khalifa University of Science and Technology (KU) Graduate Catalog is intended for students of the University who are admitted to a Master's or Doctorate program in the 2020 – 2021 Academic Year. Students admitted to College of Medicine and Health Sciences programs should also refer to the **CMHS Medical Student Handbook.**

THE UNIVERSITY

HISTORY OF KHALIFA UNIVERSITY

In 2017, UAE President and Ruler of Abu Dhabi, His Highness Sheikh Khalifa bin Zayed Al Nahyan, issued a decree to merge Khalifa University of Science, Technology and Research, Masdar Institute of Science and Technology, and The Petroleum Institute under one university called Khalifa University of Science and Technology (Khalifa University).

Khalifa University is a comprehensive research-intensive university with three colleges, three research institutes, 18 research centers, and 36 departments covering a broad range of disciplines in science, engineering, and medicine. The internationally top-ranked university is the one university in the UAE with the research and academic programs that address the entire range of strategic, scientific and industrial challenges facing the UAE's knowledge economy transformation and our rapidly evolving world.

Khalifa University's world-class faculty and state-of-the-art research facilities provide an unparalleled learning experience to students from the UAE and around the world. The university brings together the best in science, engineering and medicine in the UAE, to offer specialized degrees that can take promising high school graduates all the way to top-rated doctorate degree holders. It will continue to evolve with the UAE's rapidly developing national goals and needs and nurture the innovation ecosystem required for the country's targeted knowledge economy transformation.

The histories of the three merged institutions are integral to the vision and mission of the unified university. Khalifa University of Science, Technology and Research (KUSTAR) was inaugurated on 13 February 2007 by the President of the UAE, His Highness Sheikh Khalifa bin Zayed Al Nahyan, and had in its remit to provide Bachelor's, Master's and Doctoral-level education primarily in engineering and the sciences. The university opened its Abu Dhabi campus (now the Main Campus) in October 2008 to add to the campus in Sharjah (formerly Etisalat University College, EUC). The Sharjah branch campus, which has since closed, had a very proud history that stretched back to 1989.

The establishment of Masdar Institute of Science and Technology (MI) on 25 February 2007 as a graduate-only institute was part of a resource diversification plan for the Emirate of Abu Dhabi. Abu Dhabi's leadership views research and education in alternative energy fields as a cornerstone for the future development of the Emirate and expressed their commitment through the establishment of the Masdar Initiative, Masdar City, the Zayed Future Energy Prize (renamed Zayed Sustainability Prize), and the Masdar Institute.

The Petroleum Institute (PI) was established in 2000 through Emiri decree. Prior to the merger with KUSTAR and MI, it was financed and governed by a consortium of five major oil companies: ADNOC, Royal Dutch Shell, BP, Total S.A., and Japan Oil Development Company, a wholly owned subsidiary of INPEX. PI admitted its first students in the Fall of 2001 and offered Bachelor's and Master's programs, as well as a research program tailored to the needs of the oil and gas industry. The purpose of the PI, as part of Khalifa University, will continue to provide highly-trained engineers and geoscientists for the UAE oil, gas and broader energy industries.

INSTITUTIONAL VISION AND MISSION STATEMENT

University Vision

To be a catalyst for the growth of Abu Dhabi and the UAE's rapidly developing knowledge economy, the engineering and science education destination of choice, and a global leader among research intensive universities in the 21st century.

University Strategic Goals

As a world-class, research-intensive institution, Khalifa University will:

- Set new standards in education, research, and scholarship that will benefit the UAE and the world.
- Drive Abu Dhabi and the UAE as a knowledge destination and engine for socio-economic growth through active translation of research into the nation's economy.
- Seamlessly integrate research and education to produce world leaders and critical thinkers in applied science, engineering, management, and medicine.
- Continuously innovate and integrate the global standard in methods of learning and discovery.
- Build a diverse community of service-oriented, ambitious and talented individuals, through an environment that encourages and nurtures creative inquiry, critical thinking, and human values.
- Empower the community with practical and social skills, business acumen and a capability for lifetime learning that will enrich the workforce of the country.

Research

The KU research community responsibly manages funding, collaborations and research compliance in a manner consistent with international standards, and the mission and objectives of KU.

The university provides support for the development, submission, and management of proposals and awards for both internal and external funding. KU's research priorities address specific industry and sector needs, technical platforms and expertise. These include clean and renewable energy, water and environment, hydrocarbon exploration and production, healthcare, aerospace, supply chain and logistics, advanced materials and manufacturing, robotics, AI and data science, information and communication technologies.

LICENSURE AND ACCREDITATION

Khalifa University of Science and Technology, located in the Emirate of Abu Dhabi, is officially licensed by the Ministry of Education of the United Arab Emirates to award degrees/qualifications in higher education. All the academic programs offered by Khalifa University of Science and Technology are accredited by the Commission for Academic Accreditation (CAA) of the United Arab Emirates.

UNIVERSITY FINANCIAL RESOURCES

Khalifa University of Science and Technology is a not-for-profit, public institution. The core budget of the University is provided by the Government of the Emirate of Abu Dhabi. The University is a semi-government entity with an independent legal personality, financial and administrative independence, and full legal competence to practice its activities and achieve its objectives.

BOARD OF TRUSTEES

Khalifa University of Science and Technology Board of Trustees consists of prominent individuals with extensive experience in academia and industry.

H.E SHEIKH HAMED BIN ZAYED AL NAHYAN

Member of the Executive Council, Chief of Abu Dhabi Crown Prince's Court

H.E. HUSSAIN BIN IBRAHIM AL HAMMADI

Cabinet Member and UAE Minister of Education

H.E. ALI RASHID AL KETBI

Member of the Executive Council, Chairman of Department Government Support

H.E. DR. SULTAN AHMAD AL JABER

Director-General and CEO of the Abu Dhabi National Oil Company

H.E. SALEM RASHID AL NUAIMI

Chairman, SEHA

H.E. SALEH ABDULLAH AL ABDOOLI

Chief Executive Officer of Etisalat

H.E. DR. ENG. MOHAMMED NASSER AL AHBABI

Director General of the UAE Space Agency

H.E. FAISAL AL BANNAI

CEO and Managing Director of EDGE Company

MR. HOMAID ABDULLAH AL SHIMMARI

Deputy Group CEO and Chief Corporate & Human Capital Officer, Mubadala

MR. JEFF F. SIMMONS

Senior Vice President, Technical Planning and Evaluation, Occidental Petroleum Corporation

DR. STEVEN H. WALKER

Vice President and Chief Technology Officer, Lockheed Martin Corporation

PROF. SIR JOHN O'REILLY

Chairman, Science and Engineering Research Council, A*STAR Singapore

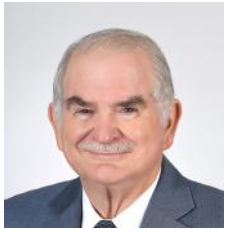
UNIVERSITY LEADERSHIP

DR. ARIF SULTAN AL HAMMADI
Executive Vice President

DR. AHMED AL SHOAIBI
Senior Vice President, Academic and Student Services

DR. BAYAN SHARIF
Acting Provost, Professor and Dean of Engineering

DR. STEVEN WESLEY GRIFFITHS
Senior Vice President, Research and Development



DR. JOHN ROCK
Founding Dean of Medicine and Health Sciences and Senior Vice President for Health Affairs, Professor of Obstetrics and Gynaecology

MR. EBRAHIM JAFAR ALAHMED
Vice President, Finance and Business Development, Acting Vice President, Administration, Facilities, EHS

MR. MOSALLAM SUHAIL AL KATHIRI
Vice President, Human Resources and Procurement

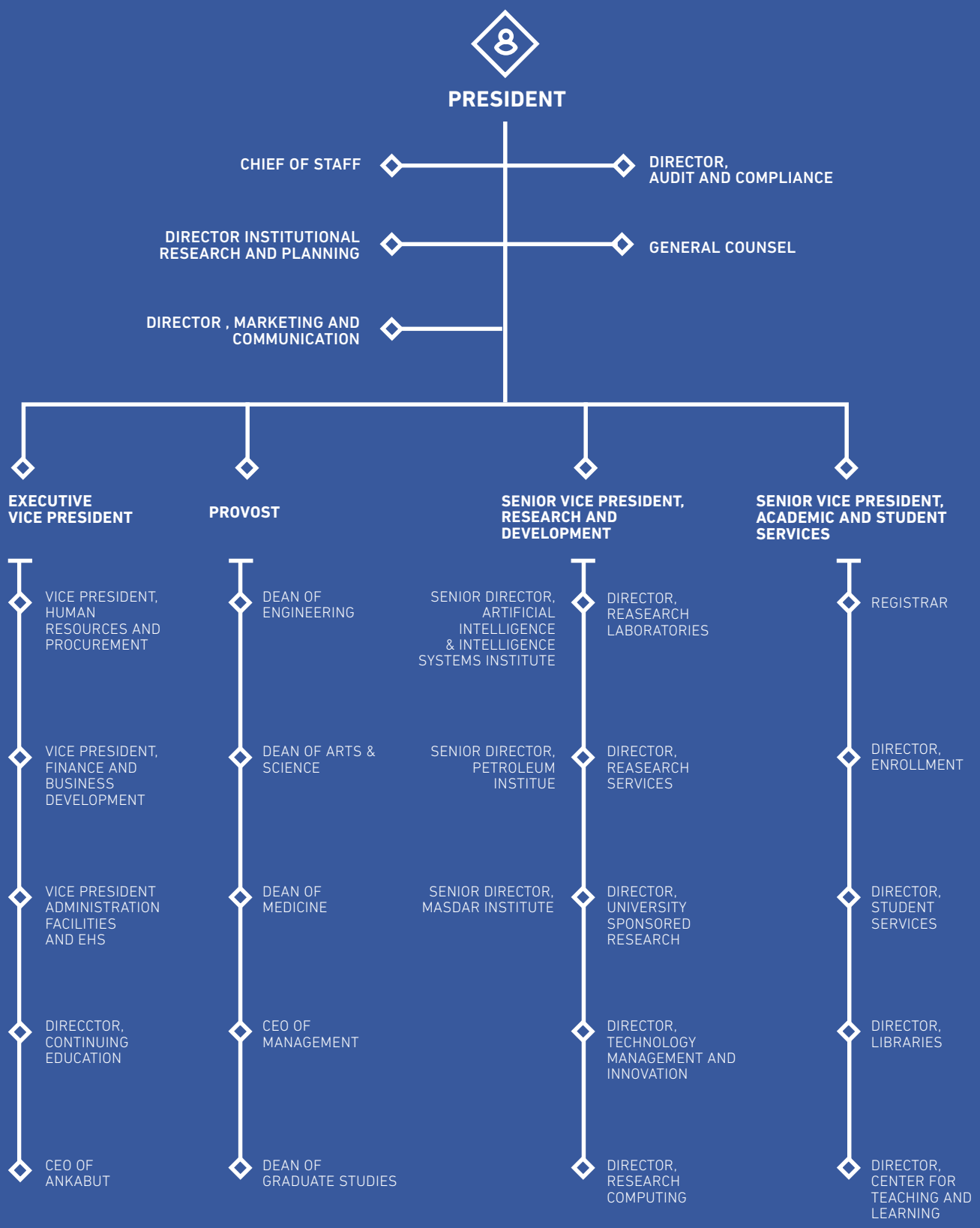
MR. FAHEM SALEM AL NUAIMI
CEO Ankabut

DR. DAVID SHEEHAN
Dean of Arts and Sciences, Professor of Biochemistry

DR. YOUSOF AL-HAMMADI
Acting Dean of Graduate Studies

ORGANIZATIONAL STRUCTURE

KU High Level Positional Structure



UNIVERSITY FACILITIES

MAIN CAMPUS

BANKING SERVICES

A number of ATMs are provided on the Main Campus for the convenience of students, faculty, and staff. The ATMs are located in the G building and near the Student Hub link bridge.

BUILDING ACCESS AFTER-HOURS

Students may be granted building access during non-operational hours provided that a responsible University employee completes an online request form and submits it to the relevant Department Head. The form must contain the names of each student being granted access and the termination date for this access. Student access will be automatically terminated at the end of each semester. The relevant Department Head and employee must approve the form. Facilities Management will reprogram the electronic lock within three days of the receipt of the request or issue a key as applicable.

EMERGENCY SERVICES

Emergency services are provided by the campus Security Department, which operates 24 hours daily. These services can be requested by calling or contacting the Security Department. Emergency phones are located throughout campus for your safety and convenience. Please refer to the University's Emergency Plan for additional information. Rapid response is generally initiated when Security Services is contacted by staff, students or visitors by:

- Calling to the emergency line 02 401 8200
- Approaching one of the Patrolling Security on the campus
- Any lift phone
- Alarm notification, e.g. fire alarm

ENVIRONMENT, HEALTH, AND SAFETY

The University conducts periodic Environment, Health and Safety (EHS) briefings, which are mandatory for students. Students are responsible for understanding the environment, health and safety materials and instructions presented at these briefings and for acting in accordance with them. Further information is available in the Environment, Health and Safety manuals.

In an engineering university, students are expected to use instruments, equipment, and materials that are potentially hazardous. For this reason, students are required to attend environment, health, and safety inductions and orientations, and to read the Environment, Health and Safety manuals associated with all lab and workshop activities.

Students will not be allowed to participate in lab or workshop activities unless they have demonstrated a clear understanding of the safety procedures involved.

Students may not work alone in a lab or workshop in case of an accident or medical emergency. Inattention or disruptive behavior will not be tolerated in any lab or workshop activity. Repeated cases will be referred for disciplinary action. Equipment, tools, and materials must be handled in a manner that is safe for the student as well as for other students and the instructor. Students have a responsibility to report any infringements that they witness.

FOOD OUTLETS AND RETAILERS

The primary dining area and main restaurant are located in the Student Hub, E-Building, and offers students a comfortable place to relax between classes, do classwork, or have a lunch or coffee with friends. There are a wide variety of restaurant and food options on the Main Campus, including:

- Doctor Shawerma, House of Tea and Starbucks located in the Student Hub Building on the Ground Level.
- Subway is located on the Ground Level of L Building.
- Costa is located on the Ground Level, beside the R Building.
- Circle K Minimart is located in the M Building (The Hive) on the Ground Level.
- Vending machines are located directly outside the R Building, L Building, and 1st floor of G Building.

HEALTH SERVICES

The Main Campus Clinic is located on the ground floor of D Building. Male and female nurses provide first aid services, emergency care and can also give advice on healthy lifestyle and other related health issues. Students are required to complete a Medical Record Form giving details of their medical history and specific instructions for emergency situations. Students should inform the nurse of any medical ailments or ongoing treatment. A female nurse is on full time duty to care for female students who require emergency treatment while on campus. Minor ailments will be treated at the First Aid Clinic in private treatment rooms.

In cases of accident or emergency, a nurse is on call to attend to the patient. Except in life threatening situations, the patient will not be moved, until an authorized person arrives and assesses the injury. Guardians will be notified as quickly as possible and instructions on the student's Medical Record Form adhered to where possible.

NURSERY

The Nursery is located at the new extension to the Main Campus. The aim of the Nursery is to provide a warm, caring and safe environment for the small children of our students, to develop their abilities by using play and planned activities for all age ranges. We look forward to working with you and your child to ensure that their time spent at the nursery is productive and happy.

PRAYER ROOMS

Purpose built rooms are located across all campuses for prayers, including separate areas for wudhu ablution. Prayer rooms for male and female students are located in the R Building, L Building, G Building and E Building.

SAFETY AND SECURITY

The University maintains public areas that are open, well-lit and staffed by receptionists and uniformed security personnel. Although movement on the campus is free, female students are encouraged not to linger in public areas in the interest of safety. Female students may request a personal safety escort to and from any campus location, should they be on campus after dark.

SPORT FACILITIES

All sports and fitness facilities are gender specific and provided for the use of University students with a valid

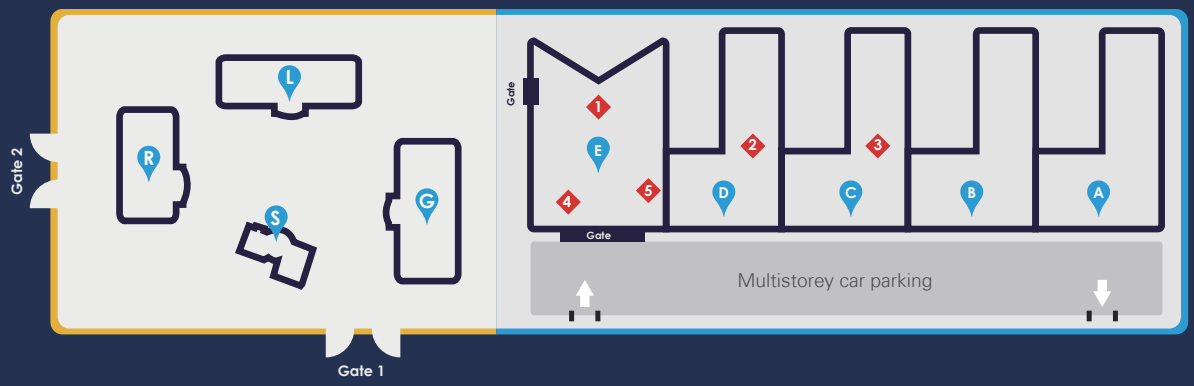
student card. The facilities are strictly for the University's students, staff and faculty and all users are required to produce their ID cards if so requested by staff manning the Reception area or security. The Sports Complex in the Main Campus is located in Building D, next to the Student Hub. The state-of-the-art sports facility includes:

- Climbing wall (for males and females)
- Weightlifting Area (one for males and one for females)
- Cardio Area (one for male and one for females)
- Outdoor tennis court
- Outdoor basketball court
- Outdoor running track
- Outdoor miniature basketball court
- Stretching area
- Group exercise studios (three studios for each gender)
- Multi-use indoor fields for basketball, football, handball, volleyball, badminton, etc.
- Table tennis room
- Pool table room

STUDENT LOUNGES

Separate lounge areas are provided for male and female students. Please refer to the campus map to locate the student lounges.

MAIN CAMPUS MAP



Building

Current campus

New campus expansion

1 Library
2 Multi purpose hall
3 Auditorium
4 Food court
5 Prayer room

Google maps code
54.394882 ,24.447427

MASDAR CITY CAMPUS

DINING SERVICES
The Spinney's campus cafeteria caters to the needs of staff and students with buffet and a la carte menu of hot meals three times a day. A number of retail outlets also operate on campus, including Caribou Café, Sumo Sushi and Bento, Cento Café, and Papparoti. In addition, student residences include basic kitchenette facilities for self-preparation of simple meals.

LAUNDRY
There are shared laundry rooms located within each of the residential blocks.

MAINTENANCE
Masdar City Campus residents are requested to notify/email the Helpdesk immediately for any disrepair, damage or defect affecting the room or buildings. We will then arrange for the repair to be carried out. Please remember that access to the property will be required by the contractors in order to complete a repair.

MAJLIS / COMMON AREAS
Common areas are provided for male and female students. Common spaces can be found in Building 1B, restaurants, cafes, and canteen. There are also several common sitting spaces and external balcony areas within each of the residential blocks.

PARKING
At the Masdar City Campus, cars are permitted to be parked in the North Car Park adjacent to the Personal Rapid Transport (PRT) station.

Parking is limited, as spaces must accommodate faculty, students, and staff, and cannot be reserved. All student cars are required to display a valid MI access sticker to enter the Masdar City site. To apply for an MI car parking sticker, submit an application form to the Security Office of the EHSS Department. Student cars are not allowed for drop-offs or pickups on the podium level.

PRAYER ROOMS
There are both male and female prayer rooms located within the campus (please refer to the campus map).

RECYCLING
Dedicated bins are provided in the kitchens for recycling at each of the residence buildings.

SECURITY
Security guards are located at each accommodation site and are present 24 hours daily. The security guards are responsible for controlling entry and exit and for carrying out regular patrols of the area.

STUDENT RESIDENCES
Residences at Masdar City Campus house male graduate students. Each apartment has a bedroom, kitchen, toilet and shower, living/dining and study area. All apartments have private balconies. Daily shuttle bus to Main Campus.

MASDAR CAMPUS MAP

Main Buildings

- A Incubator Building
- B Knowledge Center
- C Multi-use Hall
- D Siemens Building
- E Wind Tower
- Masdar Institute Campus

Cafés and Restaurants

1. Barbacoa Mexican Restaurant
2. Café Cento
3. Caribou Coffee
4. IL Café Di Roma
5. Jim's Kitchen Table
6. Just Falafel
7. Osha Emirati Gourmet
8. Papparoti Café
9. Quiznos Sub
10. Spinneys Cafeteria
11. Sumo Sushi & Bento

Services

14. Al Hilal Bank
15. Al Manara Pharmacy
16. Emirates Post
17. Etisalat
18. Modern Laundry
19. NBAD Bank
20. The Doctors Medical Centre

Retail

12. F-Mart Supermarket
13. Organic Supermarket

Bus Stops

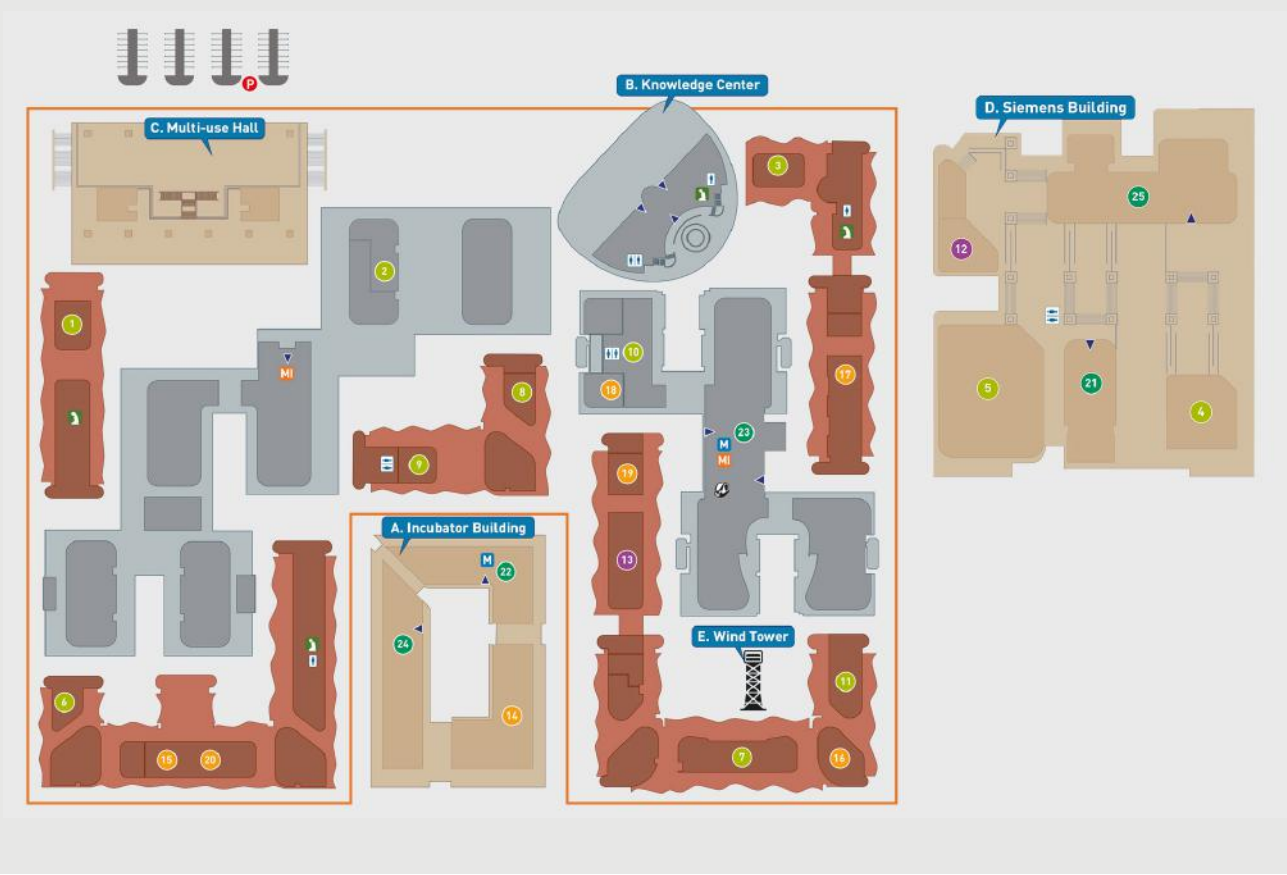
- Public Bus
- Big Bus

Corporate Offices

21. Etihad Airways
22. Masdar City Offices
23. Masdar Corporate Offices
24. Masdar Free Zone One-Stop Shop
25. Siemens Middle East

Facilities

- Personal Rapid Transit (PRT)
- Male Prayer Room
- Female Prayer Room
- Toilets
- Masdar Reception
- Masdar Institute Reception
- Building Entrance
- Car Park (Staff Only)



SAS AL NAKHL CAMPUS

DINING SERVICES

Spinneys cafeterias, open for breakfast, lunch, and snacks, are located in Habshan, and Arzanah Buildings. Costa café is also available in Habshan, Bu Hasa and Arzanah Buildings offering coffee, breakfast, light lunch and snacks. An ADNOC Oasis convenience store is located in the center of the Campus. The Arzanah building has a large dining facility for female students

HEALTH SERVICES

First Aid Clinics provide primary health care to the students, faculty, and staff members on the Sas Al Nakhl Campus. The Sas Al Nakhl Clinic (open to male students) is open Sunday-Thursday 7:00am to 11:00pm and provides 24-hour accident and emergency care. Depending on the nature of the illness, patients may be referred to other hospitals or clinics for further treatment. A dedicated clinic for female students is available in Arzanah and is open Sunday-Thursday, 7:30am to 5:00pm.

HOUSING

The Um Al Lulu Housing Complex at SAN Campus houses female graduate students. Each student is provided with a single bedroom, as well as a shared living room and kitchen facilities. Daily shuttle bus to Main Campus.

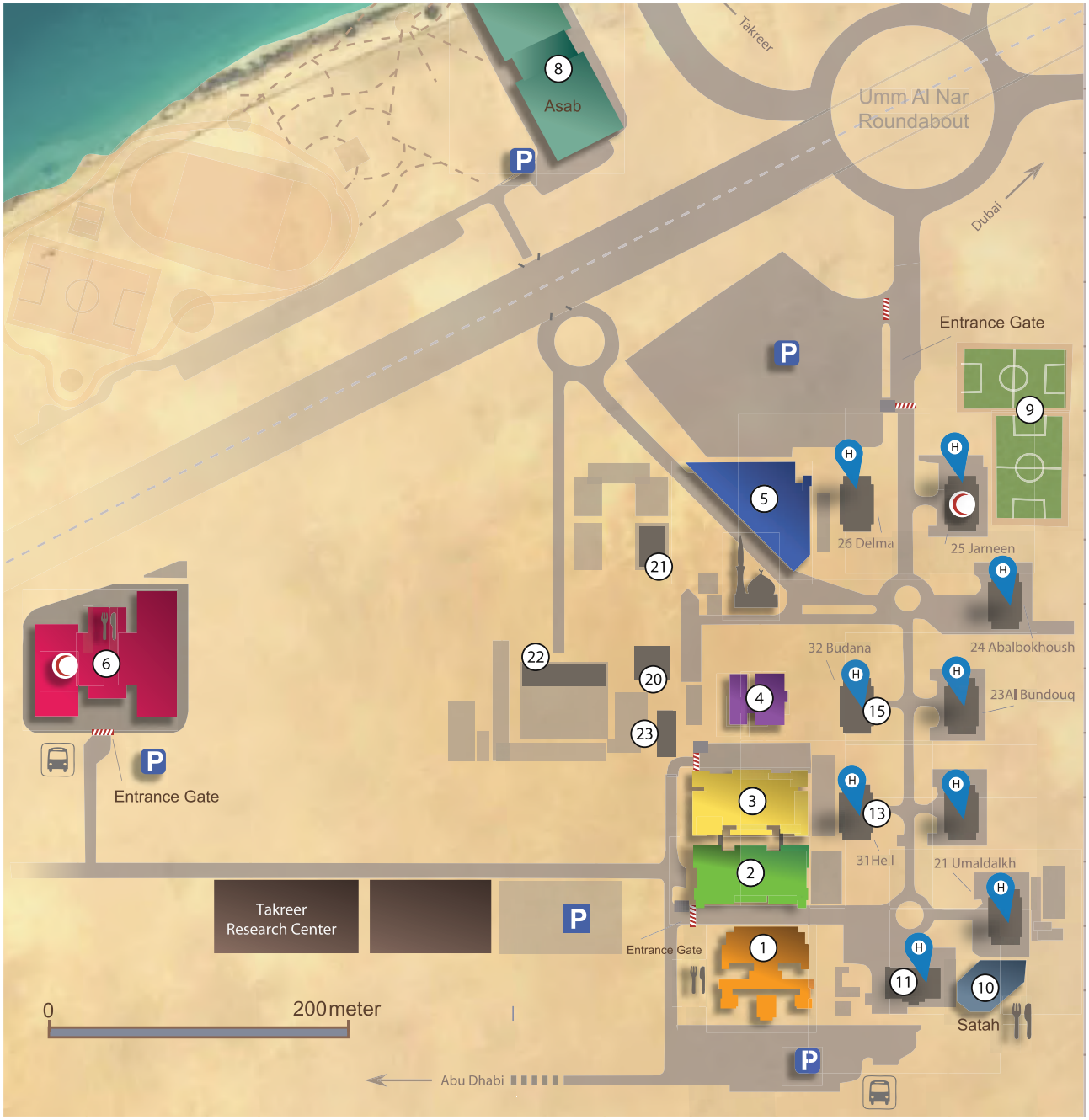
SPORTS AND FITNESS FACILITIES

The men's section of the campus has a grass soccer field and outdoor basketball court. The second floor of the Satah, Student Center houses a variety of fitness and weightlifting equipment and is open for use from 7:00am -11:00pm daily. The women's section of the campus features a gym, an outdoor volleyball and badminton court and a jogging and circuit fitness track. Regular intramural sports tournaments are organized, including indoor soccer, basketball, volleyball and table tennis. The women's dorm has a multi-function fitness room in Tower 2, the main administrative building. Furthermore, one of the residential villas contains a variety of fitness equipment, bicycle 'spinning' room and floor exercise facilities.

STUDENT CENTERS

The Student Centers are located in the Bu Hasa Building in the co-ed section and the Arzanah Building in the women's section. A number of student lounges are also available. These student-centered facilities provide a dedicated setting for social, organizational, and extracurricular activities. The Student Centers are equipped with computers, gaming tables, large flat screen televisions, etc.

SAS AL NAKHL CAMPUS MAP



- 1 Zarkuh (AUP, Classrooms, Cafeteria, Student Support, Student Lounge)
- 2 Bu'Hasa (A&S, CE, Classrooms, Labs, Faculty Offices, Athletics, Student Affairs, SOS, Dietician)
- 3 Ruwais (EE, ME, PE, & PG, Classrooms, Labs, Faculty Offices)
- 4 Umm Shaif (Faculty Offices, Classroom)
- 5 Habshan (Library & Administration)
- 6 Arzanah (WiSE Facilities)
- 8 ASAB (Sports Hall, Recreation & Fitness Center)
- S Smoking Designated Area
- Assembly Point

- 9 Football Fields
- 10 Satah (Student Center, Cafeteria)
- 11 Student Dorm , Resident Life, Learning Center
- 13 HEIL B31 (Student Clubs, FMS Offices,Printing Center)
- 15 BU DANA B32 (Student Dorm, Laundry)
- 20 C-Store - OASIS
- 21 Block-C (Graduate Student)
- 22 HSE Lab, Solar Car Workshop
- 23 Old ATI (ME Workshop, Graduate Student)

- Clinic
- Mosque
- Parking
- Restaurent
- Student Dorm

GRADUATE PROGRAMS AND DEGREE STRUCTURE

Khalifa University of Science and Technology (KU) offers a range of graduate programs designed for the pursuit of advanced specialized knowledge and skills in engineering, medicine, security, science and technology. Students engage in cutting-edge research and formulate innovative solutions to contemporary global challenges. Selected programs also allow students to focus their coursework in a chosen area via an optional track or concentration. Please note that programs marked with an asterisk (*) are offered to UAE National applicants only.

MASTER OF ARTS (MA)

PROGRAM OUTLINE

The Master of Arts (MA) is designed for students seeking advanced training in fields focused on international, regional and civil security. The MA is a nationally-ranked, research-intensive, graduate program which advances the critical and analytical skills of students. KU offers the following MA program:

- International and Civil Security*

PROGRAM COMPONENTS

The MA program typically consists of 36 credit hours.

- **Taught Courses:** In this component students are required to complete a program of advanced study in a given area. The taught courses component is equivalent to a minimum of 24 credit hours and typically consists of eight courses comprising a combination of core and electives.
- **Thesis:** In this component students are required to carry out an independent investigation in their chosen area of study. The thesis component is typically equivalent to a minimum of 12 credit hours. Students must successfully defend the thesis in an oral examination.

MASTER OF ENGINEERING (MENG)

PROGRAM OUTLINE

The Master of Engineering (MEng) is directed towards engineers that would like to pursue advanced studies and intend to have a professional career in industry. The program consists of courses, which emphasize applications of fundamental engineering concepts to industrial problems, including advanced technical and business management elements. KU offers MEng programs in:

- Health, Safety and Environmental Engineering

PROGRAM COMPONENTS

An MEng by Courses degree typically consists of a minimum of 30 credit hours.

- **Taught Courses:** In this component the student is required to complete a set of taught core and elective courses equivalent to a minimum of 30 credit hours.

MASTER OF SCIENCE (MSC)

PROGRAM OUTLINE

The Master of Science (MSc) programs emphasize fundamental concepts and are designed for students that wish to become involved in research, either through a PhD degree or in a corporate environment.

The MSc program consists of core and elective courses, as well as research work culminating in a Master's thesis. KU offers MSc programs in:

- Applied Chemistry
- Biomedical Engineering
- Chemical Engineering
- Civil and Infrastructural Engineering
- Computer Science
- Cyber Security
- Electrical and Computer Engineering
- Engineering Systems and Management
- Materials Science and Engineering
- Mechanical Engineering
- Nuclear Engineering*
- Petroleum Engineering
- Petroleum Geosciences
- Sustainable Critical Infrastructure
- Water and Environmental Engineering

PROGRAM COMPONENTS

An MSc by Courses and Thesis program typically consists of 36 credit hours.

- **Taught Courses:** In this component the student is required to complete a program of advanced study in a given area. The taught courses component is equivalent to a minimum of 24 credit hours and typically consists of eight courses comprising a combination of core and electives.
- **Thesis:** In this component the student is required to carry out an independent investigation in the area of study. The thesis component is typically equivalent to a minimum of 12 credit hours. The student must successfully defend the thesis in an oral examination.

DOCTOR OF PHILOSOPHY (PHD)

PROGRAM OUTLINE

The Doctor of Philosophy (PhD) endeavors to stimulate research and development to foster innovative solutions to challenges in science, technology, and engineering. The PhD programs are structured with integral taught core and elective courses in addition to the central research component. A shared pool of elective courses from different departments are available to students undertaking each program. KU offers the following PhD programs:

- **PhD in Engineering:**
  - Aerospace Engineering
  - Biomedical Engineering
  - Chemical EngineerinCivil Infrastructure and Environmental Engineering
  - Electrical and Computer Engineering
  - Engineering Systems and Management
  - Material Science and Engineering
  - Mechanical EngineeringNuclear Engineering*
  - Petroleum Engineering
  - Robotics
- **PhD in Petroleum Geoscience**

PROGRAM COMPONENTS

The PhD program typically consists of 60 credit hours.

- **Taught Courses:** In this component the student is required to complete a program of advanced study in a given area. The taught courses component is equivalent to a minimum of 24 credit hours and typically consists of eight courses comprising one core course and seven electives.
- **Dissertation:** In this component the student is required to carry out an independent investigation in the area of study. The research component is typically equivalent to a minimum of 36 credit hours. The student must successfully defend the dissertation in an oral examination.

For the award of the PhD degree, the student must satisfy the following requirements:

- **Courses:** The student must satisfy all taught course requirements of the program.
- **Written Qualifying Examination (WQE):** The student must successfully pass a written qualifying examination on a set of topical areas.
- **Research Proposal Examination (RPE) or Oral Qualifying Examination (OQE):** The student must prepare a research proposal and pass an oral research proposal examination before being allowed to progress further in the program.
- **Dissertation Examination:** The student must complete a dissertation on original research and defend it successfully in a dissertation oral examination (Dissertation Defense).

DOCTOR OF MEDICINE (MD)

The mission of the College of Medicine and Health Sciences is to enhance the healthcare ecosystem of Abu Dhabi and the United Arab Emirates through outstanding education, research, healthcare and service to the community. The Doctor of Medicine program is a four-year, post-baccalaureate program that prepares the highest quality physicians who are able to seamlessly integrate technology into medical practice.

Medical students must meet established minimum requirements in order to complete the Doctor of Medicine (MD) degree. For the award of the MD degree, the student must satisfy the following requirements:

- **Courses:** The student must satisfy all taught course and elective rotations requirements of the program
- **Licensing Examinations:** The student must successfully complete Step 1 of the USMLE (required for promotion to Period 4), Step 2CK and Step 2CS.
- **Competency Assessments:** The student must meet standards in ten competency domains (domains adapted from the Association of American Medical College Physician Competency Reference Set).
- **Professional Performance:** The student must consistently display professional behaviors and values appropriate for the practice of medicine.

For policies and processes concerning the College of Medicine and Health Sciences, please refer to the **CMHS Medical Student Handbook.**

PROGRAM CONCENTRATIONS AND TRACKS

The below definitions of concentrations and tracks are applicable unless stated otherwise in the relevant section of the specific program outline. Students should familiarize themselves with the definitions and requirements applicable to their program of study.

CONCENTRATION

Concentrations refer to a grouping of courses which represent a sub-specialization taken within the major field of study. A concentration at Khalifa University of Science and Technology leads to a specialized degree. It will be specified on the student's academic record (transcript), but not on the degree certificate.

TRACK

A track is a narrow area within the major field of study which the student may choose to follow, but does not lead to a specialized award or degree and is not listed on the diploma nor the academic record (transcript). Tracks are normally used to help students focus their selection of advanced elective courses within the chosen program.

GRADUATE ADMISSION

Admission to graduate programs at Khalifa University of Science and Technology is open to highly qualified students from the UAE and abroad. Admission of graduate students is governed by KU Academic Policy ACA 5150 Graduate Admissions. For policies and processes concerning the College of Medicine and Health Sciences, please refer to the CMHS Medical Student Handbook.

REQUIRED QUALIFICATIONS

FULL ADMISSION

Applicants seeking admission to a graduate program at Khalifa University must meet the following minimum criteria in order for the application to be considered:

MASTER'S PROGRAM APPLICANTS

- Completed Bachelor's degree in a relevant discipline with a minimum Cumulative Grade Point Average (CGPA) of 3.0 out of 4.0, or equivalent, from an accredited institution;
- Minimum level of English proficiency in the form of an iBT TOEFL (internet-based test) score of 91 or equivalent, an overall academic IELTS score of 6.5, or an EmSAT English score of 1550;
- Minimum quantitative score of 150 in the general Graduate Record Examination (GRE) for all programs, with the exception of Master of Engineering in Health, Safety and Environment Engineering and the Master of Arts in International and Civil Security, where a minimum threshold is not set. Applicants for all programs should attempt all three sections of the GRE.
- Statement of Purpose (500 – 1,000 words);
- Minimum of two referee recommendations; and
- Admission interview.

DOCTORATE PROGRAM APPLICANTS

- Completed Master's degree in a relevant discipline with a minimum CGPA of 3.25 out of 4.0, or equivalent, from a reputable accredited institution;
- Minimum level of English proficiency in the form of an iBT TOEFL (internet-based test) score of 91 or equivalent, an overall academic IELTS score of 6.5, or an EmSAT English score of 1550;
- Minimum quantitative score of 150 in the general Graduate Record Examination (GRE) is required for admission to all Doctorate programs. Applicants for all programs should attempt all three sections of the GRE;
- Minimum of two referee recommendations;
- Statement of Purpose (500-1,000 words);
- Research Statement (500-1,000 words); and
- Admission interview.

Subject to review and approval, the English test score requirement may be waived for an applicant who is:

- A native English speaker who has completed his/her Bachelor's/Master's qualification in an English medium institution, or
- A graduate from an English-medium institution who can provide evidence of acquiring a minimum overall academic IELTS score of 6.0, or a minimum TOEFL score of 79 iBT (or equivalent), or a minimum EmSAT English score of 1400 at the time of admission to the completed Bachelor's/Master's degree program.

All applicants must provide evidence of meeting the English language requirement by uploading the relevant document with their application, even if he/she may be eligible for an exemption.

CONDITIONAL ADMISSION

- Applicants with a lower CGPA score (Minimum 2.5 out of 4.0 or equivalent) may be considered for conditional admission to a Master's program in special circumstances. If conditional admission is granted, the student must achieve a minimum CGPA of 3.0 out of 4.0 in the first nine credits of taught courses. In addition, each academic program has specific conditions that must be satisfied for the student to remain in the program. If the student fails to satisfy the conditions, then his/her registration will be terminated.
- Applicants with a recognized Bachelor degree and iBT TOEFL score of 79 or equivalent, or an overall academic IELTS score of 6.0, or an EmSAT English score of 1400 may be considered for conditional admission to a Master's program in special circumstances. If conditional admission is granted, the student must achieve a minimum iBT TOEFL score of 91 or equivalent, or an overall academic IELTS score of 6.5 by the end of their first semester of registration.
- Applicants who do not attain the minimum GRE quantitative score required for the relevant Master's program may be considered for conditional admission. If conditional admission is granted, the student will be required to achieve a minimum GRE quantitative score of 150 by the end of their first semester of registration.
- Applicants with insufficient prior background in the chosen Master's or Doctorate program may be considered for conditional admission, but will be assigned undergraduate and/or graduate courses and/or specially tailored remedial courses as specified by the relevant program. Credits from these prerequisite bridging courses do not count toward fulfilment of the particular degree requirements and are not used to calculate the graduate Cumulative Grade Point Average (CGPA).

TRANSFER STUDENTS

A student who has completed at least one semester of graduate studies at an accredited or recognized institution may be considered for admission as a transfer student (dual degree programs are subject to specific guidelines). Admission as a transfer student is highly competitive and is based on the number of students that can be accommodated in a particular program or level of study. The decision to admit a transfer student takes into account the student's record of achievement in both undergraduate and graduate studies. The following rules apply:

- Only students in good academic standing with a cumulative grade point average (CGPA) of 3.0 or greater (out of 4.0, or equivalent) will be considered for transfer admission.
- Only students transferring from a federal or recognized and lawfully accredited institution in the UAE, or a recognized and lawfully accredited foreign institution of higher learning, are eligible for admission.
- Transfer applicants must meet the Khalifa University graduate program admission requirements in effect for the semester in which they intend to enroll.
- Official transcripts from all institutions of higher learning previously attended must be submitted.
- Students must be eligible to continue their enrollment at the institution from which they wish to transfer.
- Up to a maximum of nine credit hours may be approved as transfer credits for taught graduate courses.

- Graduate courses with a minimum grade of B and deemed equivalent in content and level to those offered at KU will be transferred as equivalent KU courses. Other appropriate graduate courses with a minimum grade of B may be transferred as free/open electives or unassigned courses in the relevant area. No transfer credit will be awarded for taught coursework taken on a pass/fail basis.
- Courses completed more than five years prior to being admitted as a graduate student at KU are not transferable.
- Graduate program credits will not be given for work experience, vocational or training courses or coursework that is not considered graduate level.

If a transfer student is admitted, the student may request to transfer courses and credit hours (not grades) from the student's previous institution to Khalifa University. This request and all supporting documents must be submitted at least two weeks prior to the start date of the first semester of enrollment at KU. A decision to accept a course in transfer will be provided before the end of the Add/Drop period of that semester. The decision to accept a course in transfer is discretionary. The application for transfer credit hours will follow the policy provisions of KU Academic Policy ACA 3270 Transfer Credits and Advanced Standing.

ADMISSION OF NON-DEGREE SEEKING STUDENTS

At the discretion of the University, a limited number of individuals may be admitted as non-degree seeking students on either a full-time or part-time basis. Non-degree students are not candidates for a KU degree and may be enrolled temporarily for personal/professional improvement. Admission of non-degree seeking students is governed by KU Academic Policy ACA 5150 Graduate Admissions.

- Non-degree seeking students must demonstrate that they are qualified to undertake graduate course work, satisfy the admission and English proficiency requirements at the time of their admission, and have met prerequisite requirements for any courses taken.
- Students enrolling in courses as an exchange student are governed by the exchange agreement between KU and the student's home institution.
- Admission as a non-degree graduate student is valid only for one semester and a new application for each subsequent semester must be approved. Approval can only be granted if the student has earned a minimum grade of B in all courses taken in previous semesters.
- Admission as a non-degree graduate student does not imply any commitment on the part of KU toward an individual's admissibility to regular student status. If a non-degree graduate student is subsequently admitted as a regular graduate student, courses completed may be used in partial fulfillment of the requirements for an advanced degree. The program faculty will determine the extent to which the courses meet the requirement of the desired program.

DEFERRED ADMISSION

Admission is valid only for the academic semester specified in the offer letter. If an applicant is offered admission, but for any reason intends to join the University in a subsequent semester, then he/she must submit a written request to the Admissions Team. Requests for deferred admission are subject to approval by the Dean of Graduate Studies (or designee) and the following guidelines:

- Admission may normally be deferred for one regular semester only.

- Deferral for National Service is automatically granted. The student must register for classes in the semester immediately following the completion of National Service.
- If a student is unable to enroll in the semester to which they were deferred, he/she must re-apply for admission.

APPLICATION PROCEDURE

Applications for Khalifa University graduate programs are accepted online, via the University's Graduate Admission Portal. Applications must be made by the deadline published on the University website for the relevant semester (Fall or Spring). Applicants must complete the application form and upload the following documents (incomplete applications may not be considered):

- Certified copy of Bachelor's/Master's degree certificate.
- Certified copy of Bachelor's/Master's transcript showing the grading scale.
- Equivalency certificate(s) issued by the UAE Ministry of Education for applicants that have graduated from institutions outside of the UAE.
- English language proficiency score certificate (IELTS, TOEFL or EmSAT). Official TOEFL score reports can be sent directly by your institution to Khalifa University of Science and Technology using the institutional TOEFL code 0960.
- Graduate Record Examination (GRE) score report. Official score reports can be sent directly to Khalifa University of Science and Technology using the institutional GRE code 0822.
- Detailed Curriculum Vitae (CV).
- Statement of Purpose (500 to 1,000 words)
- Research Statement (500 to 1,000 words – PhD applicants only)
- Passport-style photograph on a white background.
- Valid passport (for UAE National applicants should include the union number page).
- Valid UAE visa (for international applicants who reside in the UAE).
- Valid Emirates ID Card (for UAE National and international applicants who reside in the UAE).
- Family Book (Khulasat Al Qaid for UAE National applicants only).

All documents supplied for admission purposes become the property of the University and will not be returned to the applicant.

Admission decisions are made in good faith and on the basis of the information provided in the application form. The University reserves the right to withdraw any admission offer or terminate a student's registration if it is found that an applicant has made a false statement or has omitted significant information.

SCHOLARSHIPS AND FEES

Scholarships

Khalifa University offers graduate students comprehensive scholarships that cover educational expenses and may provide an opportunity to earn a monthly stipend. Please refer to the University website for detailed information on the range of scholarships available. Graduate scholarship provisions are governed by KU Academic Policy ACA 5160 Graduate Scholarships and Stipends.

All graduate students admitted under a Khalifa University scholarship must sign the relevant award contract or agreement before the end of the Add/Drop period in the first semester of registration. Students must abide by the terms and conditions stipulated in the award contract or agreement to maintain scholarship eligibility.

Buhooth Scholarship

The Buhooth Scholarship Program is an ambitious initiative that aims to achieve the vision of His Highness Sheikh Mohammed Bin Zayed Al Nahyan, Crown Prince of Abu Dhabi and Deputy Supreme Commander of the UAE Armed Forces, to transform the UAE into a center of excellence in engineering and science research. The initiative offers Master's and Doctorate scholarships to full-time UAE National students with the aim of promoting graduate studies and research, as well as developing specialized human capital in the areas of science and engineering for the benefit of national institutions. The scholarship benefits include:

- Monthly stipend
- Full coverage of tuition fees
- Support to attend international research conferences
- Opportunity to visit international research centers

International Buhooth Scholarship

This scholarship aims to provide an opportunity for applicants to pursue Master's and Doctorate degree studies at top international universities. The scholarship is open for selected majors only, as determined by Khalifa University. The scholarship is highly competitive and will only be offered to a limited number of successful applicants each year. Applicants awarded the International Buhooth Scholarship will sign a contract committing to accept employment in a suitable post as determined by Khalifa University for a defined period of time, which must be at least equal to the length of time of the study period. The scholarship benefits include:

- Monthly stipend, including an additional allowance to UAE Nationals living outside the UAE.
- Registration in the Abu Dhabi Retirement Pensions and Benefits Fund.
- Medical insurance for student, spouse and eligible dependents.
- Yearly round trip airline tickets for student, spouse and eligible dependents.

In order to be considered for the International Buhooth Scholarship, applicants must UAE Nationals with excellent credentials and provide a letter of offer from a top-ranked international institution. The letter should be submitted at the time of application to Khalifa University.

Graduate Research / Teaching Assistant (GRTA) Scholarship

The GRTA scholarship is available to qualified international students pursuing graduate study at Khalifa University on a full-time basis. The scholarship benefits include:

- Monthly stipend.
- Full coverage of tuition fees.
- Support to attend international research conferences.
- Medical insurance coverage for students holding a Khalifa University sponsored visa.

China Scholarship Council – Khalifa University Joint PhD (CSC-KU) Scholarship

Khalifa University, in collaboration with the China Scholarship Council (CSC), offers the CSC-KU Scholarship to highly qualified Chinese nationals admitted to a PhD in Engineering or Science on a full-time basis. The scholarship benefits include:

- Monthly stipend from KU and an additional stipend from CSC.
- Flight tickets provided by CSC.
- Full coverage of tuition fees.
- Free University accommodation or accommodation assistance if University accommodation is not available.
- Support to attend international research conferences.
- Medical insurance coverage for students holding a Khalifa University sponsored visa.

Waived-Fees Scholarship
This scholarship is available to employed UAE National students undertaking graduate studies on a part-time basis and provides full coverage of tuition fees.

TUITION FEES

MASTER
AED 5,000 per credit hour

DOCTORAL
AED 6,666 per credit hour

Please note that tuition fees are subject to review. Detailed guidance on fees, payment processes and deadlines can be found in the KU Fees, Scholarships and Payment Guide, which is published by the Registrar's Office every semester.

DISCLAIMER

The University reserves the right to make changes to the published scholarship and fees information without prior notice, at any time before the beginning of an academic semester.


KHALIFA

REGISTRATION

ORIENTATION

Newly-admitted students participate in an orientation event that introduces them to various aspects of the Khalifa University community. During orientation, students can plan their academic program, register for courses, learn about University resources and campus life, and meet with faculty, staff and new classmates. Orientation sessions are normally held in the Fall and Spring semesters. For policies and processes concerning the College of Medicine and Health Sciences, please refer to the CMHS Medical Student Handbook.

NUMBER OF DEGREES

A student may be registered for only one degree at any time, and work to be submitted for a degree cannot be submitted elsewhere for a degree or other similar award.

REGISTRATION PROCESS

The Registrar's Office is responsible for the management of the registration process by which students enroll in classes. Registration information is provided to students before the registration period begins. Through the registration process, students assume academic and financial responsibilities for the classes or research in which they enroll. All graduate students are required to re-register on a semester basis. Such re-registration is subject to satisfactory progress.

REGISTRATION DEADLINES

Khalifa University policies determine when students may enroll or adjust their enrollment in classes. The Registrar's Office has the most up to date information regarding these policies. The registration period and other important dates are published in the Academic Calendar, which can be downloaded from the University website.

REGISTRATION HOLDS

Students will not be permitted to register if there is a "hold" on their record. Holds may be related to academic standing (probation or dismissal), non-academic offense violations (disciplinary), incomplete admission (missing documents), financial or scholarship matters. Holds may also be placed on students who are not UAE citizens and have not submitted required immigration documentation. To clear a hold, the student must contact the office that has issued the hold to find out what must be done to fulfil the obligation(s).

ACADEMIC ADVISING

In order to register each semester, students must meet with a faculty advisor to discuss their academic progress, course selection and obtain approval for registration. This process ensures that the student is on track to meet the graduation requirements of his or her degree program. Academic advising is an integral aspect of academic progress and a shared responsibility between the student and their advisor.

The appropriate Department Chair (or designee) will serve as the academic advisor for all newly admitted graduate students in their first semester of study. By the end of the first semester, full-time students will have an opportunity to nominate their preferred research project and research advisor. For part-time students, this is normally completed by the end of the second semester of study. MEng students are not required to complete a research thesis and their academic advisor will be appointed by the relevant academic department. Please refer to the **"Research Project Allocation and Advisor Appointment"** section of this catalog for further details.

Academic Advising Guiding Principles
Academic advising is guided by the following principles:

- Effective academic advising can play an integral role in student development.
- Mutual respect and shared responsibility should govern the personal interactions between advisors and students.
- Students and advisors must prepare for, actively participate in, and take appropriate action following advising sessions.
- Advising information provided to students must be accurate, accessible, and timely.
- Academic advising should encourage students to explore many possibilities and broaden their educational experience.
- Academic advising should encourage a positive attitude toward lifelong learning.
- Academic advising should use all available resources and means to provide advising tailored to the individual needs of students.
- Academic advisors should keep records of the advising sessions held with a student.

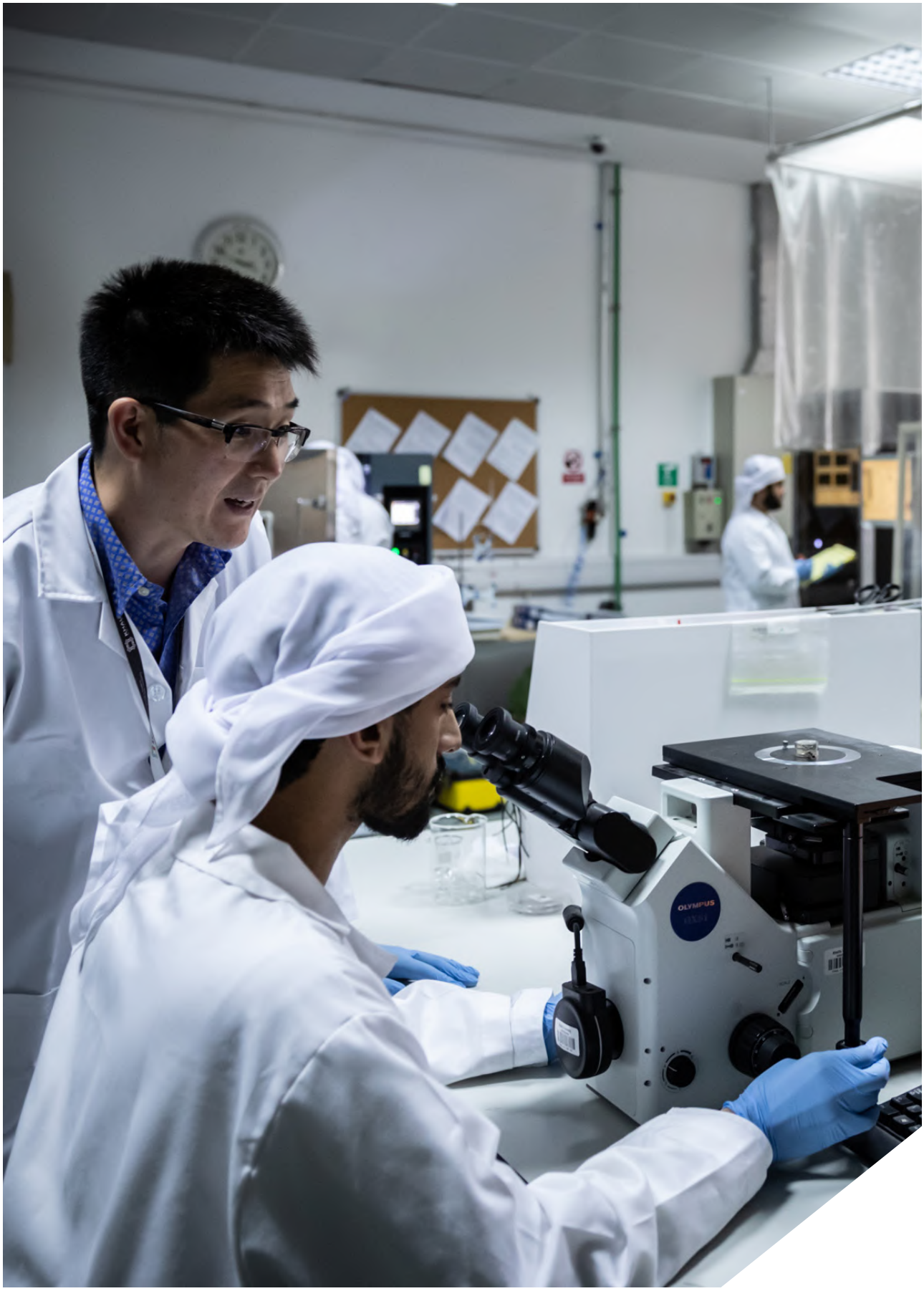
FACULTY OFFICE HOURS

Faculty office hours are allocated for student consultation. Faculty are required to display office hours on their office doors. Students are encouraged to make use of these times for consulting with faculty on the courses they are taking.

STUDY PLAN

The study plan outlines the minimum academic requirements of the degree program, which must be completed by a student in order to be eligible to graduate. Study plans change over time, and consequently students are required to follow the approved plan and degree requirements that were in effect at the time of their admission to the academic program.

Students may petition the Department Chair for approval of changes to the prescribed study plan. Small changes may be approved by the Department Chair. Significant changes require approval from the Department Chair, Associate Dean for Graduate Studies at the relevant College and the Dean of Graduate Studies.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ACADEMIC REGULATIONS

THE ACADEMIC YEAR

The academic year at Khalifa University includes two regular semesters (Fall and Spring), as well as a Summer Term. There are normally fifteen weeks of teaching in a regular semester and six weeks of teaching during the Summer Term. For policies and processes concerning the College of Medicine and Health Sciences, please refer to the CMHS Medical Student Handbook.

LANGUAGE OF INSTRUCTION AND EXAMINATION

English is the official language of Khalifa University. All courses are taught and examined in English with the exception of non-English content courses such as Arabic language.

OFFICIAL COMMUNICATION METHOD (E-MAIL)

Khalifa University has adopted e-mail as the primary means for official communication to its students, faculty, and staff. The university will send all official communication regarding academic and administrative matters, important information, and time-sensitive notices to the e-mail accounts provided by the university. It is the student's responsibility to monitor their university e-mail regularly to ensure that such communication is received. Failure to check e-mail, errors in forwarding e-mail, and returned e-mail due to full mailbox, will not excuse a student from missing announcements or deadlines. Students are expected to use the e-mail account provided by the university to communicate official matters to the university.

DURATION OF STUDY

Students are required to make steady progress towards meeting degree requirements and must successfully pass all program components (taught course and thesis/dissertation) within the normal allowed time to completion. Any Khalifa University scholarship is generally awarded only for the duration of the normal time to completion. Graduate program completion and graduation requirements are governed by KU Academic Policy ACA 3250 Graduate Program Completion Requirements.

PROGRAM LEVEL	STUDY MODE	TIME TO COMPLETION		
		MINIMUM	NORMAL	MAXIMUM
Master's	Full-time	1.5 years	2 years	4 years
Master's	Part-time	2 years	4 years	5 years
Doctorate	Full-time	3 years	4 years	7 years
Doctorate	Part-time	5 years	6 years	8 years

EXTENSION OF DURATION OF STUDY

Students must satisfy degree requirements within the normal time to completion specified in the "Duration of Study" section of this Catalog. In exceptional circumstances, an extension of registration may be granted by the Dean of Graduate Studies on the recommendation of the student's academic department and approval from the Associate Dean for Graduate Studies of the relevant College. The student must submit an Exception to Policy Request and attach a supporting letter from their Advisor(s) providing justification for seeking an extension and clearly outlining the student's plan of work towards graduation. Students sponsored by external entities must also attach written approval from their sponsor.

Students should note that any extension will normally only be granted within the maximum allowable time to completion. The maximum allowable time to completion includes any periods of leave taken by the student and the time taken to write-up the thesis/dissertation. An approved academic extension does not automatically grant or guarantee continuation of any scholarship benefits. Students seeking a scholarship extension must submit a separate appeal to the Graduate Studies Office, which will be reviewed by the appropriate committee.

MODES OF STUDY

Students are admitted to graduate study on a full-time or part-time basis. To be considered full-time, a student must be registered for nine or more credit hours during a regular semester. Due to the intense nature of summer coursework, students may take no more than two courses or six credits in the Summer Term. Summer Term registration is mandatory for full-time students.

STUDY MODE	FALL OR SPRING SEMESTER	SUMMER TERM
Full-time	Minimum 9cp / Maximum 12cp	Maximum 6cp
Part-time	Typically 6cp	Maximum 6cp

Registration above or below the standard credit hour limits requires advance approval from the student's Advisor, Department Chair (or designee) and Associate Dean for Graduate Studies at the relevant College. Registration below nine credit hours for full-time students requires additional approval from the Dean of Graduate Studies. Externally sponsored students must obtain the written approval of their sponsor before varying the registration credit load.

The status of a student is determined by the number of credits for which he/she is registered at the close of the Add/Drop period published in the Academic Calendar. Full-time students who fail to earn a minimum of nine credit hours in a regular semester are at risk of not completing their degree program in the allotted time and may be issued an academic progress warning if prior permission was not obtained. For potential impacts on scholarships, refer to KU Academic Policy ACA 5160 Graduate Scholarships and Stipends.

CHANGE OF PROGRAM, SCHOLARSHIP OR STUDY MODE

A student may request to change his/her degree program or study mode after admission to Khalifa University. Normally, the student must be in good academic standing and submit the Request to Change Graduate Degree Program before completing no more than 12 credit hours of taught courses. All such requests must be approved by the relevant Department Chair(s), Associate Dean for Graduate Studies and the Dean of Graduate Studies. Students must note that a change of program or study mode may delay their graduation, affect their scholarship eligibility and render the student liable for a financial penalty if a scholarship contract is breached. Students are advised to refer to the terms and conditions of their scholarship award before applying to change study mode or program. Students sponsored by organizations external to KU must obtain the approval of their sponsor.

INTERNSHIPS

Internships provide an important opportunity for Khalifa University graduate students to experience a unique facility or specialization offered by an academic institution, research centre or company. Internship experiences can enhance the research students undertake at Khalifa University and facilitate real world applications. Students gain professional experience by interacting with potential research partners and employers, as well as an understanding of the skills needed in different industry sectors. Internship students will promote Khalifa University as a world class institution among government and industry entities in the UAE and all over the world. Students who demonstrate promising potential for independent work and whose research topic lends itself to external collaboration may be considered for an internship.

INTERNSHIP GUIDELINES

All registered graduate students can apply for an internship during their studies at Khalifa University. Internships are optional and subject to approval. The following general guidelines apply:

- Students must be in good academic standing to be eligible to apply for an internship.
- Students must have the permission of their Main Advisor prior to pursuing an internship.
- An internship must not interfere with the student's academic studies, research and teaching duties, thus it is normally undertaken during the summer, for a period not exceeding 3 months. Students may apply for a longer internship period and any such request will be subject to approval.
- Students may not sign any agreement with a host organization until their internship application is approved by Khalifa University. The approval process includes review of all agreement documents.
- Students may not simultaneously accept employment from Khalifa University or any other organization.
- Based on approval from Khalifa University, the student may accept compensation from the host organization for internship expenses such as travel, accommodation, visa, etc. Depending on the financial arrangements made with the host, the student may not be eligible to receive a stipend from Khalifa University during the internship period.
- Pursuing an internship will not extend the duration of the student's scholarship.

TYPES OF INTERNSHIPS

Research-Based
This internship provides students with experience in a research laboratory at a research-intensive international institution or research centre. The work undertaken during this internship must be relevant to the student's research at Khalifa University. It is the responsibility of the Main Advisor to monitor the student's progress during the internship.

Industry-Based
This internship provides students with an opportunity to gain experience in industry. Such activity may include collecting data, building case studies and obtaining a deeper understanding of the application area of the research topic or problem.

Course-Based
This internship allows students to attend a specialized graduate-level course available at a high-ranking international institution. Students must obtain the approval of their Advisor(s), the Associate Dean for Graduate Studies at the relevant College and the Dean of Graduate Studies prior to registering for courses outside Khalifa University. Students wishing to transfer credit for courses completed during an internship must adhere to Khalifa University policy ACA 3270 Transfer Credit and Advance Standing.

APPLICATION PROCEDURE

The Graduate Studies Office (GSO) manages the internship application and approval process for graduate students. Internship applications are assessed on the basis of student's academic merit, quality of the application and the perceived benefit to the student's program of study. Internships may be sought with existing Khalifa University partner institutions, industry entities, or through ad hoc links with leading international universities and research centres.

Before the Internship

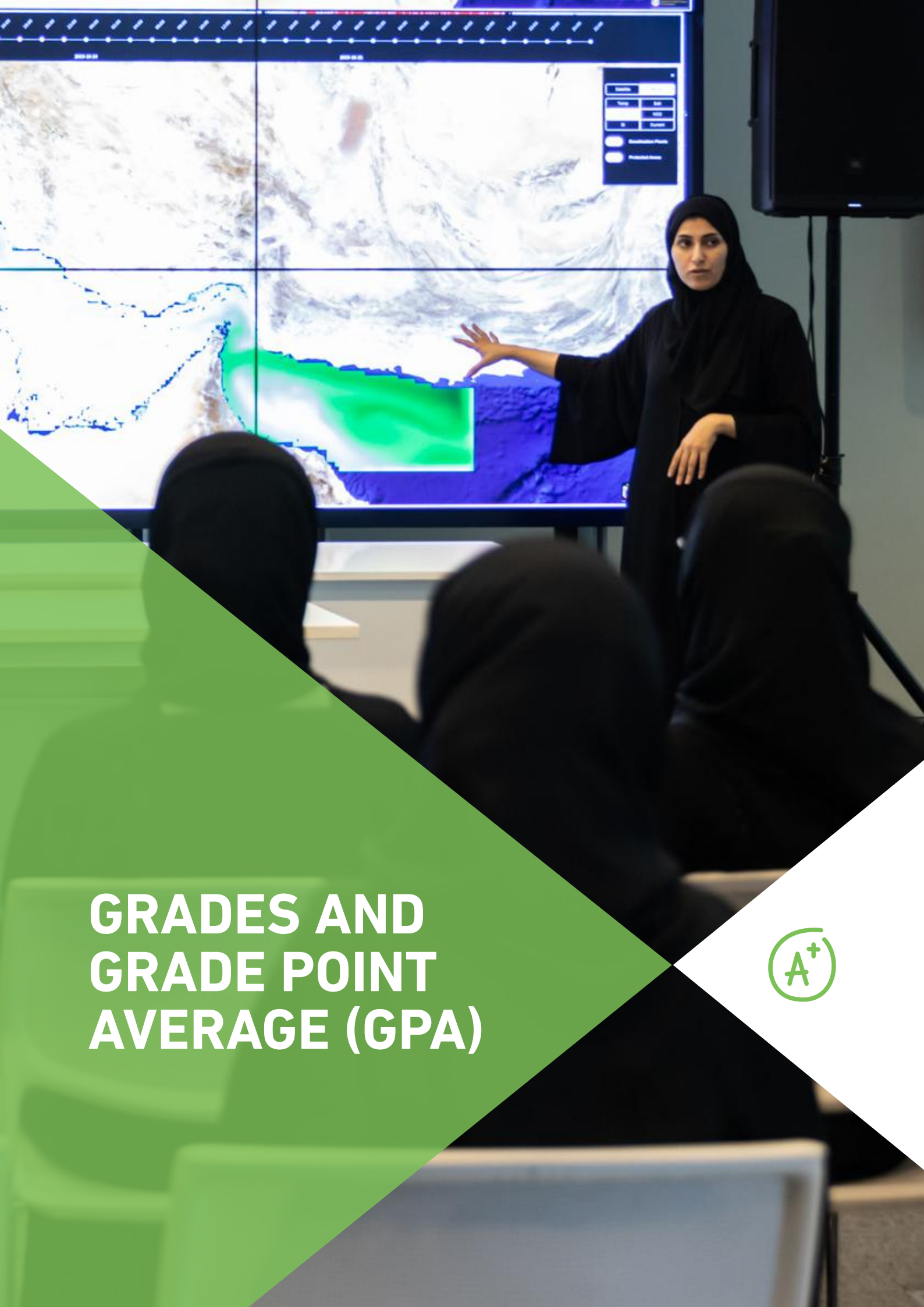
- The student must consult his/her Main Advisor and secure his/her support before pursuing an internship. The Main Advisor may assist the student in identifying a suitable host organization, if necessary.
- The student must obtain a formal letter from the host organization detailing the terms of the internship, including duration and any financial benefits offered to the student.
- The student must complete the Internship Application Form, obtain the approval of the Main Advisor, Department Chair, Associate Dean of Graduate Studies at the relevant College and submit it to GSO with supporting documentation. The student's participation in the internship is confirmed once approval is received from GSO and student's Banner record is updated, as appropriate.
- Applications for Research-Based internship should include the scope of planned work, a list of tasks to be conducted and expected outcomes. The Main Advisor must provide a letter of support stating how the intended internship will benefit and enhance the student's research at Khalifa University.
- Once the internship assignment is approved, the student should register for thesis/dissertation credits for the relevant semester.

During the Internship

- The student must maintain active communication with his/her Main Advisor and provide regular updates on the progress of the internship.
- The student is encouraged to keep a personal log covering the work carried out at the host institution to facilitate writing the final report that will be submitted to the Graduate Studies Office and the Main Advisor upon completion of the internship period.
- The student must behave in the utmost professional manner, be a good ambassador for Khalifa University and adhere to the regulations and guidelines of the host organization.
- For Research-Based internships, the Main Advisor should maintain direct communication with the student's advisor at the host organization.

After the Internship

- The student must submit a detailed report to the Graduate Studies Office on the activities carried out during the internship, endorsed by the student's advisor at the host organization and Main Advisor at Khalifa University. The report must be signed by a representative from the host organization to confirm approval for publication.
- The Main Advisor will evaluate the student's work as part of research performance and incorporate the evaluation in the thesis/dissertation grade for the relevant semester.



GRADES AND GRADE POINT AVERAGE (GPA)

GRADING SCALE

Grades are an important component of the learning assessment process. All courses must be assigned a grade in the middle and end of the semester in which the course is offered. It is the responsibility of the course instructor to inform each class at the beginning of the semester of the nature of the course assessment and corresponding grades assigned. Each course instructor should include a grading metric in the course syllabus. The grades and guidelines below are used at KU for graduate programs (refer to KU Academic Policy ACA 3350 Grading System, GPA and Course Repetition). For policies and processes concerning the College of Medicine and Health Sciences, please refer to the CMHS Medical Student Handbook.

LETTER GRADE	GRADE POINT	DESCRIPTION
A	4.00	Excellent
A-	3.70	Very Good
B+	3.30	Good
B	3.00	Satisfactory
B-	2.70	
C+	2.30	Less than Satisfactory
C	2.00	
F	0.00	Fail
XF	0.00	Failure Due to Academic Dishonesty*
WF	0.00	Withdrew Failing

*XF: Failure Due to Academic Dishonesty (this grade can only be assigned after an academic dishonesty hearing; student may petition to change this grade to F).

Additional letter grades are used to denote special cases. These letter grades do not have corresponding grade points, and hence are not used in calculating a student's grade point average.

LETTER GRADE	DESCRIPTION
AUD	Audit
EX	Student Exempt from a Course (no credit given)
I	Incomplete*
IP	In Progress (may be assigned prior to a final grade in a multi-course sequence)
N	No Grade Submitted
S	Satisfactory (denotes passing in a Pass/Fail course)
TR	Transfer (credit counted)
U	Unsatisfactory (denotes failing in a Pass/Fail course)
W	Withdrew between end of late registration and deadline for course withdrawal
WA	Administratively withdrawn due to absences
WP	Withdrew Passing after the deadline for course withdrawal through the last day of classes (must be approved by the Dean or designee)

*Incomplete Grade: The incomplete grade is an exceptional grade that can only be assigned when a student has satisfactorily completed a major portion of the work in a course but, for non-academic reasons beyond the student's control and deemed to be acceptable in accordance with university regulations, was unable to meet the full requirements of the course. It is the student's responsibility to meet with the instructor and request arrangements for the completion of the missing required coursework. A grade change request to remove the incomplete grade must be submitted no later than the end of the first week of classes in the following term. Failure to remove the "I" grade by this deadline will result in the "I" grade changing to "F".

GRADE POINT AVERAGE

The Grade Point Average (GPA) is the cumulative numerical average, which measures student academic achievement at the university. It is reflective of the credit hours the student has completed and the grades that the student has earned. A student transcript will display both a Semester GPA (SGPA) and a Cumulative GPA (CGPA).

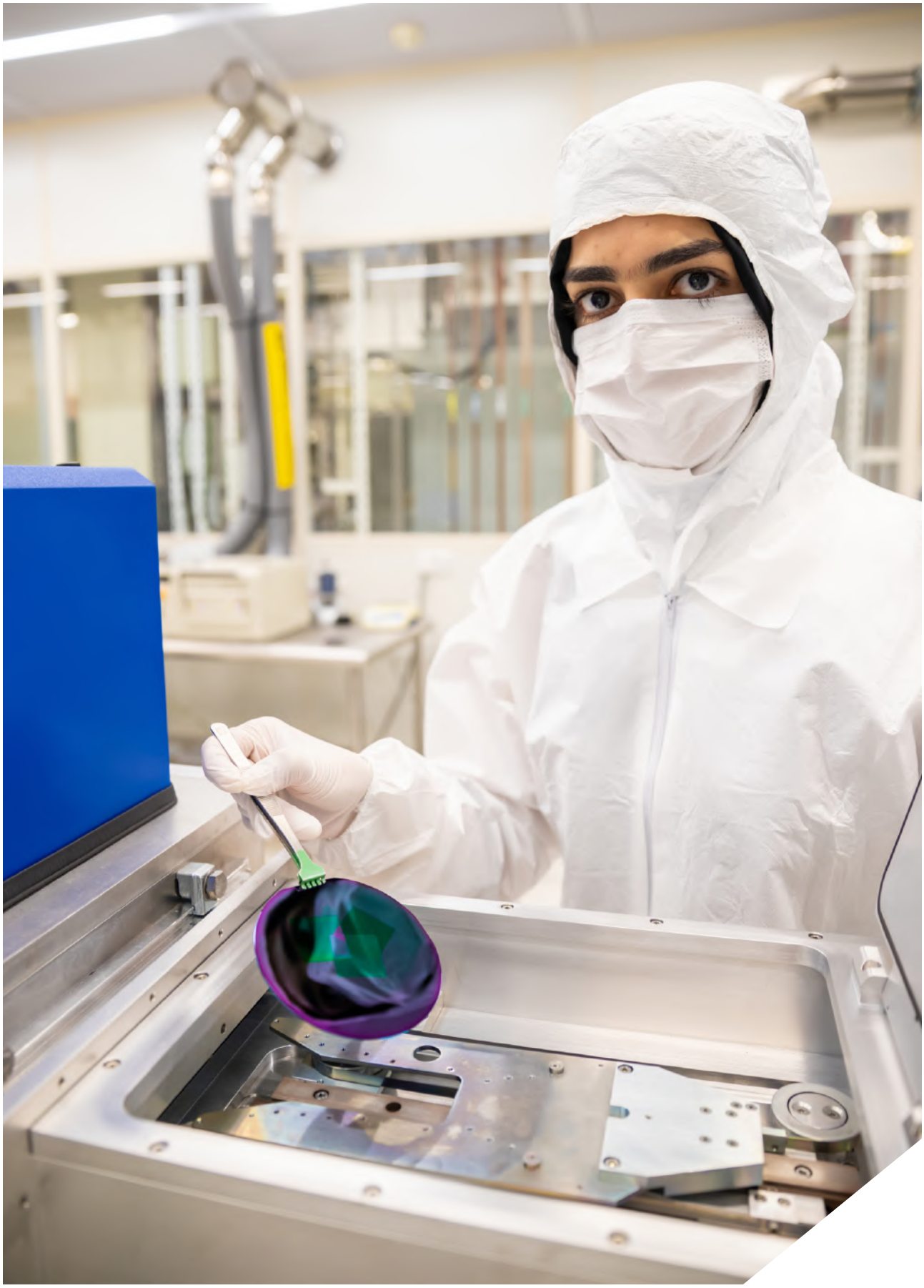
The GPA is calculated by multiplying the grade point value of the letter grade by the number of credit hours of the course. The result is the quality points that the student has achieved in the particular course. The sum of the quality points of the courses taken is divided by the total credit hours completed to obtain the GPA. Grades without a corresponding value (AUD, EX, I, IP, N, S, TR, U, W, WA and WP) are not included in the computation of the cumulative grade point average. A sample GPA calculation is shown in the table below.

SAMPLE GPA CALCULATION					
SEMESTER	**COURSE**	**CREDIT HOURS**	**GRADE**	**GRADE VALUE**	**QUALITY POINTS**
Fall	MEEN 601	3	B	3.00	9.00
	MEEN 603	3	A	4.00	12.00
	MEEN 622	3	B+	3.30	9.90
Fall Semester Total		9			30.90
SEMESTER GPA: 30.90 ÷ 9 = 3.43					
Spring	MEEN 605	3	B	3.00	9.00
	MEEN 630	3	A	4.00	12.00
	MEEN 631	3	A -	3.70	11.10
Spring Semester Total		9			32.10
SEMESTER GPA: 32.1 ÷ 9 = 3.57					
Cumulative Total		18			63.00
CUMULATIVE GPA: 63 ÷ 18 = 3.50					

GRADE CHANGES AND APPEALS

Final course grades are officially reported by the instructor at the end of an academic semester and recorded by the Registrar's Office. Officially recorded grades can only be changed with the approval of the Department Chair and Associate Dean for Graduate Studies. A request to change a grade may be initiated in writing by the student or the course instructor.

A student may appeal an officially recorded grade by submitting a "Grade Appeal" form to the Registrar's Office no later than the first day of classes of the next regular semester. Grade appeals will be processed as per the provisions in KU Policy STL 5450 Student Grievances and Appeals.



MANAGING COURSES

COURSE TITLE, CODE, CREDIT VALUE AND DESCRIPTION

Each course offered at the University has a unique alphanumeric code, a title and a credit value. The course code consists of four letters that reflect its discipline or field of study, followed by a three-digit number that indicates its level. The title of the course gives an indication of its content. The course credit value consists of three numbers: the first indicates the number of lecture hours per week, the second shows the number of laboratory or problem solving hours per week, and the third gives the overall credit hours of the course. The example below further explains the course code and value information.

ENGR
Letter part of the code.

605
Numeric part of the code.

Optimization Methods for Engineers
Course title.

(3-0-3)

Lecture hours per week (3).
Laboratory hours per week (0).
Overall credit value (3).

ADDING/DROPPING COURSES

Students may add or drop a course, or change a course section at the beginning of a semester during the official Add/Drop period. Such changes are not recorded on the student's transcript, provided that they are finalized by the end of Add/Drop for graduate courses, as specified in the Academic Calendar. Provisions and guidelines related to course management are outlined in KU Academic Policy ACA 3700 Withdrawal, Discontinuing and Resuming Studies. For policies and processes concerning the College of Medicine and Health Sciences, please refer to the CMHS Medical Student Handbook.

COURSE WITHDRAWAL

Courses that are dropped after the Add/Drop deadline will be assigned a "W" grade on the student's transcript, provided that the request is submitted during the official withdrawal period published in the Academic Calendar. The "W" grade will not affect the student's Grade Point Average (GPA).

A student who withdraws from a course after the deadline for withdrawal has passed will be assigned a grade of "WF" (Withdrew Failing). The "WF" is equivalent to an "F" (0.0 quality points), and is used in the calculation of the GPA (see ACA 3350 Grading System, GPA, and Course Repetition). Upon appeal, this grade may be changed to a WP (Withdrew Passing).

Students should consult their academic advisor before making changes to course registration. Withdrawing from a course may affect the student's timely progress toward graduation and impact the terms of their scholarship. Full-time students must normally maintain a minimum load of nine credit hours in a regular semester, while part-time students must normally maintain a minimum load of six credit hours. Under exceptional circumstances, a student's credit load may drop below these minimum requirements, subject to approval from the Associate Dean for Graduate Studies at the relevant College and the Dean of Graduate Studies.

COURSE RESTRICTIONS, PREREQUISITES AND CO-REQUISITES

Enrollment in some courses may be restricted. For example, a course may be open to students within a specific program or require that a student has Master's or Doctoral level standing. In some cases, registration may not be permitted without the approval of the course instructor.

A program of study may also require that courses be taken in a certain order or taken together. A course that is required to be taken before another course is called a "pre-requisite". Students are not permitted to register for a course with a pre-requisite unless the pre-requisite course has been completed with a passing grade or student has an approved pre-requisite waiver. Approval for a pre-requisite waiver should be obtained from the course instructor, Main Advisor, Department Cahir and the Associate Dean for Graduate Studies at the relevant College.
A "co-requisite" is a course that is designed to be taken together with another course.

- A co-requisite course may be satisfied if the student has previously completed it with a passing grade.
- Students may not drop a course if it is a co-requisite of another course in their schedule. In this case both courses would have to be dropped.
- If a student repeats a co-requisite course in which the student earned a grade of B- or lower, the companion course (if passed) does not have to be repeated.

REPETITION OF COURSES

Students should meet with their advisor before repeating a course, as it may affect the student's academic standing and scholarship. A repeated course must be taken when it is regularly offered and cannot be taken in independent or individual format. Graduate students may repeat a course subject to the following:

- A given taught course can be repeated only once. Approval of the Dean of the relevant College (or designee) is required if a student wishes to repeat a course in which he/she previously earned a grade of B- or higher.
- A maximum of two taught courses can be repeated during the student's enrolment in a particular graduate program at the university.
- Degree credit for a course is only given once, but the grade assigned each time the course is taken is permanently recorded on the transcript.
- Only the highest grade earned for a repeated course will be used in calculating the grade point average.
- A student who fails a course twice is subject to dismissal for failure to make satisfactory academic progress (see ACA 3650 Academic Standing Graduate Programs).
- A repeat course must be taken at Khalifa University.

AUDITING COURSES

Subject to availability, admitted degree students in good academic standing may audit graduate courses without credit, with the permission of the instructor and the approval of the Department Chair and Associate Dean for Graduate Studies at the relevant College. Approvals must be obtained prior to registration, and the student must register as an auditor. Registration priority will be given to matriculated degree-seeking students.

Auditors are required to follow the same registration procedures as persons taking the course for credit. Auditors do not receive grades or credits. Participation

in class discussion and written work is permitted at the discretion of the instructor. A fee per credit hour will be charged and must be paid prior to registration. The status of Auditor cannot be changed after the course has begun. The University reserves the right to cancel an audit registration if the class size is an issue.

Normally, a student will not be permitted to audit a course if this results in exceeding the maximum allowable credit load per semester. Furthermore, a student cannot use course audit to change his/her study mode (full-time/part-time).

COURSE SUBSTITUTION

Graduate students are expected to satisfy all degree program requirements that were in effect when the student was first admitted or most recently re-enrolled as a degree candidate. A student seeking a minor deviation from program requirements must submit a Variation to Academic Program request and if needed, a Prerequisite Waiver request. The student's advisor, the Department Chair and the Dean of the relevant College (or designee) must approve the request. The course to be substituted must be at the same level as the required course and the student must be in good academic standing when the permission for deviation is requested.

LIMITATION OF COURSES OFFERED

The University reserves the right to cancel any course listed in the Catalog or scheduled to be offered. Notification of a cancelled course will be sent to any affected students at their University email address.

CLASS CANCELLATIONS

On rare occasions, it may be necessary to cancel a scheduled class. Under such circumstances, students will be notified in advance, as much as possible.

COURSE FEEDBACK

Students are required to give their feedback on all courses at the end of every semester, which ensures the quality of course delivery. Student feedback is further considered during course review and development.

ATTENDANCE, LEAVE AND WITHDRAWAL

Graduate students are expected to regularly attend University and participate in all elements of their program of study, including taught coursework, research and teaching duties. All faculty members are required to maintain accurate and up-to-date records of graduate student attendance. A student who is not able to attend University for any reason is required to inform the relevant course instructor, their Main Advisor and/or the Graduate Studies Office (as applicable). Student attendance is governed by KU Academic Policy ACA 3555 Student Attendance (Graduate Programs).

The University recognizes that personal circumstances may require a student to temporarily or permanently withdraw from their studies. Provisions for managing such circumstances are outlined in KU Academic Policy ACA 3700 Withdrawal, Discontinuing and Resuming Studies. For policies and processes concerning the College of Medicine and Health Sciences, please refer to the CMHS Medical Student Handbook.

INSTITUTIONAL SANCTIONS FOR NON-ATTENDANCE

The following shall apply when a graduate student has been absent for more than 50% of scheduled classes in which he/she is currently enrolled (either excused or unexcused):

- If the 50% limit is reached on or before the last day to withdraw from classes, as specified in the Academic Calendar, a letter grade of WA (Withdrawn Administratively) will be automatically assigned.
- In all other cases a letter grade of WF (Withdrew Failing) will be assigned.
- Appeals must be submitted with all necessary documentation within three working days of the WA or WF grade notification. All appeals should be referred to the Graduate Studies Council, which will provide a recommendation to the Provost whose decision is final.
- Full-time students holding a KU scholarship are expected to be on campus full-time (including during official study breaks), unless a period of absence is approved by the Graduate Studies Office. Unapproved absence may result in the loss or suspension of the student's scholarship.

EXCUSED ABSENCE (SHORT-TERM)

Students who participate in KU sanctioned activities or encounter unavoidable circumstances can apply to obtain an excused absence for failure to attend a scheduled class or other University activity. Applications should be submitted through the Office of Student Success and students should seek prior approval whenever possible. Applications to excuse absence post facto must be made no later than three working days after the absence. An excused absence may be approved with implication on attendance record (absence is removed from the percentage) or without implication on attendance record (percentage of missed contact time remains unchanged). If the student is applying for excused absence on medical grounds, the application will be verified and approved by the KU nurse.

Where an excused absence causes a student to miss an assessment, then the student's grade for the assessment shall be calculated in accordance with the course syllabus and the guidelines of the relevant College. Unexcused absences that cause a student to miss an assessment will result in the student receiving a grade of zero for the missed assessment with a concomitant effect upon the student's final grade.

The decision by Student Success in consultation with the Graduate Studies Office to grant or decline a student's application is final, notwithstanding an appeal submitted by the student.

The following excused absence types shall be considered:

- Appointment with official authorities.
- Legal and judicial orders.
- National Service duties (short-term).
- Representing KU on official business (e.g. conference, presentation, fieldtrip, internship).
- Hospitalization (in patient for more than one night).
- Serious injury.
- Contagious disease.
- Medical treatment abroad either personal or escorting an immediate family member - parent, grandparent, sibling, spouse, child (may be granted to students who have not reached 50% absences, with pre-approval).
- Death of an immediate family member - parent, grandparent, sibling, spouse, child (may be granted for up to five calendar days).
- Maternity leave (may be granted for up to fourteen calendar days).
- Paternity leave (may be granted for up to three calendar days).
- Hajj (pre-approval is required minimum ten working days prior to travel).
- Emergency (determined by Office of Student Success).

NATIONAL SERVICE LEAVE

Leave for National Service is automatically granted. The student must return to the university in the semester immediately following the completion of National Service. Leave taken for National Service does not affect the student's Leave of Absence entitlement.

ANNUAL LEAVE

Full-time graduate students holding a Khalifa University scholarship may be eligible to take annual leave as per the entitlement stated in the relevant scholarship award contract. Students must meet, discuss and obtain the approval of their Advisor(s) prior to applying for leave. The Advisor is responsible for guiding the student and approving annual leave requests on behalf of the Department. In all cases, annual leave for graduate students must be approved by the Associate Dean for Graduate Studies at the relevant College and the Dean of Graduate Studies. The Graduate Studies Office oversees the leave process for graduate students and the decision of the Dean of Graduate Studies is final. Students can apply for annual leave in accordance with the following guidelines:

- Students must apply for annual leave at least two weeks prior to the first day of absence. In exceptional circumstances, this requirement may be waived.
- Students may be granted a maximum number of leave days within the period of study or any related extension in accordance with provisions made in the relevant scholarship award contract.
- Generally, annual leave can be taken only during the official study breaks published in the Khalifa University Academic Calendar, i.e. Summer, Winter or Spring. In exceptional circumstances, the Dean of Graduate Studies may approve leave days outside official study breaks, in consultation with the student's Advisor(s).
- Annual leave will be accrued pro-rata on the basis of time studied and the accrual rate will be based on the student's annual entitlement.
- Annual leave must be taken within the calendar year, during the period of study. Leave days not utilized at the end of each year will be forfeited. Leave days not utilized at the end of the study period, any related extension or at the end of the scholarship award contract will be forfeited.
- In exceptional circumstances, students may apply to exceed their annual leave entitlement and must provide justification, as well as supporting documents. Any additional leave days will normally be unpaid and can be granted only with approval from the student's Advisor, Associate Dean for Graduate Studies at the relevant College, and the Dean of Graduate Studies.

- Students are eligible for all paid Public Holidays announced by the University.

LEAVE OF ABSENCE AND RESUMING STUDIES

Under exceptional circumstances, students may apply for a temporary Leave of Absence (LoA) for a maximum of two semesters during their degree studies. Students should be aware that taking leave will have an impact on their scholarship terms and timely progress toward graduation. The LoA must be approved by the student's Advisor, Department Chair, the Associate Dean for Graduate Studies at the relevant College and the Dean of Graduate Studies. The following guidelines apply:

- Generally, a student must be in good academic standing.
- The student must submit the LoA request, specifying the reason and duration of requested leave, supported by relevant documentation.
- If the LoA request is submitted on or before the last day of the Add/Drop Period, as specified in the Academic Calendar, student will be automatically withdrawn from all registered courses for the semester in which LoA is approved.
- If the LoA request is submitted on or before the last day to withdraw from courses, a letter grade of "W" (Withdrew) will be assigned for all registered courses. If the LoA request is submitted after this date, a letter grade of "WF" (Withdrew Failing) will be assigned for all registered courses.
- Students are not eligible to receive scholarship benefits for the semester in which LoA is approved.
- Students sponsored by non-KU agencies may not take a Leave of Absence without their sponsor's approval.

To resume studies after LoA, students must contact the Registrar's Office to request re-activation latest before the end of the Add/Drop period for the relevant semester. The Resume of Study Request must be approved by the student's Advisor, Department Chair, Associate Dean for Graduate Studies at the relevant College and the Dean of Graduate Studies. A student who does not return from LoA by the semester specified in the leave request is dismissed from the University.

A student who is away from the university, for any reason other than National Service, for more than two consecutive regular semesters must submit a new application for admission, prior to the semester for which registration is sought. Students will be required to follow the graduate catalog and program study plan for the semester in which they are re-admitted.

PERMANENT WITHDRAWAL FROM THE UNIVERSITY

A student may voluntarily withdraw from the university in accordance with withdrawal clearance procedures and subject to the terms and conditions of their scholarship contract or agreement. The student must withdraw officially and complete the clearance process, which can be initiated by submitting the Application for Permanent Withdrawal. The withdrawal is effective on the date the form is received by the Registrar's Office.

- No record of enrollment in courses will appear on the transcript of a student who withdraws during the official Add/Drop period.
- A student who withdraws before the deadline for course withdrawal, but after the official Add/Drop period, will receive a grade of "W" for all courses in progress.
- Students withdrawing after the course withdrawal deadline and before the last day of classes will receive a grade of "WF" for all courses. The student has the right to appeal a grade of WF as per the provisions of STL 5450 Student Grievances and Appeals. In cases of a successful appeal, a grade of WP will be assigned.

- Any student who leaves the university before the close of a semester without withdrawing officially will receive a failing grade of "F" in each course for which the student was registered.

DISMISSAL OR SUSPENSION FROM THE UNIVERSITY

A student may be dismissed from the university for, but not limited to, the following reasons:

- The student is absent for 15 successive days without a valid reason.
- The student fails to satisfy the progression rules of the program.
- The student fails to satisfy the completion requirements of the program.
- The student does not maintain adequate contact with his/her thesis/dissertation Advisor.
- The student is in violation of the university code of conduct.
- The student is in violation of the academic integrity policy.

A student who was dismissed from the university will not be readmitted. A student who was suspended for a period of time can be readmitted to the university after completion of the suspension period, subject to the student signing an undertaking of not repeating the cause of suspension.

Refer to the "Academic Standing" section of this Catalog for guidelines relating to academic dismissal.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ASSESSMENT AND ACADEMIC STANDING

ASSESSMENT OF STUDENT LEARNING

Achievement of intended learning outcomes shall be evaluated through a variety of assessment instruments in a process of frequent evaluation that includes regular and timely feedback to students regarding their performance (refer to KU Academic Policy ACA 3300 Assessment of Student Learning). For policies and processes concerning the College of Medicine and Health Sciences, please refer to the CMHS Medical Student Handbook. Final grades are determined by the student's performance in a combination of the following:

- Assigned work, term papers, projects, presentations.
- Progress tests.
- Laboratory tests and/or laboratory work.
- Semester and/or final examinations.
- Level of written expression.

The performance of each student in a course must be evaluated by the instructor(s) responsible for that course. The weight accorded to the various elements is at the discretion of the academic department responsible for the course. Course policies regarding the submission, grading, return and weighting of all assessment instruments must be clearly communicated in the course syllabus, which is to be shared with students on the first day of class.

To assist students in preparing for final exams, no tests or significant assessments should be administered during the final week of classes.

EXAMINATIONS

One or more major examinations may be administered for a course to assess achievement of learning outcomes. All examinations at Khalifa University must follow clear and established guidelines to ensure examination integrity and compliance with best practices. Major examinations shall be included in the course syllabus and any changes communicated to students in advance. Final examinations are scheduled through the Registrar's Office. Guidelines and procedures governing the administration of examinations are outlined in KU Academic Policy ACA 3370 Examinations. Normally, instructors will submit final grades no later than three days after the scheduled final examination in a course or, where there is no final examination, seven days after the last scheduled class in a course.

A student who is absent from an examination without a valid excuse will normally receive a "zero" for that examination. For provisions governing excused absences see ACA 3555 Student Attendance (Graduate Programs).

COURSEWORK

Coursework is an essential component at all levels of study and normally takes the form of a combination of assignments, projects and quizzes. Students should be given clear deadlines for coursework submission. Penalties for late submission or missing coursework must be clearly communicated to students at the beginning of the semester. If late submission is unavoidable due to circumstances beyond the student's control (e.g. serious illness), the student must inform the concerned instructor as soon as possible and present relevant documentary evidence. The approval of the excuse and any make-up assessment is at the discretion of the instructor. Students should receive timely grades and comments on submitted coursework. In some cases, the instructor may keep the student's work but must allow students access to review it and the grading breakdown.

RESEARCH

The student's research progress is assessed in each semester that he/she registers for thesis/dissertation credits. The student's Main Advisor must submit the progress evaluation to the Registrar's Office latest by the end of the final examination period in the relevant semester. Accordingly, a grade of Satisfactory (S) or Unsatisfactory (U) will be recorded on the student's transcript for the thesis/dissertation course.

RECORDS AND TRANSCRIPTS

A permanent academic record for each student enrolled in the University is maintained in the Registrar's Office. The written consent of the student is officially required to disclose his/her academic record. Exceptions are made for parents, sponsors, and authorized University officials and in compliance with a judicial order. Students may obtain official transcripts of their academic records from the Registrar's Office. A transcript will only be released with a signed request from the student concerned.

ACADEMIC STANDING

Academic standing is based on the Cumulative Grade Point Average (CGPA) and indicates if a student is meeting the University's standard for expected academic performance. Academic excellence, rigorous scholarship, demonstrated attainment of learning outcomes and timely progress towards graduation are critical measures of student academic success. The standards of academic standing for graduate students are stipulated by KU Academic Policy ACA 3650 Academic Standing (Graduate Programs).

GOOD STANDING

A student with a CGPA of 3.00 or higher is in good standing and eligible to register for courses.

ACADEMIC PROBATION

A student whose CGPA falls below 3.00 and/or who receives a grade of Unsatisfactory (U) for thesis/dissertation credits, is placed on academic probation for the following regular semester. A note is made on the student's academic record (transcript). The following provisions apply for a student on academic probation:

- Unless otherwise approved by the Dean of Graduate Studies, a full-time graduate student on probation is allowed to register for a maximum of nine credit hours per semester;
- Unless otherwise approved by the Dean of Graduate Studies, a part-time graduate student on probation is allowed to register for a maximum of six credit hours per semester;
- While on probation, a student may enroll in a course on a Pass/Fail basis.

The student will return to good academic standing if he/she achieves a minimum CGPA of 3.00 and/or a grade of Satisfactory (S) for thesis/dissertation credits by the end of a regular semester on probation.

ACADEMIC DISMISSAL

If, at the end of one regular semester on academic probation, the student's CGPA remains below 3.00 or student receives a subsequent Unsatisfactory (U) thesis/dissertation grade, the student shall be academically dismissed from the University.

If, subsequent to returning to good standing after having been on Academic Probation, a student's CGPA falls below 3.00 a second time, or the student receives a second grade of Unsatisfactory (U) for thesis credits, the student shall be academically dismissed from the University.

Students have the right to appeal a dismissal (refer to KU Policy STL 5450 Student Grievances and Appeals) and must comply with the following provisions:

- All appeals must be submitted in writing to the Registrar's Office within ten working days from the dismissal decision date. The Registrar's Office will forward the appeal to the Graduate Studies Council for consideration in line with relevant policy.
- In the case of a successful appeal of a dismissal decision, the student shall be placed on academic probation upon resumption of studies.
- A successful dismissal appeal does not guarantee reinstatement of scholarship benefits.
- A dismissed student is prohibited from re-enrolling at KU.

PROGRESSION AND COMPLETION REQUIREMENTS

Students must meet established minimum requirements for the award of a graduate degree. It is the student's responsibility to familiarize themselves with the requirements specific to their program. Students can refer to the "Academic Regulations", "Research Milestones" and "Graduate Programs" sections of this catalog, as well as relevant KU policy. In addition, each department shall provide relevant program information to all incoming graduate students. For policies and processes concerning the College of Medicine and Health Sciences, please refer to the CMHS Medical Student Handbook.

RESEARCH PROJECT ALLOCATION AND ADVISOR APPOINTMENT

The appropriate Department Chair (or nominee) will serve as the academic advisor for all newly admitted graduate students and will guide the students' course selection in their first semester of study. By the end of the first semester, full-time students will have an opportunity to nominate their preferred research project and research advisor. For part-time students, this is normally completed in the second semester of study.

The Graduate Studies Office will instruct eligible students on the research project selection process and appropriate timelines. Generally, students are asked to select from a list of research projects available in the present semester. Each project outline will specify the problem statement, desirable outcomes, tentative thesis title, as well as the advisory team made up of KU faculty and industry experts (if appropriate). The research project will form the student's thesis/dissertation work, therefore each student must ensure that he/she contacts the Main Advisor of each project they are interested in to discuss objectives and requirements before making the final selection.

Each student must submit their project nominations by the specified deadline. In cases where a student does not make a selection, a project will be allocated based on the recommendation of the student's academic department.

The final allocation of a research project to each graduate student will be made by a committee and approved by the relevant Department Chair, Associate Dean for Graduate Studies and the Dean of Graduate Studies. Once the allocation is confirmed, the faculty member listed as the Main Advisor (this may or may not be the project Principal Investigator) will take the leading role in guiding the student in course selection and supervising his/her research work until graduation. The following guidelines apply:

- The Main Advisor must be a faculty member from the student's home department. An exception to this requirement may be made for multidisciplinary fields such as Robotics and programs that have cross-departmental support, such as MSc in Water and Environmental Engineering.
- In addition to the Main Advisor, the student must have at least one Co-Advisor to provide support to the research supervision process and guidance of the student. The Co-Advisor does not necessarily have to be from the student's home department.
- The Main Advisor and Co-Advisor must be full-time members of KU faculty with professorial rank appointments (Professor, Associate Professor, Assistant Professor). Subject to approval, additional co-advisors may be selected from adjunct professors and on/off-campus experts from industry or academia.

- At least one of the Advisors must have prior experience in supervising a graduate research thesis or dissertation.

The MEng degree program does not include a thesis component, thus MEng students are not required to participate in the research project allocation process and complete research milestones. The student's academic advisor will be appointed by the Department Chair.

Students who are sponsored by organizations external to KU must have their sponsor's approval before a research project can be allocated.

CHANGE OF ADVISOR

A change of assigned advisor may be requested in exceptional circumstances, for example if the advisor leaves the University or in the case of communication difficulties between the student and the advisor. Students and advisors must make an effort to resolve any differences as early as possible and should consult with the Department Chair before formally requesting a change. The student, the Main Advisor or the Department Chair can initiate the process by completing the "Change of Supervisory Arrangement" form. Any such request requires the approval of the Department Chair and the Associate Dean for Graduate Studies at the relevant College.

FORMING THE RESEARCH COMMITTEE

Following research project allocation and Main Advisor appointment, a research committee must be formed for each student. While the Advisors assume primary responsibility for monitoring and directing the student's research, the role of the committee is to evaluate the student's progress, provide comments and finally, vote on the recommendation to award the graduate degree. The student should meet with committee members regularly to present his/her progress, discuss any research problems and receive feedback. The committee is formed in consultation with the student and typically consists of the Main Advisor, Co-Advisor(s) and two additional full-time KU faculty members who are familiar with the student's area of study. Committee members are recommended by the student's Main Advisor, appointed by the relevant Department Chair and the Associate Dean for Graduate Studies, and approved by the Dean of Graduate Studies. The following guidelines apply:

MA STUDENTS

- MA students are required to complete a Thesis Workshop course and the student's research is supervised by his/her Advisor(s).

MSC STUDENTS

- The Research Supervisory Committee (RSC) should be formed within a month of the confirmed research project allocation.
- The student's Main Advisor serves as the Chair of the RSC and he/she is responsible for leading meetings of the RSC.
- One of the two additional RSC members must be KU faculty from the student's home department.

PHD STUDENTS – COLLEGE OF ENGINEERING

- The Research Supervisory Committee (RSC) should be formed following the confirmed research project allocation and prior to the end of the second semester of study for full-time students or fourth semester of study for part-time students.
- The student's Main Advisor serves as Chair and he/she is responsible for

leading all meetings of the RSC, with the exception of the student's Research Proposal Examination and the final dissertation defense.

- One of the two additional RSC members must be KU faculty from the student's home department.
- An additional external member of the RSC may be selected as follows:
  - Faculty from a department at KU, a national or a regional university, or an industry expert. In this case, the member must possess a Doctoral degree.
  - Faculty from a reputable international university. Such members are likely, but not necessarily, drawn from departments working on collaborative projects with KU.

PHD STUDENTS – COLLEGE OF ARTS AND SCIENCES

The PhD Advisory Committee (PAC) should be formed following the confirmed research project allocation and prior to the end of the second semester of study for full-time students or fourth semester of study for part-time students. The PAC shall consist of a minimum of four (4) members selected as follows:

- The student's Main Advisor serves as Chair and he/she is responsible for leading all meetings of the PAC, with the exception of the student's Oral Qualifying Examination and the final dissertation defense. The Main Advisor and Co-Advisors account for a total of one vote.
- The student's Co-Advisor (s) (shared vote with Main Advisor).
- One PAC member must be KU faculty from the student's home department and familiar with the research area. This committee member has one vote.
- One PAC member from another KU department. This committee member has one vote.
- An additional external member of the PAC may be selected as follows (no vote):
  - Faculty from a national or a regional university, or an industry expert. In this case, the member must possess a Doctoral degree.
  - Faculty from a reputable international university. Such members are likely, but not necessarily, drawn from departments working on collaborative projects with KU.

REGISTRATION FOR THESIS OR DISSERTATION

Thesis/dissertation registration is mandatory in every regular semester following research project allocation and until the student's successful final defense (subject to good academic standing). Students must register for research credit hours appropriate to the level and discipline of their program: Master's Thesis (XXXX 699) or PhD Dissertation (XXXX 799). All full-time students holding a Khalifa University scholarship must also register for thesis/dissertation in the Summer Term. Failure to register for thesis/dissertation in the Summer Term may result in the loss or suspension of the student's scholarship.

In exceptional circumstances, registration for thesis/dissertation may be approved in the first semester of study by the Department Chair, the Associate Dean for Graduate Studies at the relevant College and the Dean of Graduate Studies.

GRADUATING IN EXPECTED TIME

Students must regularly consult their Advisor(s) to ensure that their academic preparation is appropriate for the courses they plan to undertake. It is important to understand the content of the chosen degree program and the options it will provide for future studies and employment.

Students must be aware of the structure of their degree and the number of credit hours required to graduate. In order to graduate within allowable time, each year students must fulfill the minimum number of credit hours according to their study-mode and the appropriate research milestones.

Core courses should be completed as soon as possible (as not all courses are offered every semester) and students should be flexible about course times. If a required course is not available, advisors can help determine an alternative.

COMPLETION REQUIREMENTS

In order to be awarded the MA or MSc degree, a student must:

- Successfully pass all program components (taught courses, research proposal and thesis).
- Achieve a minimum overall Cumulative Grade Point Average of 3.0 out of 4.0.
- Complete all graduation requirements within the maximum allowable time to completion.

In order to be awarded the MEng degree, a student must:

- Successfully pass all program components (taught courses).
- Achieve a minimum overall Cumulative Grade Point Average of 3.0 out of 4.0.
- Complete all graduation requirements within the maximum allowable time to completion.

In order to be awarded the PhD degree, a student must:

- Successfully pass all program components (taught courses, qualifying examinations, research proposal and dissertation).
- Achieve a minimum overall Cumulative Grade Point Average of 3.0 out of 4.0.
- Complete all graduation requirements within the maximum allowable time to completion.

APPLYING TO GRADUATE

It is mandatory for all graduate students to submit the "Intent to Graduate" form via the Student Information System in the penultimate semester. The Registrar's Office will check to ensure that all degree requirements have been met before the student becomes eligible to graduate. The Catalog of Record is used for purposes of academic standing and degree requirements verification.

TIME LIMIT ON DURATION OF STUDY AND RE-ADMISSION

All graduate degree requirements must be completed within the maximum allowable time for the relevant program, inclusive of all periods of leave (refer to the "Duration of Study" section in this catalog).

A student who is away from the university, for any reason other than National Service, for more than two consecutive regular semesters must submit a new application for admission, prior to the semester for which registration is sought. Students will be required to follow the graduate catalog and program study plan for the semester in which they are re-admitted.

PUBLICATION GUIDELINES FOR THESIS OR DISSERTATION

DEFERRED ACCESS TO THESIS OR DISSERTATION

Students may request to defer public access to the final thesis/dissertation for a designated period of 6 months, 1 year or 2 years. Such an embargo may be requested due to contractual obligations, ethical confidentiality, a pending patent or publication. The student must submit a "Request to Defer Access to Graduate Thesis or Dissertation" at the time of final submission and any such request is governed by KU Policy ACA 3900 Publishing a Thesis or Dissertation.

PUBLICATIONS

Advisors should encourage their students to publish their thesis/dissertation results in refereed international conferences and journals. This provides a useful measure of the quality of the work undertaken by the student. For those cases where the student is not a co-author, the advisor should acknowledge the contribution of the student in any published material or presentation which involves the student's work.

INTELLECTUAL PROPERTY

Khalifa University promotes academic research, scientific discoveries, technology advancements, and innovation. KU recognizes the importance of Intellectual Property and innovation in transferring scientific knowledge and discoveries into products or services for the public benefit and the economic development of Abu Dhabi, the UAE and the rest of the world.

Students should acknowledge and must agree to abide by the University's Intellectual Property policy (R&D 4100 Intellectual Property), including the stipulations concerning allocation of income arising from the exploitation of intellectual property rights.

COPYRIGHT

Khalifa University encourages and promotes the dissemination of knowledge through publications and other scholarly works. Students involved in academic and scholarly activities, including research, must adhere to University policy KUP 9250 Copyright Ownership and Right to Publish. KU authors must follow R&D 4950 Research Integrity policy regarding the principles of authorship.

MASTER'S RESEARCH MILESTONES

Research milestones for Master's students are summarized in the table below. The typical timeline is made with reference to regular academic semesters (i.e. Fall and Spring), however students are expected to continue to work on their research during the Summer Term.

RESEARCH MILESTONE	TIMELINE FOR EXPECTED NORMAL PROGRESSION	
	FULL-TIME STUDENTS	PART-TIME STUDENTS
1 Research Project Allocation and Advisor Appointment	By end of the 1st semester of study.	By end of the 2nd semester of study.
2 Forming the Research Supervisory Committee (RSC)	Within one month of the confirmed research project allocation.	Within one month of the confirmed research project allocation.
3 Registration for Thesis	Normally, in semester immediately following research project allocation. Thesis registration is required every semester (including Summer) until final defense.	Normally, in semester immediately following research project allocation. Thesis registration is required every semester until final defense.
4 Thesis Proposal and Presentation	By end of the 2nd semester of study.	By end of the 4th semester of study.
5 Thesis Progress Report and Presentation	By end of the 3rd semester of study.	By end of the 5th semester of study.
6 Submit "Intent to Graduate" form via Banner.	By end of the 3rd semester of study.	By end of the 5th semester of study.
7 Thesis Defense and Final Submission	4th semester of study, according to published Graduation Timeline.	6th semester of study, according to published Graduation Timeline.

THESIS PROPOSAL AND PRESENTATION

Students must write and defend a Thesis Proposal, which consists of the following:

- The main research problem that the student intends to work on and why it is important.
- A review of the principal literature relevant to the thesis research topic.
- Results the student expects to achieve, and why they would be of significant value in the area of research.
- The general strategy that the student intends to pursue in dealing with the research problem, together with a work-plan for the stages of the work.

The proposal should be submitted to the Main Advisor and Co-Advisor(s) for approval, before being circulated to RSC members. The Main Advisor will arrange for a presentation typically within two weeks of receipt of the Thesis Proposal. MA students will complete the presentation at the end of the IICS 698 Thesis Workshop course. The presentation will normally take 30 minutes (20 minutes for student's presentation and 10 minutes for questions). In his/her written proposal and during the presentation, the student is required to:

- Demonstrate a clear understanding of the research problem;
- Defend the general strategy that he/she intends to pursue in dealing with the research problem;
- Write clearly, accurately, cogently, and in a style appropriate to purpose;
- Construct coherent arguments and articulate ideas clearly; and
- Present a plan to execute the entire work.

RSC members will evaluate the student's Thesis Proposal and presentation. Any comments made by the RSC should be taken into account by the student and his/her Advisor(s) during the execution of the thesis work.

Following the conclusion of the presentation, the Main Advisor must forward a copy of the student's Thesis Proposal and the completed Research Proposal Evaluation Report to the Department Chair (or designee), Associate Dean for Graduate Studies at the relevant College and the Graduate Studies Office.

THESIS PROGRESS REPORT AND PRESENTATION

It is mandatory for students to write and present a Thesis Progress Report as outlined in the Master's Research Milestones section. The Progress Report should include:

- A summary of the main research problem, its importance, and the general strategy that the student is pursuing in dealing with the problem;
- A critical review of the principal literature relevant to the thesis topic placing the student's contribution in context, accompanied by a full bibliography of relevant sources;
- An outline of work that the student has already carried out in the area and a discussion of results;
- A review of the status of each task and sub-task of the work and, if applicable, a revised work-plan;
- A provisional table of contents for the thesis.

The Thesis Progress Report should be submitted to the Main Advisor and Co-Advisor(s) for approval, before being circulated to RSC members. The Main Advisor will arrange for a presentation typically within two weeks of receipt of the

report. The presentation will normally take 30 minutes (20 minutes for student's presentation and 10 minutes for questions). In his/her written report and during the presentation, the student is required to:

- Show awareness of pertinent background literature and current efforts in the thesis area of interest;
- Demonstrate a clear understanding of the research problem;
- Achieve some initial progress towards solving the research problem and constructively defend his/her results;
- Write clearly, accurately, cogently, and in a style appropriate to purpose;
- Construct coherent arguments and articulate ideas clearly;
- Demonstrate that he/she is following a plan to execute the entire work.

Following the conclusion of the presentation, the Main Advisor must forward a copy of the Thesis Progress Report and Research Progress Evaluation Report to the Department Chair (or designee), Associate Dean for Graduate Studies at the relevant College and the Graduate Studies Office.

The RSC may at their discretion request a progress report every semester. This is encouraged particularly for students who stay in the program longer than the normal study period.

THESIS DEFENSE AND FINAL SUBMISSION

The Graduate Studies Office publishes a Graduation Timeline for the Fall, Spring and Summer semesters. The timeline provides a guide to processes students and faculty must complete leading up to the final thesis submission and defense, including the thesis formatting guidelines. Graduate students are required to follow this timeline and adhere to the specified deadlines during their final semester of study in order to graduate on time. A student should normally be in good academic standing and registered for thesis credits during the semester he/she intends to defend.

The Department Chair (or nominee) appoints a full-time KU faculty member as the Thesis Defense Coordinator and informs the Associate Dean for Graduate Studies at the relevant College and the Dean of Graduate Studies on the nomination. The primary responsibilities of the Defense Coordinator are:

- Schedule the final thesis defense in consultation with all RSC members, make the relevant logistical arrangements and inform the student about the date and time.
- Attend the final thesis defense and the private RSC meeting to ensure that the examination is conducted in accordance with all relevant KU academic policies and procedures. The Defense Coordinator has a non-voting role in the defense process.
- Report the examination result to the Graduate Studies Office and confirm that the correct examination process was followed.

The student must submit an initial thesis draft to the Main Advisor and Co-Advisor(s), who will work with the student on the necessary revisions. Upon receiving the approval of the advisors, the revised thesis is submitted to all RSC members and the Defense Coordinator for examination. The student must submit his/her thesis

to the RSC by the deadline published in the Graduation Timeline for the relevant semester.

The final thesis defense consists of two parts: a public presentation and a private examination. In the first part, the student delivers a thesis presentation open to the public (normally 30 minutes), followed by questions (normally 10-15 minutes). The second part is a private examination with a nominal duration of 60 minutes, attended by the RSC members, the Defense Coordinator and any relevant ex-officio members. During the private examination, the committee will interview the student, ask more detailed questions and examine a demonstration of the completed work, if applicable. The committee will also convey to the student any changes that he/she is required to make before the final submission of the thesis.

During the final thesis presentation and defense, the student is required to:

- Demonstrate a high level of understanding and specialization in the thesis area;
- Show evidence that he/she has conducted an independent investigation with rigor and discrimination;
- Demonstrate the acquisition and collation of information through the effective use of appropriate sources and equipment;
- Appreciate the relationship of the area of his/her thesis to a wider field of knowledge;
- Demonstrate a critical appreciation of the literature in his/her thesis area;
- Demonstrate an ability to appraise critically his/her contribution in the context of his/her overall investigation;
- Constructively defend his/her thesis outcomes;
- Make reference to the thesis that has been written clearly, accurately, cogently, and in a style appropriate to purpose; and
- Construct coherent arguments and articulate ideas clearly.

Following the examination, the RSC members and the Defense Coordinator will meet privately to vote on whether the student has successfully defended the thesis. The advisor(s) vote is divided equally among the Main Advisor and Co-Advisor(s) such that each may vote independently but the total advisor(s) vote equals one. The other RSC members have one vote each, with the exception of any external members who have a non-voting role. However, feedback from external members on the thesis and any suggested improvements should be recorded in the examination report. The following RSC recommendations are possible:

PASS

That the candidate be recommended for the award of Master's degree. No further revisions are required for the thesis.

PASS WITH MINOR CORRECTIONS

That the candidate be recommended for the award of Master's degree, subject to the satisfactory completion of such minor corrections as may be required by the RSC. Minor corrections shall normally be completed within a period of two weeks of the decision of the RSC. The RSC may stipulate that the minor corrections made shall be scrutinized by the RSC as a whole or by the Main Advisor prior to the award process being initiated.

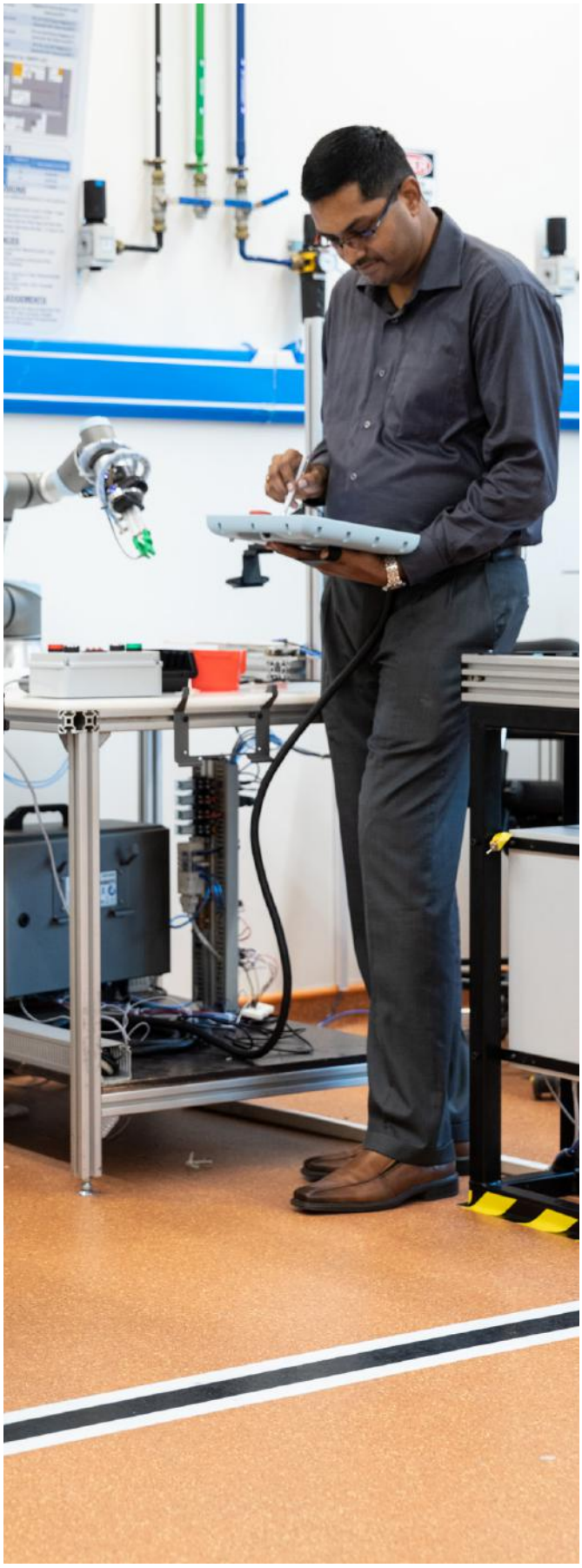
FAIL WITH REVISE AND RESUBMIT

The thesis should be referred back for major revisions. This normally means there are some major conceptual issues with the thesis and/or the student's performance during the oral examination does not meet the required standards. The student is failed in the thesis evaluation in the semester in which the thesis examination is conducted. However, the revised thesis may be re-submitted for a second and final attempt at passing the examination subject to the conditions specified by the examination committee. The re-submission shall normally take place within a period not exceeding 12 weeks from the date of the decision of the RSC. The RSC must specify in the examination report whether they require (a) re-submission of the revised thesis without oral examination or (b) full re-examination of the revised thesis including the oral defense.

FAIL

That the candidate be not recommended for the award of Master's degree and no further submission is permitted. The candidate must then be terminated from the Master's program.

The final, corrected copy of the thesis post-examination and endorsement of the student's Main Advisor, Co-Advisor(s) and RSC members must be submitted to the Associate Dean for Graduate Studies at the relevant College and subsequently to the Dean of Graduate Studies for approval.



PHD RESEARCH MILESTONES

Research milestones for PhD students are summarized in the table below. The typical timeline is made with reference to regular academic semesters (i.e. Fall and Spring), however students are expected to continue to work on their research during the Summer Term.

RESEARCH MILESTONE	TIMELINE FOR EXPECTED NORMAL PROGRESSION	
	FULL-TIME STUDENTS	PART-TIME STUDENTS
1 Research Project Allocation and Advisor Appointment	By end of the 1st semester of study.	By end of the 2nd semester of study.
2 Forming the Research Committee (RSC or PAC)	By end of the 2nd semester of study.	By end of the 3rd semester of study.
3 Registration for Dissertation	Normally, in semester immediately following research project allocation. Dissertation registration is required every semester (including Summer) until final defense.	Normally, in semester immediately following research project allocation. Dissertation registration is required every semester until final defense.
4 Written Qualifying Exam (WQE)	By end of the 2nd semester of study.	By end of the 4th semester of study.
5 Research Proposal Exam (RPE) (College of Engineering) or Oral Qualifying Exam (OQE) (College of Arts and Sciences)	By end of the 4th semester of study.	By end of the 6th semester of study.
6 Dissertation Progress Report (DPR)	By end of each semester following successfully passing RPE.	By end of each semester following successfully passing RPE.
7 Submit "Intent to Graduate" form via Banner.	By end of the 7th semester of study.	By end of the 11th semester of study.
8 Submit "Intent to Submit PhD Dissertation for Examination" form.	By end of the 7th semester of study.	By end of the 11th semester of study.
9 Dissertation Defense and Final Submission	8th semester of study, according to published Graduation Timeline.	12th semester of study, according to published Graduation Timeline.

PHD QUALIFYING EXAMINATIONS

Achieving PhD candidacy is contingent upon successfully passing a two-stage qualifying examination. The purpose of the qualifying examinations is (a) to ensure that the student has the required breadth and depth of content knowledge, and (b) to evaluate the student's ability to research a specific topic and critique its state of the art.

STAGE ONE: WRITTEN QUALIFYING EXAMINATION (WQE)

The main objectives of the Written Qualifying Examination (WQE) are (a) to enable early assessment of the technical background of the student in the selected major field of study, and (b) to provide an opportunity for early evaluation of the potential of the student to satisfactorily complete the PhD program.

The WQE is intended to test the student's understanding of the chosen field of study as evidenced by his/her proficiency in three pertinent topical areas. Each topical area will have a well-defined syllabus, similar to that of a standard course, which details its scope and content, as well as a recommended list of references and supplementary material. The student must choose three exam topical areas from an approved list, in consultation with his/her Main Advisor and Co-Advisor(s).

Students must register for the WQE before the end of the Add/Drop period of the semester in which they plan to take the WQE. At the time of application, the student must indicate three topical areas chosen from an approved list. The exams are held twice in each academic year over a one-week period. The duration for each exam is three hours. A minimum score of 73 percent is required to pass the exam for each topical area.

Failing any topical area of the WQE will result in the student failing the entire WQE. However, a failed WQE can be retaken only once and passed upon the next offering of the examination. If the student repeats the WQE, then he/she will be required only to retake the exams in the topical areas that he/she failed during the WQE at the first attempt. The student may have the option to retake the exams in topical areas other than those he/she failed at the first attempt. PhD students who fail the PhD WQE at the second attempt will be placed on Academic Probation Level 2 and will be subject to dismissal from the PhD program.

College of Engineering WQE

The examination is coordinated by the Associate Dean for Graduate Studies and the Chair(s) of the relevant Department(s) (or designees).

College of Arts and Sciences WQE

The examination is coordinated by the Department Graduate Committee (DGC) and the Department Chair. The DGC is appointed by the Department Chair and is usually composed of the Graduate Program Coordinator (Chair of the DGC), as well as three faculty members, who are not on the student's advisory committee.

STAGE TWO: DISSERTATION PROPOSAL AND EXAMINATION

Following successful completion of the Written Qualifying Exam (WQE), the student is required to submit a written Dissertation Proposal to his/her research committee (RSC or PAC), who will conduct a proposal examination (RPE or OQE, as detailed below). Students must submit and successfully defend the research proposal in order to be eligible to proceed to PhD Dissertation research.

The purpose of preparing the Dissertation Proposal is to focus the student's attention on a careful description of the proposed

research problem and its background and context. The proposal should clearly specify the following:

- The main problem that the student intends to work on and why it is important;
- The kind of results which the student hopes to achieve, and why they would be original and of significant value in the area of research;
- A critical review of the principal literature relevant to the research topic placing the student's contribution in context, accompanied by a full bibliography of relevant sources;
- An outline of work that the student has already carried out in the area and how it supports the proposed research;
- The general strategy that the student intends to pursue in dealing with the research problem, together with a work-plan for the stages of research; and
- A provisional table of contents for the dissertation.

Typically, the questions presented to the student at the proposal examination will address the research proposal and topics related to the general subject area of the proposal.

The purpose of the examination is to:

- Evaluate the proposed research problem to ensure that, if completed as proposed, it constitutes an original contribution to knowledge;
- Evaluate the progress made by the student since starting to work on the research problem;
- Ensure that the relevant expertise and facilities are available within the University to support the proposed research;
- Determine whether the student is adequately prepared to undertake the proposed research and communicate the results; and
- Provide the student with research direction and feedback.

The following outcomes of the dissertation proposal and examination are possible:

PASS

The proposal should be accepted as it stands. The student is passed and should be allowed to progress further on the program.

PASS WITH MINOR CORRECTIONS

The proposal should be accepted subject to inclusion of minor corrections and revisions. This normally means that there are some editorial errors and/or minor conceptual issues that need to be addressed before the proposal is approved. The student is passed and should be allowed to progress further on the program once the corrections and revisions are approved. The re-submission of the revised proposal shall take place within a period not exceeding 4 weeks from the date the student is formally informed of the decision of the examination committee.

FAIL WITH REVISE AND RESUBMIT

The proposal should be referred back for major revisions. This normally means there are some major conceptual issues with the research proposal and/or the student's performance during the proposal oral examination does not meet the required standards. The student is failed in the research proposal examination in the semester in which the proposal examination is conducted. However, the revised proposal may be re-submitted for a second and final attempt at passing the examination subject to the conditions specified by the examination committee.

The re-submission shall take place within a period not exceeding 24 weeks from the date of the decision of the examination committee. The examination committee must specify in the examination report whether they require (a) re-submission of the revised research proposal without oral examination or (b) full re-examination of the revised research proposal including the oral examination.

FAIL

The proposal should be rejected outright. This normally means that the proposal is conceptually very weak and/or the student's performance during the oral examination is well below the required standards. The student is failed and his/her registration on the program should be terminated.

College of Engineering Research Proposal Examination (RPE)

All students must register to take the RPE before the end of the Add/Drop period of the semester in which they plan to take the exam. The RPE consists of a public presentation of the proposal followed by a private examination session with the RSC as described below.

The RPE will typically be arranged within one month of receiving the Dissertation Proposal from the student. The Associate Dean for Graduate Studies chairs the RPE Committee (RPEC) or appoints a full-time KU faculty member as RPEC Chair in consultation with the relevant Department Chair. The RPEC Chair has a non-voting role in the RPE process.

The RPE consists of a public presentation of 45 minutes' duration (typically, 30 minutes for student presentation and 10-15 minutes for questions) followed by a private examination session of up to 60 minutes' duration. Following the examination, the RPEC members including the Chair will meet privately to vote on whether the student has successfully defended the research proposal. The advisor(s) vote is divided equally among the Main Advisor and Co-Advisor(s) such that each may vote independently but the total advisor(s) vote equals one. The other RPEC members have one vote each, with the exception of any external members who have a non-voting role. The Chair will report the examination result to Associate Dean for Graduate Studies who subsequently informs the Graduate Studies Office.

College of Arts and Sciences Oral Qualifying Examination (OQE)

All students must register to take the OQE before the end of the Add/Drop period of the semester in which they plan to take the exam. The OQE consists of a public presentation of the proposal followed by a private examination session with the PAC as described below. The duration of the public presentation is 50 minutes (typically, 40 minutes for student presentation and 10 minutes for questions), while the private examination session may take up to 90 minutes.

Following the examination, the PAC members including the Chair of the OQE Committee (the Associate Dean for Graduate Studies appoints the committee Chair in consultation with the relevant Department Chair) will meet privately to vote on whether the student has successfully defended the research proposal. The OQE Committee Chair has a non-voting role in the OQE process. The advisor(s) vote is divided equally among the Main Advisor and Co-Advisor(s) such that each may vote independently but the total advisor(s) vote equals one. The other PAC members have one vote each, with the exception of any external members who have a non-voting role. The Chair will report

the examination result to Associate Dean for Graduate Studies who subsequently informs the Graduate Studies Office.

DISSERTATION PROGRESS REPORT (DPR)

The Dissertation Progress Report (DPR) is a tool for the PhD student to provide an update on his/her progress, difficulties, resource requirements, publications, and planning for the next semester. Towards the end of each semester (typically week 10) following successful completion of the RPE / OQE, students should submit a short progress report to the RSC / PAC. The committee reviews the DPR and provides feedback to the Advisors. The Main Advisor should consider this feedback when submitting the research progress evaluation of the student at the end of the semester.

The DPR shall include, but not necessarily be limited to, the following:

- Original/revised research goals;
- Completed work;
- Status of completed and proposed goals; and
- Publications.

Completion of the DPR on a semester basis helps students to carry out well-paced research, making it easier to complete their dissertation and publications in time. It also acts as an important communication channel between the student and his/her research committee, especially when a large team is involved.

DISSERTATION DEFENSE COMMITTEE (DDC) AND EXTERNAL EXAMINER

The Dissertation Defense Committee (DDC) shall include members of the RSC / PAC and a PhD External Examiner. The External Examiner should be a full professor from a reputable international university who is an internationally recognized researcher in the subject area of the dissertation. To avoid any potential conflict of interest, the External Examiner must not have been affiliated with KU in the last five years up to the present day, in any capacity including the examination of thesis or dissertation. Furthermore, the Main Advisor and/or Co-advisor(s) must not have had joint publications or any collaboration with the External Examiner over the past five years.

The External Examiner is nominated by the Main Advisor in consultation with the Co-Advisor(s), relevant Department Chair (or nominee) and Associate Dean for Graduate Studies, and appointed as a voting member of the DDC by the Dean of Graduate Studies. It is expected that the External Examiner attends the final dissertation defense in person. In exceptional circumstances, it is permissible to arrange participation by synchronous electronic methods.

DISSERTATION DEFENSE

Every semester, the Graduate Studies Office publishes a Graduation Timeline specific to the current term. The timeline provides a guide to processes students and faculty must complete leading up to the final dissertation submission and defense, including the dissertation formatting guidelines. Graduate students are required to follow this timeline and adhere to the specified deadlines during their final semester of study. A student should normally be in good academic standing and registered for dissertation credits during the semester he/she intends to defend.

The Graduate Studies Office schedules the final dissertation defense in accordance with the approved "Intent to Submit PhD Dissertation for Examination" request and in consultation with all DDC members. Graduate Studies Office will make the relevant logistical arrangements and inform the student about the date and time.

The Associate Dean for Graduate Studies at the relevant College chairs the DDC or appoints a full-time KU faculty member as DDC Chair in consultation with the relevant Department Chair. The composition of the DDC is communicated to the Dean of Graduate Studies. The primary responsibilities of the DDC Chair are:

- Attend the final dissertation defense and the private DDC meeting to ensure that the examination is conducted in accordance with all relevant KU academic policies and procedures. The DDC Chair has a non-voting role in the defense process.
- Report the examination result to the Graduate Studies Office through the Associate Dean for Graduate Studies and confirm that the correct examination process was followed.

The student must submit an initial dissertation draft to the Main Advisor and Co-Advisor(s), who will work with the student on the necessary revisions. Upon receiving the approval of the advisors, the revised dissertation is submitted to all RSC / PAC members and the Graduate Studies Office, who will forward it to the External Examiner. The student must submit his/her dissertation by the deadline published in the Graduation Timeline for the relevant semester.

The final dissertation defense consists of two parts: a public presentation and a private examination. In the first part, the student delivers a presentation open to the public (typically 45 minutes), followed by questions (typically 10-15 minutes). The second part is a private examination, which does not normally exceed 180 minutes, attended by the DDC members, the DDC Chair and any relevant ex-officio members. During the private examination, the committee will interview the student, ask more detailed questions and examine a demonstration of the completed work, if applicable. The committee will also convey to the student any changes that he/she is required to make before the final submission of the dissertation.

A high level of achievement is expected for the award of the PhD degree. In his/her dissertation and during the viva voce examination, a candidate for the degree of PhD is required to:

- Demonstrate a high level of understanding and specialization in his/her field of study;
- Show evidence that he/she is able to conduct independent investigation with rigor and discrimination;
- Demonstrate the ability to acquire and collate information through the effective use of appropriate sources and equipment;
- Appreciate the relationship of the area of his/her research to a wider field of knowledge;
- Demonstrate a critical appreciation of the literature in his/her area of research;
- Demonstrate an ability to recognize and validate research problems;
- Demonstrate an understanding of relevant research methodologies and techniques and their appropriate application to his/her research;
- Have made a significant and original contribution to the body of knowledge in his/her field of study;
- Demonstrate an ability to appraise critically his/her contribution in the context of his/her overall investigation;
- Constructively defend his/her research outcomes;

- Write clearly, accurately, cogently, and in a style appropriate to purpose;
- Construct coherent arguments and articulate ideas clearly; and
- Show awareness of relevant research issues including environmental, political, economic, social, copyright, ethical, health and safety, exploitation of results, and intellectual property rights.

Following the examination, the DDC members and the Chair will meet privately to vote on whether the student has successfully defended the dissertation. The advisor(s) vote is divided equally among the Main Advisor and Co-Advisor(s) such that each may vote independently but the total advisor(s) vote equals one. The External Examiner and the other DDC members have one vote each, any other external members have a non-voting role. The DDC Chair will report the examination result to the Graduate Studies Office through the Associate Dean for Graduate Studies. The following DDC recommendations are possible:

PASS

That the candidate be recommended for the award of PhD. No further revisions are required for the dissertation.

PASS WITH MINOR CORRECTIONS

That the candidate be recommended for the award of PhD, subject to the satisfactory completion of such minor corrections as may be required by the DDC. This normally means that there are typographical, grammatical and/or editorial errors that need correcting before the dissertation is approved. Such minor corrections shall be completed within a nominal period of four weeks of the decision of the DDC. The DDC may stipulate that the minor corrections made shall be scrutinized by the DDC as a whole or by the Main Advisor prior to the award process being initiated.

FAIL WITH REVISE AND RESUBMIT

That the candidate be not recommended for the award of PhD, but be allowed to modify the dissertation and re-submit it for the award of PhD on one further occasion. This normally means there are some major conceptual issues with the dissertation and/or the student's performance during the oral defense does not meet the required standards. The student is failed in the dissertation evaluation in the semester in which the dissertation examination is conducted. However, the revised dissertation may be re-submitted for a second and final attempt at passing the examination subject to the conditions specified by the DDC. The re-submission shall take place within a period not exceeding 24 weeks from the date of the decision of the DDC. The DDC must specify in the examination report whether they require (a) re-submission of the revised dissertation without oral examination or (b) full re- examination of the revised dissertation including the oral defense.

FAIL

That the candidate be not recommended for the award of PhD and no further submission is permitted. The candidate must then be terminated from the PhD program.

The final, corrected copy of the dissertation post-examination and endorsement of the student's Main Advisor, Co-Advisor(s) and DDC members must be submitted to the Associate Dean for Graduate Studies at the relevant College and subsequently to the Dean of Graduate Studies for approval.

GRADUATE ASSISTANTSHIPS

Students holding a Khalifa University full-time scholarship will provide service of up to 12 hours per week during the academic semester. Service may include, but is not limited to, activities such as course work and lab supervision as assigned by the University. Students perform their assigned duties under the active tutelage and supervision of a faculty member. These appointments do not carry faculty status or other faculty rights or responsibilities.

MSC GRADUATE RESEARCH / TEACHING ASSISTANT (GRTA OR BUHOOTH)

Graduate Assistants pursuing a Master's qualification will typically be responsible for tasks related to the instruction of students and may support the faculty by:

- Preparing for class sections and/or laboratories;
- Presenting material in a classroom or lab setting;
- Facilitating group discussions and team-based learning;
- Offering technical support;
- Assisting with conduct and evaluation of assessment tasks; and
- Holding regular office hours.

These responsibilities will not generally extend to the instructional content of a course, the selection of student assignments, planning of examinations, determining the term grade for students or the instruction of an entire course.

Graduate full-time students engaged in Master's level studies at Khalifa University who assume substantial research responsibilities may aid the research of an investigator or a member of faculty on a research project or program. Graduate Assistants are required to adhere to all University policies addressing research.

PHD GRADUATE RESEARCH / TEACHING ASSISTANT (GRTA OR BUHOOTH)

Graduate Assistants at the Doctoral level may have an opportunity to gain substantial teaching experience and may be given primary charge and responsibility for a course (with the mentorship of a faculty member), including:

- Preparation and/or development of course material;
- Teaching at undergraduate level;
- Preparing for examinations and proctoring;
- Evaluating and grading assessment tasks; and
- Holding regular office hours and counseling students to improve their academic performance.

A Graduate Assistant is never responsible for assigning final grades. Graduate full-time students engaged in doctoral level studies at Khalifa University who assume substantial research responsibilities may provide high-level, experienced research support to an investigator or a member of faculty on a research project or program. Graduate Assistants are required to adhere to all University policies addressing research.

STUDENT RIGHTS AND RESPONSIBILITIES

ACADEMIC INTEGRITY

Khalifa University is committed to the principles of truth and academic honesty. It is the responsibility of all university community members – students, faculty, staff and administration alike – to promote academic integrity through active deterrence and reporting of violations. Every student admitted to KU is expected to fully comply with the university's Academic Integrity Policy and understand their rights and responsibilities (ACA 3500 Academic Integrity, STL 5410 Student Code of Conduct, STL 5420 Student Rights and Responsibilities). Admission to Khalifa University and registration in a course constitute an affirmation and acknowledgement by the student of their responsibility to abide by the terms and conditions of the academic integrity policy in its entirety. For policies and processes concerning the College of Medicine and Health Sciences, please refer to the CMHS Medical Student Handbook.

STUDENT ACADEMIC RIGHTS

Every enrolled student has the right to access and receive quality education.

- KU is obliged to provide students with information on available funds and financial aid.
- KU is obliged to uphold and preserve its students' rights to exercise principles of academic freedom.
- KU is obliged to advise on and provide sufficient course information to permit students to make informed course selections.
- KU is obliged to make each course outline available to students including (but not limited to):
  - A description of the topics to be considered in the course.
  - Objectives and learning outcomes.
  - A list of all required readings and other materials, a description of the means of evaluation to be used in the course, the instructor's office hours, and locations for office appointments.
- Instructors are obliged to clearly communicate the learning outcomes and assessment tools to students.
- Instructors are obliged to provide a fair and reasonable evaluation of a student's performance in a course, with evaluation measures reflecting the content of the course.
- The students have the right to a fair and impartial assessment of their performance.
- Subject to reasonable administrative arrangements and provided that a request is made by a student within a reasonable time after the notification of a decision, students have the right to appeal an academic decision.

STUDENT RESPONSIBILITIES

The policy on student responsibilities to the University, the faculty and fellow students includes The Honor Code of Conduct. Modelled after the "Fundamental Standard" established at Stanford University in 1896, the Khalifa University statement of student conduct applies to all students in the University community. This statement is as follows:

"Whether engaging in university activities or engaging in their lives outside the University, students at the Khalifa University of Science and Technology are expected to show respect for order, morality, personal honor and the rights of others as is demanded of good citizens. This includes conforming to applicable laws and respect at all times for the cultural norms and expectations of the society we live in. Failure to do this will be sufficient cause for removal from the University."

More specifically, student responsibilities include:

- Abiding by all academic policies and procedures, and adhering to the academic integrity policy (including work ethics, attendance, etc.).
- Conforming to all non-academic administrative rules and regulations (including those related to health, safety and environment).
- Conducting oneself in accordance with the Student Code of Conduct.
- Respect the norms of UAE society and behave in a way that does not offend cultural sensitivities (see STL 5410 Student Code of Conduct).
- Observe decency in conduct and behavior, whether the student is on campus or off campus (see STL 5410 Student Code of Conduct).
- Adhere to the appearance appropriate to university students. Give special attention to clothing and cleanliness. Ensure that clothes do not conflict with public morals (see STL 5430 Student Dress Code).
- Abide by all academic policies and procedures and conform to all non-academic administrative rules and regulations.
- Complete his/her academic program. This includes being familiar with KU Catalogs, maintaining good academic standing, and meeting all other degree requirements.
- Abide by KU attendance policy (see ACA 3555 Student Attendance (Graduate Programs)).
- Maintain communication with KU and keep accurate student information including current address, home address, telephone number and e-mail address etc.
- Keep their ID card with them at all times and present it on demand to university personnel.
- Participate in campus and community life in a manner that will reflect credit upon the student and the university.
- Be punctual in attending lectures, labs, workshops and events.
- Be an active listener while in any educational setting and avoid any disruption.
- Maintain the cleanliness and tidiness of KU facilities.
- Refrain from using, circulating or displaying pamphlets, leaflets or posters in KU premises without prior approval.
- Assume responsibility of all resources such as apparatus, equipment, computer, books and other provided materials.
- Refrain from using any university computer for games or other purposes not related to the educational programs.
- Park only in the designated areas. Students are not allowed to use the parking area designated for faculty and staff.
- Be fully responsible for personal property. KU shall bear no responsibility for any lost or missing items.
- Consume food only in designated dining facilities. Food, tableware and utensils cannot be removed without permission.
- Refrain from engaging in spreading rumors or making false accusations.
- In case of a fire alarm, follow the instructions of the safety and security staff and leave KU premises as quickly as possible.
- Respect payment deadlines.
- Irrespective of religion or nationality, behave and dress in a modest manner. Harassment or intimidation of students will not be tolerated and students should report any such cases to the Student Services Office.

CONFIDENTIALITY AND PRIVACY OF STUDENT RECORDS

Khalifa University creates and maintains a variety of records for prospective, current and former students. Documents submitted by students become the property of the university including, but not limited to application/ enrollment forms, school certificates, academic or other transcripts and English language test scores. University faculty and staff are permitted to access a student's academic record only when necessary to the performance of their assigned duties and responsibilities.

Current and former students, their guardians and/or sponsors have access to the student's academic records upon written request to the Registrar's Office and provision of valid identification in accordance with ACA 3850 Confidentiality and Privacy of Student Records policy. Other parties may be given limited access to student academic records as follows:

- Organizations, their employees, agents and/ or representatives authorized to act on the University's behalf or providing a service or function for or on behalf of the University may have access such as may reasonably be considered necessary to the service or function.
- Government and other authorized officials including accrediting bodies.
- To comply with a judicial order.
- Other institutions to which a student is transferring;
- Organizations conducting educational studies, on the condition that no personally identifiable information is released, or is released only in aggregate form.
- University employees, agents or representatives investigating a suspected security breach or conduct violation.
- Emergency personnel where there is a health or safety concern.

A student, guardian, or sponsor has the right to request changes to the content of the student's education record if the content is considered to be inaccurate, misleading, or in violation of the student's privacy or other rights. Such a request should be submitted in writing to the Registrar's Office.

ACADEMIC INTEGRITY CODE

The academic community, like all communities, functions best when all its members treat one another with honesty, fairness, respect, and trust. Khalifa University expects high standards of scholarship and integrity from all members of its community. To accomplish its mission of providing an optimal educational environment and developing leaders of society, the University promotes the assumption of personal responsibility and integrity and prohibits all forms of academic dishonesty. The purpose of education is to develop a student's ability to think logically and to express himself/ herself accurately.

Members of the University community are expected to carry out their work with intellectual honesty and professional integrity, adhering to the highest standards of ethical behavior consistent with the codes of conduct set down by relevant professional societies. Unethical behavior is not worthy of members of the University community and will be dealt with severely. Academic dishonesty in any form undermines the very foundations of higher education and will not be tolerated by the University. The most common form of academic dishonesty is plagiarism. Other forms of academic dishonesty are described in the sections below.

PLAGIARISM

Plagiarism is the act of representing another's words or ideas as one's own or failing to give appropriate credit to outside sources of information in any academic assignment, exercise, examination, project, presentation, report.

FORMS OF PLAGIARISM

- Word-for-word copying of someone else's work, in whole or in part, without acknowledgment, whether that work be a magazine article, a portion of a book, a newspaper piece, another student's paper, or any other composition not one's own. Any such use of another's work must be acknowledged by:
  - Enclosing all such copied portions in quotation marks; and/or
  - Providing a complete reference to the original source either in the body of one's work or in a note. As a general rule, one should make very little use of quoted matter in papers, project reports and assignments.
- An unacknowledged paraphrasing of the structure and language of another person's work. Changing a few words of another's composition, omitting a few sentences, or changing their order does not constitute original composition and therefore can be given no credit. If such borrowing or paraphrasing is ever necessary, the source must be indicated by appropriate reference.
- Writing a work based solely on the ideas of another person. Even though the language is not the same, if the thinking is clearly not one's own, then the person has committed plagiarism. If, for example, in writing a work a person reproduces the structure and progression of ideas in an essay one has read, or a speech one has heard, the person, in this case, is not engaging his/her own mind and experience enough to claim credit for writing his/her own composition.

In summary plagiarism includes, but is not limited to:

- Using published work without referencing (the most common);
- Copying coursework;
- Collaborating with any other person when the work is supposed to be individual;
- Taking another person's computer file/program;
- Submitting another person's work as one's own;
- The use of unacknowledged material published on the web;
- Purchase of model assignments from whatever source; or
- Copying another person's results.

AVOIDING PLAGIARISM

To avoid plagiarism, a student must give credit whenever he or she uses:

- Another person's idea, opinion, or theory;
- Any facts, statistics, graphs, drawings, any pieces of information that are not common knowledge;
- Quotations of another person's actual spoken or written words; or
- Paraphrase of another person's spoken or written words.

Direct quotations should be put in "inverted commas", and referenced. Paraphrased or edited versions should be acknowledged and referenced.

IDENTIFICATION AND ANALYSIS OF PLAGIARISM GUIDELINES

It is University policy that electronically-submitted coursework produced by students be regularly submitted to suitable plagiarism-detection software for the identification and analysis of possible plagiarism. The University holds a site license for reputable plagiarism-detection software and makes available to all teaching staff relevant access to the software. It is mandatory that all teaching staff use such software for all major student assignments and final project reports. Plagiarism is deemed to have occurred if the plagiarism score is equal to or greater than 15%, after all individual instances of scores of 2% or less are discounted. All coursework items that achieve a plagiarism score equal to or greater than 15% (after all individual instances of scores of 2% or less are discounted) will be awarded zero grades. The only faculty member who may submit a coursework item for a particular course to a plagiarism-detection software program is the assigned instructor for that course. No other academic course member should submit any coursework item that relates to another faculty member's assigned course.

OTHER FORMS OF ACADEMIC DISHONESTY

CHEATING

Using or attempting to use unauthorized materials and/or assistance in any academic assignment, exercise, examination, project, presentation, report, etc. This includes the possession of a mobile phone or any other unauthorized electronic devices during a test or an examination.

COLLUSION

Collusion includes cooperation of student(s) with faculty or staff personnel in securing confidential information/material (tests, examinations, etc.); bribery by student(s) to change examination grades and/or grade point average(s); cooperative efforts by student(s) and student assistant(s) to gain access to examinations or answers to examinations for distribution; seeking, obtaining, possessing, or giving to another person an examination or portions of an examination (not yet given), without permission of the instructor.

FABRICATION OF DATA

Falsifying or inventing research, citations, or any information on any academic assignment, exercise, examination, project, presentation, report, etc.

FALSIFYING SIGNATURES

Forging monograms, imprimaturs and other forms of authorization or identification – whether handwritten, electronic or otherwise – on official forms or documents, attendance lists or any academic assignment, exercise, examination, project, presentation, report, etc.

FALSIFICATION OF RESULTS

This means the alteration, modification, or misrepresentation of results (including selective inclusion or exclusion of results).

RECYCLING

Recycling is the submission of one's previous work to count as new work. For example, submission of a student's work that has previously counted in another unit of study is not allowed, unless explicitly authorized by the faculty members of both study units. In such case, students must reference their previous work.

SABOTAGE

Destruction of, or deliberate inhibition of, the progress of another student's work related to a course is considered sabotage and is viewed as academically dishonest. This includes the destruction or hiding of shared resources such as library materials and computer software and hardware to tampering with another person's laboratory experiments.

PROCEDURE AND PENALTIES FOR ACADEMIC MISCONDUCT

ACADEMIC DISHONESTY - MINOR VIOLATIONS

If an instructor suspects that a student has committed a minor violation, he/she should meet with the student to discuss the allegation. The meeting must take place within three working days from when the alleged violation was identified. If the instructor determines that no academic violation has occurred, the matter is dropped. If the instructor determines that a minor violation has occurred, he/she shall:

- Apply a sanction, if any, in accordance with KU policy ACA 3500 Academic Integrity (see also "Possible Sanctions for Academic Dishonesty Violations" below).
- Notify the student, the instructor's Department Chair and the relevant College Dean in writing, detailing the violation and sanction applied (if any) within five working days from when the meeting with the student(s) took place.

ACADEMIC DISHONESTY - MAJOR VIOLATIONS

If an instructor suspects that a student has committed a major violation, he/she should meet with the student to discuss the allegation. The meeting must take place within three working days from when the alleged violation was identified. If the instructor determines that no academic violation has occurred, the matter is dropped. If the instructor determines that a major violation has occurred, he/she shall:

- Notify the student, the instructor's Department Chair, and the relevant College Dean in writing, detailing the violation within five working days from when the meeting with the student(s) took place.
- The student will be notified in writing of the incident in question and the policy violation(s) under consideration. The notice (typically sent via email) will be delivered sufficiently in advance of the hearing to afford a reasonable opportunity to prepare a presentation and have access to the case file.
- The student's file will be automatically referred to the Judicial Officer (or designee) who will review the case, gather the evidence and present it, in writing, to the Academic Integrity Council (AIC).
- Upon submission of the case to the AIC,
  - The AIC will hold a meeting with the Judicial Officer (or designee) and, if necessary, the student and/or instructor for the purpose of examining the evidence and questioning any witnesses or relevant parties.
  - The student shall have the right to be assisted by an advocate. The advocacy role may be assigned to an academic advisor or counselor. External attorneys are not permitted to be involved in any grievance or appeal case.
  - The committee may consult the university legal assessors or an expert (e.g. medical, psychological, etc.) for advice regarding any evidentiary issue.
  - Based on the evidence, if the AIC decides that the student has committed an academic violation, they will recommend an appropriate sanction. The AIC may recommend any sanction in accordance with KU policy ACA 3500 Academic Integrity (see also "Possible Sanctions for Academic Dishonesty Violations" below).
  - The AIC submits a full report, including the recommended sanction, to the Provost (or designee) for a final decision. Such decision will be communicated to the Registrar's Office. Where the Provost (or designee) determines to impose a sanction other

than that recommended by the AIC, written justification shall be provided to the AIC.
- The Registrar's Office will communicate the final decision to the student, the instructor, the Department Chair, the relevant College Dean and the Graduate Studies Office.

DURING AN ACADEMIC DISHONESTY INVESTIGATION

A student under investigation for violation of this policy document may not withdraw from the course in question. A student may not graduate as long as any alleged violation of the Academic Integrity Policy remains unresolved. Non-availability of any of the concerned parties will not hinder the continuation of the investigation. Students may seek advice about the policy and the associated procedures from the Judicial Officer (or designee).

POSSIBLE SANCTIONS FOR ACADEMIC DISHONESTY VIOLATIONS

Sanctions for academic dishonesty are applied based on the severity of the violation:

- **Requirement to attend scheduled developmental workshops on relevant topics**
  Opportunistic cheating in assignments, exercises, examinations, projects, presentations, reports, etc. that have a limited effect on a student's course grade.
- **Reduced grade or 0 for the work**
  Opportunistic cheating in assignments, exercises, examinations, projects, presentations, reports, etc. that have a limited effect on a student's course grade.
- **Reduction in course grade by one letter grade**
  Premeditated cheating in assignments, exercises, examinations, projects, presentations, reports, etc. that have a limited effect on a student's course grade.
- **XF or reduction in grade for the course**
  Opportunistic cheating in assignments, exercises, examinations, projects, presentations, reports, etc. that have a significant effect on a student's course grade.
- **Suspension for one semester and an XF for the course**
  Premeditated cheating in assignments, exercises, examinations, projects, presentations, reports, etc. that have a significant effect on a student's course grade.
- **Expulsion from KU**
  Premeditated and/or repeated cheating in assignments, exercises, examinations, projects, presentations, reports, etc. that have a significant effect on a student's course grade.
- **Suspension from KU**
  A student found guilty of academic dishonesty may be suspended for one or more semesters. The AIC recommends the length of suspension. Once imposed, the AIC recommends the effective date for suspension, which could be immediate. If suspended during an academic semester, the student will receive a grade of XF (Failure due to Academic Dishonesty) for the concerned course and a W for all remaining courses. KU will report the case to the student's guardian and/or sponsor.

APPEALS

A student may, prior to graduation, appeal an XF grade recorded or other imposed sanction in accordance with STL 5450 Student Grievances and Appeals.

RECORDS OF SANCTIONS

All records of sanctions for all cases will be maintained in the student's file. In cases of major violations, KU will provide a record of sanction upon request from the guardian and/or sponsor (see ACA 3850 Confidentiality and Privacy of Student Records).

STUDENT GRIEVANCES AND APPEALS

Khalifa University aims to provide a fair, equitable and productive learning environment for all its students that includes a variety of means by which student grievances are brought to consideration and subsequent resolution in a timely manner (STL 5450 Student Grievances and Appeals). A student has the right to appeal or file a grievance against academic or financial decisions or rulings, or a sanction resulting from a code of conduct violation. Students must follow the established procedures and adhere to time limits for filing a grievance or appeal. The University will issue an official written response. For policies and processes concerning the College of Medicine and Health Sciences, please refer to the CMHS Medical Student Handbook.

APPEALS PROCEDURE

In situations involving the appeal of a grade or an instructor imposed sanction related to a minor violation of the academic integrity policy, the student and instructor are encouraged to resolve the matter informally, amicably and promptly. Should the discussion fail to lead to resolution, the student may file an appeal with the relevant Department Chair. If the Department Chair, instructor and student are unable to resolve the issue, the student or Department Chair may further raise the appeal to the attention of the Dean of the College (or designee). In the case of an appeal of an instructor imposed sanction, the decision of the Dean of the College (or designee) will be final.

A student has the right to appeal a university imposed academic or non-academic sanction or a financial ruling subject to the following provisions:

- All appeals must be in writing and provide new information not considered previously.
- A student may appeal an officially recorded grade through submission of a "Grade Appeal" form to the Registrar's Office no later than the first day of classes of the next regular semester.
- All appeals of a sanction imposed by the Academic Integrity Council for an academic integrity violation must be submitted to the SVP of Academic and Student Services within ten working days from the decision date. The SVP of Academic and Student Services will forward the case to the Graduate Studies Council, as appropriate.
- All appeals of a dismissal due to poor academic performance must be submitted to the Registrar's Office within five working days from the decision date. The Registrar's Office will forward the case to the Graduate Studies Council, as appropriate.
- All appeals of a sanction imposed by the Student Conduct Council for a code of conduct violation must be submitted to the Director of Student Services within ten working days from the decision date. The Director will forward the case to the Graduate Studies Council, as appropriate.
- Financial appeals must be submitted to the SVP of Academic and Student Services by the last day of the Add/Drop period of the current semester. The appeal will be forwarded to the appropriate committee for consideration.
- Appeals may result in the application of a lesser, identical or more severe sanction or grade.
- The recommendation of the Graduate Studies Council shall be reviewed by the Provost whose decision is final.
- The outcome of an appeal will be provided to the student in writing by the Registrar's Office and a copy of the final decision placed in the student's file.

STUDENT LIFE AND SERVICES

Student Services is the department that fosters the intellectual, social, ethical, and personal development of students, preparing them to become engaged and constructive members of a diverse, dynamic, and global society within and out of the university. The department advocates students' needs, facilitates student involvement, and encourages students to accept responsibilities of membership in a campus community to explore personal interests through clubs, associations and focus groups. Additionally, there is strong emphasis on various health, safety and fitness programs, as well as recreational and educational activities. The KU Student Handbook provides further details on the activities and support provided by the Student Services department. For policies and processes concerning the College of Medicine and Health Sciences, please refer to the CMHS Medical Student Handbook.

STUDENT LIFE

Students at Khalifa University are encouraged to participate in extracurricular activities. Student Services plan, in a student-centered manner, athletic, cultural, and social activities enabling students to develop personal talents and interests. The university has many facilities and services at each of the three campuses tailored to the needs of KU students. The aim is to promote a campus climate that enhances the educational, physical, social and emotional well-being of students, and creates a collaborative, caring, and participatory work environment. For policy governing student-organized events, clubs or activities, refer to STL 5620 Student Groups and STL 5630 Student Activities.

CO-EDUCATION

The University maintains a multicultural and multi-structural educational environment that offers both an integrated and segregated education experience. All members of the community affirm the norms of UAE society and behave in ways that respects cultural sensitivities. All students, whether male or female, have access to equal educational opportunities and facilities.

STUDENT HOUSING

Khalifa University residences offer an environment where students from different parts of the world can meet and learn from one another. On-campus residences at Masdar City Campus are available to all full-time and registered graduate students as per eligibility, and based on a rental fee. All housing facilities are managed by on-site staff and security team. Masdar City Campus residences are dedicated for male students and female students reside in the Um Al Lulu complex near Sas Al Nakhl campus.

For further information, students are encouraged to refer to the Student Residence Guidebook or contact the Residence Life team via pgr.life@ku.ac.ae. Rules and regulations governing all university student residences can be found in STL 5700 Residential Life.

STUDENT TRANSPORTATION

The university provides a range of transportation services for students, subject to availability (STL 5720 Student Transportation Services):

- Daily transportation between university campuses.
- Weekend transportation from/to other Emirates, subject to online registration.
- Daily transportation within 80km radius within Abu Dhabi.
- Transportation to external events off-campus, as required and subject to approval.

STUDENT SUCCESS

The Student Success department provides services and experiences which allow each student to develop their capacity to achieve academic success, as well as meaningful personal and professional growth. The department focuses on the key areas of Student Guidance and Student Engagement and Development. Student Guidance provides counseling services, as well as academic and non-academic workshops. Student Engagement and Development offers students opportunities such as study abroad and student exchange, engagement in volunteering, qualifying for Honor Societies, and developing social entrepreneurial competencies.

WORKSHOPS

Workshops are offered throughout the academic year to support students' academic success and personal development. The topics include, but are not limited to Time Management, Test Anxiety, Goal Setting, Study Skills, Stress Management and Emotional Intelligence.

COUNSELING SERVICES

Counselling provides support and intervention services to assist Khalifa University students. A dedicated team of qualified counselors work to contribute to students' university experience at a personal and academic level. All counseling sessions are held to a high level of confidentiality and are governed by KU Policy STL 5510 Student Counseling.

Counseling services offered throughout the academic year will help students by:

- Providing a safe environment where students can get help in coping with personal challenges.
- Strengthening personal skills through counseling sessions, activities and workshops.
- Assisting with study skills and time management to support academic achievements.
- Providing conflict mediation and arising misunderstandings between students and faculty/staff.
- Helping with productive decisions and use positive problem-solving techniques.
- Assisting transition and adjustment to the new campus life.
- Supporting and accommodate special needs.
- Helping you cope with trauma or crisis.

SPECIAL NEEDS SERVICES

Students, irrespective of any special need, have a right to equal access to education, resources, and facilities at the university. Students with documented special needs are entitled to reasonable accommodation within the available resources. Students are assured of the confidentiality of their special needs documentation.

The services provided include information on accessibility, identification of accommodations, filing of medical reports, and liaison with faculty and staff in establishing accommodations (e.g. equipment, tests, note-taking, etc.) and the provision of auxiliary aids when required. Please refer to ACA 5200 Special Needs Students for additional information.

CAREER SERVICES

Khalifa University assists students in career planning and securing appropriate employment through provision of career related activities and professional services that follow best practices and meet the needs of students, alumni, and employers (refer to STL 5520 Career Services). Career Services are available from first registration and aim to help students

develop career plans and goals, become employment ready and build relationships with employers. Students can develop effective study habits, discover personal learning styles, understand the importance of managing time, explore personal values and interests, as well as attend workshops on resume writing, interview preparation and networking skills. KU has a visible presence in the market as one of the first universities to cover the job demands of engineers in various industries, including clean technology and renewable energy.

KU ALUMNI ASSOCIATION COUNCIL

MISSION STATEMENT

The Khalifa University (KU) Alumni Association (KUAA) is set up to position KU as a leading global academic and research University and to place KU alumni at the forefront of the global local and global community focusing on facilitating a robust between alumni, current KU students, KU faculty, and collaborative network consisting of KU graduates, KU administration, and other relevant stakeholders.

Alumni Relations Charter/Mandate
Within the KUAA, comprised of all KU graduates, a KUAA Council (KUAAC) has been selected to serve this office and will be liaising with administration in order to engage, inform, and create a mutually beneficial platform for interaction with key stakeholders (including industry, academia, global leaders) in the UAE and abroad.

STUDENT COUNCIL

Khalifa University strongly believes in the active participation of students in the governance of the university. Every student on campus is eligible to serve on a student council, university committee or departmental advisory board as applicable (see STL 5610 Student Governance). The purpose of the Student Council is to provide a platform that promotes interaction among students and the University body. The Student Council works closely with Student Services to foster a spirit of community, understanding, and harmony throughout the campuses. The work of the Council also aims to provide students with unique opportunities to develop life skills and leadership qualities by organizing activities and hosting events of interest to students. All KU students in good academic standing are eligible to run for office.

STUDENT COUNCIL OBJECTIVES

- To provide a link between the student body and University Management.
- To encourage participation in extracurricular activities.
- To coordinate university events involving the campus community, such as UAE National Day and Global Day.
- To create a collaborative, caring, and participative work environment.
- To enhance the educational, physical, social and emotional well-being of the students.
- To provide students with a platform to voice their views and facilitate action from the campus administration on any issues, needs, and concerns.
- To organize clubs, field trips, workshops, and competitions.
- To provide opportunities for students to develop life skills.
- To develop leadership skills.

STUDENT CONDUCT

The Division of Student Services is responsible for reviewing all alleged violations of non-academic student conduct. Non-academic offenses are related to behaviors that disrupt the life of the University community and include, but are not limited to, the following categories:

- Disruption of teaching or other University activities including administrative processes.
- Unauthorized entry and/or presence on University property.
- Threat, damage, and destruction of University property or the property of other members of the University community.
- Physical abuse, harassment, and dangerous activities.
- Possession of stolen property.
- Unauthorized or fraudulent use of University facilities, equipment or services.
- Misuse of library and information technology resources.
- Any behavior or appearance deemed by UAE or the University norms to be offensive to the culture.
- Behaviors deemed to be unacceptable may lead to a variety of sanctions up to and including student dismissal from the University. The University Student Handbook and website details University policies and procedures regarding student conduct regulations, hearings and sanctions.

DRESS CODE

All students are required to adhere to the University dress code when on campus or representing the University off-campus (see KU Policy STL 5430 Dress Code).

STUDENT CODE OF CONDUCT

Every member of the University community is required to follow the principles of decency, modesty and propriety in their behavioral conduct and dress in line with the spirit of UAE cultural norms and religious traditions when on campus or representing the University off-campus. To this end, all students must comply with the conventions and regulations of University life established to maintain order, protect individuals and property, and fulfill the University's mission and purpose. It is the students' responsibility to familiarize themselves with the Code of Conduct and adhere to it (STL 5410 Student Code of Conduct).

CAMPUS ACCESS

All KU students are eligible to access University facilities during official working hours. University ID is used to control access and must be kept available when on campus. Students who have a valid University parking sticker are eligible to bring their vehicles on campus, subject to specific campus conditions and regulations. Access to laboratories and other specialized facilities, and after-hours access, require special advance permissions as stipulated by KU policy STL 5710 Campus Access for Students.

GRADUATE PROGRAMS

COLLEGE OF ARTS AND SCIENCES

MA IN INTERNATIONAL AND CIVIL SECURITY

ABOUT THE PROGRAM

Security is the insurance policy of the nation. The 21st century combines the promise of great progress with the resurgence of old dangers and the emergence of new ones. Those dangers include terrorism, warfare, weapons of mass destruction, tropical cyclones and large-scale industrial accidents. Some of these dangers are rooted in technology, others in society, and still others in nature itself. Attaining the strategic vision of the UAE will require deep understanding of those threats and hazards, and the knowledge and skills to address them. The Master of Arts in International and Civil Security (MA ICS) is a unique program that will prepare students to become leaders in this field. The MA ICS is a part-time program open to UAE National students who are working in or want to work in the field of security.

PROGRAM EDUCATIONAL OBJECTIVES

The objectives of the MA in International and Civil Security program are to:

1. Provide current and future security professionals with sophisticated knowledge of the UAE, regional and global security environment.
2. Provide current and future security professionals with the skills to produce, analyze and apply security- related research.
3. Apply higher education and research toward enhancing UAE, regional, and international security.

LEARNING OUTCOMES

MA in International and Civil Security graduates will have demonstrated:

1. Sophisticated knowledge of the international, national, and regional security environment, to include the relevant theories and history of conflict.
2. Sophisticated knowledge of natural and human caused threats to international, national, regional, and civil security.
3. An understanding of the relationships between and within the different levels of government and the private sector relative to international, national, regional and civil security.
4. Sophisticated knowledge of offensive and defensive technologies relevant to international, national, regional, and civil security.
5. The quantitative and qualitative research and analysis skills needed to contribute to the security field as practitioners, researchers and educators.
6. The written and verbal skills needed to effectively communicate within the fields of international and civil security.
7. The organizational skills needed to contribute to the security field as practitioners, researchers and educators.
8. The skills to apply appropriate technologies to support national, international, and civil security.
9. Ability to integrate and effectively utilize the theoretical frameworks, knowledge, and skills necessary for contributing to international, national, and civil security.

PROGRAM STRUCTURE AND REQUIREMENTS

Overall Program Structure

The MA ICS program is equivalent to 36 credit hours, distributed as follows: 12 credit hours of Program Core courses, 12 credit hours of Program Elective courses and 12 credit hours of Master's Workshop and Thesis. The core courses cover basic dimensions of both civil security and the broader security context in which civil security planning and policy must occur. Upon completion of the core coursework, students must take an additional four elective courses, two of which may form a specialized Track in Civil Security or Regional Security. If the student elects to complete one of the Tracks, it will be noted on his/her transcript. The components of the MA ICS program are summarized in the table below:

PROGRAM COMPONENT	CREDIT HOURS
Program Core (4 courses)	12
Program Electives (4 courses)	12
Master's Workshop and Thesis	12
Total	**36**

Program Requirements

Students seeking the degree of MA in International and Civil Security must successfully complete 36 credit hours as specified in the program requirements detailed below, with a minimum CGPA of 3.0. Course selection should be made in consultation with the student's Academic Advisor. All courses have a credit rating of three credits each, except the Master's Thesis.

Program Core (12 Credit Hours)

Students must complete the following core courses:

- IICS 601 Introduction to International Relations and Security Issues
- IICS 602 Introduction to Civil Security
- IICS 603 Social Science Research Methods
- IICS 604 Regional Security and Terrorist Threat

Program Electives (12 Credit Hours)

Students must select four courses from the list below:

- IICS 621 Technology and International Security
- IICS 622 Technology and Civil Security
- IICS 623 Regional Security Challenges and Policy Options
- IICS 624 Creating Integrated Civil Security
- IICS 625 Globalization and Middle East Security
- IICS 626 Comparative Civil Security Systems
- IICS 645 Policy Analysis
- IICS 646 Intelligence and National Security
- IICS 647 Exercise Design and Technology
- IICS 648 The Changing Nature of War and Conflict
- IICS 649 Cyber Security Policy, Practice and Implications for Statecraft
- IICS 690 Civil Infrastructure Protection Design
- IICS 691 Nuclear Security

- IICS 692 Computer and Network Security
- IICS 693 Wireless Network and Mobile Security
- IICS 694 Information Security Management
- IICS 695 Independent Study

Program Tracks

Students may organize their elective choices to complete one of the optional Program Tracks, which will be noted on the student's official transcript. The Civil Security Track focuses on preparing current and aspiring civil security professionals. The Regional Security Track aims to prepare current and aspiring policy analysts, as well as senior civilian and military officials.

Civil Security Track (select two courses from the list below):

- IICS 622 Technology and Civil Security
- IICS 624 Creating Integrated Civil Security
- IICS 626 Comparative Civil Security Systems

Regional Security Track (select two courses from the list below):

- IICS 621 Technology and International Security
- IICS 623 Regional Security Challenges and Policy Options
- IICS 625 Globalization and Middle East Security

IICS 698 Thesis Workshop and IICS 699 MASTER'S Thesis (12 Credit Hours)

Students must complete a Master's Thesis that involves creative, research-oriented work within the field of civil or international security, under direct supervision of a full-time faculty advisor from the Institute of International and Civil Security, and at least one other full-time faculty who acts as a co-advisor. The outcome of research should demonstrate the synthesis of information into knowledge in a form that may be used by others. The research findings must be documented in a formal thesis and defended successfully in a viva voce examination.

Students must enroll in IICS 698 Thesis Workshop after passing a minimum of six courses (18 Credit Hours), including the four core courses. The Thesis Workshop is a pre-requisite for IICS 699 Master's Thesis and must be successfully completed before the student can register for thesis credits.

STUDY PLAN

A typical study plan for students enrolled in the MA ICS is shown below. The program is offered on a part-time basis only.

	SEMESTER 1	SEMESTER 2
YEAR 1	IICS 602 Introduction to Civil Security IICS 603 Social Science Research Methods	IICS 601 Introduction to International Relations and Security Issues IICS 604 Regional Security and Terrorist Threat
YEAR 2	Elective Course 1 Elective Course 2	Elective Course 3 IICS 698 Thesis Workshop
YEAR 3	Elective Course 4 IICS 699 Master's Thesis	IICS 699 Master's Thesis

MSC IN APPLIED CHEMISTRY

ABOUT THE PROGRAM

The Master of Science in Applied Chemistry (MSc ACHE) is intended for candidates with a Bachelor degree in chemistry or other related specialization. The program prepares students for successful careers in industry and academia through courses, conferences, seminars, and research. The program is delivered by experienced international faculty who are engaged in various research projects and research opportunities such as biofuel, biochemistry, catalysis, computational modelling, corrosion, material chemistry, nanoparticles, polymer, and wastewater treatment. The MSc ACHE is designed to give students an opportunity to enhance their knowledge of chemistry and develop research expertise and skills in instrumentation and methodology that will prepare them for a career in applied chemistry or the pursuit of a doctorate degree.

PROGRAM EDUCATIONAL OBJECTIVES

The objectives of the MSc in Applied Chemistry program are to:

1. Provide a pool of highly trained professionals who can utilize their acquired knowledge in applied chemistry and skills in instrumentation and methods to contribute to the technical and research expertise of their employer.
2. Prepare graduates with outstanding educational skills and knowledge in applied chemistry and related areas to further their career aspirations.
3. Prepare students with effective communication and teamwork skills in areas related to applied chemistry to function successfully in their careers.
4. Provide students with sufficient expertise in applied chemistry to design and develop innovative solutions to complex scientific problems in the oil and gas industry.
5. Provide students with a quality education in applied chemistry in an academic environment committed to excellence and innovation that fosters leadership, professionalism, life-long learning and successful career.

LEARNING OUTCOMES

MSc in Applied Chemistry graduates will:

1. Be able to apply advanced concepts of fundamental and applied chemistry to the formulation and solution of complex problems in the oil and gas and related industries.
2. Develop and publish results of their research (if satisfactory) in peer-reviewed journals.
3. Have sufficient experience to successfully begin a PhD program in applied chemistry in a recognized university.
4. Be equipped with the knowledge and skills in applied chemistry to meet requirements of appropriate job opportunities at chemical companies.

PROGRAM STRUCTURE AND REQUIREMENTS

Overall Program Structure

The MSc ACHE program is equivalent to 36 credit hours, distributed as follows: 15 credit hours of Core courses, 9 credit hours of Program Elective courses and 12 credit hours of Master's Thesis. The components of the program are summarized in the table below:

PROGRAM COMPONENT	CREDIT HOURS
Program Core (4 courses)	12
CHEM 695 Graduate Seminar I	1
CHEM 696 Graduate Seminar II	1
COMM 601 Technical and Scientific Writing	1
Program Electives (3 courses)	9
Master's Thesis	12
Total	**36**

Program Requirements

Students seeking the degree of MSc in Applied Chemistry must successfully complete 36 credit hours as specified in the program requirements detailed below, with a minimum CGPA of 3.0. Course selection should be made in consultation with the student's Main Advisor. All courses have a credit rating of three credits each, except CHEM 695/696 Graduate Seminar, COMM 601 Technical and Scientific Writing and the Master's Thesis.

Program Core (15 Credit Hours)

Students must complete the following core courses:

- CHEM 625 Applied Organic Chemistry and Instrumental Analysis
- CHEM 655 Petroleum Production and Process Chemistry
- CHEM 668 Corrosion Science and Advanced Physical Chemistry
- CHEM 670 Polymers and Nanomaterials Chemistry
- CHEM 695 Graduate Seminar I
- CHEM 696 Graduate Seminar II
- COMM 601 Technical and Scientific Writing

Program Electives (9 Credit Hours)

Students must select three courses from the list below. Subject to approval, one elective course can be taken from other relevant graduate programs at KU.

- CHEM 620 Computational Chemistry
- CHEM 623 Applied Inorganic Chemistry
- CHEM 630 Advanced Industrial Catalysis
- CHEM 640 Advanced Organometallics and Applications
- CHEM 650 Spectrochemical Studies
- CHEM 660 Environmental Science and Water Technology
- CHEM 665 Fuels and Alternative Energy Sources
- CHEM 666 Construction Chemicals and Green Chemicals

CHEM 699 Master's Thesis (12 Credit Hours)

Students must complete a Master's Thesis that involves creative, research-oriented work within the field of applied chemistry, under direct supervision of a full-time faculty advisor from the Chemistry Department, and at least one other full-time faculty who acts as a co-advisor. The outcome of research should demonstrate the synthesis of information into knowledge in a form that may be used by others. The research findings must be documented in a formal thesis and defended successfully in a viva voce examination.

STUDY PLAN

The following study plan has been designed for students entering the MSc ACHE program at the start of the Fall semester. Most coursework will be completed in the first year and thesis research will be initiated in the first year but completed primarily in the second year of the program.

TYPICAL STUDY PLAN FOR FULL-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	CHEM 670 Polymers & Nanomaterials Chemistry CHEM 668 Corrosion Science & Advanced Physical Chemistry CHEM 695 Graduate Seminar I COMM 601 Technical and Scientific Writing Elective Course 1	CHEM 625 Applied Organic Chemistry & Instrumental Analysis CHEM 695 Graduate Seminar II Elective Course 2 CHEM 699 Master's Thesis
YEAR 2	CHEM 655 Petroleum Production & Process Chemistry Elective Course 3 CHEM 699 Master's Thesis	CHEM 699 Master's Thesis

TYPICAL STUDY PLAN FOR PART-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	CHEM 670 Polymers & Nanomaterials Chemistry CHEM 668 Corrosion Science & Advanced Physical Chemistry COMM 601 Technical and Scientific Writing	CHEM 625 Applied Organic Chemistry & Instrumental Analysis CHEM 655 Petroleum Production & Process Chemistry CHEM 695 Graduate Seminar I
YEAR 2	Elective Course 1 Elective Course 2 CHEM 695 Graduate Seminar II CHEM 699 Master's Thesis	Elective Course 3 CHEM 699 Master's Thesis
YEAR 3	CHEM 699Master's Thesis	CHEM 699 Master's Thesis

MSC IN PETROLEUM GEOSCIENCES

ABOUT THE PROGRAM

Geoscience is the study of the Earth, the oceans, the atmosphere and the Earth's place in the solar system. Geoscientists explore the world around them to address some of the biggest challenges facing society, including securing energy, water and mineral resources, exploring climate change, the environment and natural hazards (volcanoes, landslides and flooding). The Master of Science in Petroleum Geosciences (MSc PGEG) gives students a variety of research opportunities that include studies of both earth surface and deep processes, including geological hazards, environmental geoscience, sedimentology/facies analysis, micropaleontology, bio- and chemo- stratigraphy, seismology, petrology, tectonics, geophysics, and geochemistry.

PROGRAM EDUCATIONAL OBJECTIVES

The objectives of the MSc in Petroleum Geosciences program are to:

1. Provide graduates with an outstanding education and the research skills required to further their careers.
2. Prepare graduates for further education in PhD programs.
3. Provide the oil and gas industry with highly educated personnel who can utilize their technical knowledge and skills to increase value of petroleum assets and to develop petroleum industry business opportunities.
4. Advance the technological skill base of E & P sponsor companies, the UAE, and the regional oil and gas industry.
5. Raise the overall educational environment of the UAE through publication of scholarly work.

LEARNING OUTCOMES

MSc in Petroleum Geosciences graduates will:

1. Be able to successfully apply advanced and current concepts and methods of the geosciences to formulate and solve complex petroleum geosciences problems.
2. Be able to plan and complete a research project within a reasonable time frame by integrating knowledge and methods from different disciplines of the petroleum geosciences and using appropriately selected research methods.
3. Demonstrate an ability to communicate complex scientific problems in oral and written forms in English appropriate to the petroleum and broad energy industry.
4. Demonstrate self-direction and time management when working independently.
5. Work effectively and professionally in multidisciplinary teams, as a member and a leader.
6. Be able to manage and analyze complex ethical issues.

PROGRAM STRUCTURE AND REQUIREMENTS

Overall Program Structure

The MSc PGEG program consists of a minimum 35 credit hours, distributed as follows: 15 credit hours of Program Core courses, 8 credit hours of Program Elective courses and 12 credit hours of Master's Thesis. The components of the program are summarized in the table below:

PROGRAM COMPONENT	CREDIT HOURS
Program Core (3 courses)	12
PGEG 695 Graduate Seminar I	1
PGEG 696 Graduate Seminar II	1
COMM 601 Technical and Scientific Writing	1
Program Electives (2 courses)	8
Master's Thesis	12
Total	**35**

Program Requirements

Students seeking the degree of MSc in Petroleum Geosciences must successfully complete a minimum 35 credit hours as specified in the program requirements detailed below, with a minimum CGPA of 3.0. Course selection should be made in consultation with the student's Main Advisor.

Program Core (15 Credit Hours)

Students must complete the following core courses:

- PGEG 611 Carbonate Reservoir Petrology
- PGEG 612 Sequence Stratigraphy of Carbonate Systems
- PGEG 613 Advanced Reservoir Characterization
- PGEG 695 Graduate Seminar I
- PGEG 696 Graduate Seminar II
- COMM 601 Technical and Scientific Writing

Program Electives (8 Credit Hours)

Students must select two courses from the list below. Subject to approval, elective courses can be taken from PGEG 700-level courses offered in the Petroleum Geosciences PhD program or other relevant graduate programs at KU.

- PGEG 623 Remote Sensing for Earth Sciences Applications and GIS
- PGEG 689 Special Topics in Petroleum Geosciences
- PEEG 630 Advanced Reservoir Engineering
- PEEG 650 Advanced Petroleum Economics

PGEG 699 Master's Thesis (12 Credit Hours)

Students must complete a Master's Thesis that involves creative, research-oriented work within the field of petroleum geosciences, under direct supervision of a full-time faculty advisor from the Petroleum Geosciences Department, and at least one other full-time faculty who acts as a co-advisor. The outcome of research should demonstrate the synthesis of information into knowledge in a form that may be used by others. The research findings must be documented in a formal thesis and defended successfully in a viva voce examination.

STUDY PLAN

A typical study plan for students enrolled in the MSc PGEG is shown below.

TYPICAL STUDY PLAN FOR FULL-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	PGEG 611 Carbonate Reservoir Petrology PGEG 612 Sequence Stratigraphy of Carbonate Systems COMM 601 Technical and Scientific Writing PGEG 695 Graduate Seminar I PGEG 699 Master's Thesis	PGEG 613 Advanced Reservoir Characterization PGEG 696 Graduate Seminar II PGEG 699 Master's Thesis
YEAR 2	Elective Course 1	PGEG 699 Master's Thesis Elective Course 2

TYPICAL STUDY PLAN FOR PART-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	PGEG 611 Carbonate Reservoir Petrology COMM 601 Technical and Scientific Writing PGEG 695 Graduate Seminar I	PGEG 612 Sequence Stratigraphy of Carbonate Systems PGEG 696 Graduate Seminar II
YEAR 2	PGEG 613 Advanced Reservoir Characterization PGEG 699 Master's Thesis	Elective Course 1 PGEG 699 Master's Thesis
YEAR 3	Elective Course 2 PGEG 699 Master's Thesis	PGEG 699 Master's Thesis

PHD IN PETROLEUM GEOSCIENCES

ABOUT THE PROGRAM

Geoscience is the study of the Earth, the oceans, the atmosphere and the Earth's place in the solar system. Geoscientists explore the world around them to address some of the biggest challenges facing society, including securing energy, water and mineral resources, exploring climate change, the environment and natural hazards (volcanoes, landslides and flooding). Doctor of Philosophy in Petroleum Geosciences (PhD PGEG) students will gain a broad perspective on Earth processes as well as a research specialization in a specific discipline within the geosciences.

PROGRAM EDUCATIONAL OBJECTIVES

The objectives of the PhD in Petroleum Geosciences program are to:

1. Stimulate research and development to foster innovative solutions to challenges in science, technology, and engineering.
2. Develop the next generation of leaders in academia to drive a knowledge economy in the UAE.
3. Advance the technological profile of the UAE and the regional oil and gas industry.
4. Produce graduates who contribute to the advancement of leading-edge knowledge across multiple engineering and sciences disciplines.
5. Produce graduates who direct original research and disseminate knowledge to a variety of audiences.
6. Produce graduates who provide active and exceptional service to the profession and the society at large.

LEARNING OUTCOMES

PhD in Petroleum Geosciences graduates will possess the knowledge, skills, and aspects of competence listed below:

1. An ability to recognize, evaluate, interpret, and understand issues and opportunities at the frontiers of knowledge.
2. An ability to integrate and apply knowledge across disciplinary boundaries in order to create new knowledge.
3. An ability to conduct independent original research that results in significant contribution to knowledge in the field.
4. The competencies necessary to disseminate knowledge and research findings in a variety of formats to the scientific community and public at large.
5. A propensity to engage in life-long learning and self-development in their field as a way of contributing to its future advancement.
6. A commitment to ethical behavior in research and professional activities.
7. The skills required to manage effectively in a multidisciplinary collaborative environment.

PROGRAM STRUCTURE AND REQUIREMENTS

Overall Program Structure

The PhD PGEG program consists of a minimum 60 credit hours, distributed as follows: 24 credit hours of coursework, 36 credit hours of PhD Dissertation and two zero credit PhD Seminar courses. The components of the program are summarized in the table below:

PROGRAM COMPONENT	CREDIT HOURS
PGEG 700 Research Methods	3
PGEG 795 Graduate Seminar I	0
PGEG 796 Graduate Seminar II	0
PGEG 797 PhD Written Qualifying Exam (WQE)	0
PGEG 798 PhD Oral Qualifying Exam (OQE)	0
Program Core (2 courses)	6
Program Electives (5 courses)	15
PGEG 799 PhD Research Dissertation	36
Total	**60**

Program Requirements

Students seeking the degree of PhD in Petroleum Geosciences must successfully complete a minimum 60 credit hours as specified in the program requirements detailed below, with a minimum CGPA of 3.0. Course selection should be made in consultation with the student's Main Advisor.

Program Core (9 Credit Hours)

Students must complete the following core courses:

- PGEG 700 Research Methods
- PGEG 701 Petroleum Systems
- PGEG 795 Graduate Seminar I
- PGEG 796 Graduate Seminar II
- PGEG 797 PhD Written Qualifying Exam (WQE)
- PGEG 798 PhD Oral Qualifying Exam (OQE)

In addition, students must complete one of the two courses listed below:

- PGEG 702 Lab Techniques in Sedimentology and Geochemistry; or
- PGEG 703 Lab and Field Techniques in Geophysics

Program Electives (15 Credit Hours)

Students must complete five elective courses from the list below. Subject to approval, up to three electives may be taken from other relevant graduate programs at KU.

- PGEG 711 Carbonate Petrology and Stratigraphy
- PGEG 712 Field Geology of Petroleum Systems
- PGEG 713 Rock Physics
- PGEG 714 Seismic Interpretation in Petroleum Exploration and Production
- PGEG 715 Seismic Modeling and Imaging
- PGEG 718 Biogeochemical Cycles
- PGEG 719 Deformation and Structures of Sedimentary Rocks
- PGEG 720 Organic Geochemistry
- PGEG 721 Sedimentary Basin Analysis
- PGEG 722 Shared Earth Models
- PGEG 723 Isotope Geochemistry of Sedimentary Systems
- PGEG 793 Special Topics in Petroleum Geosciences

PGEG 799 PhD Research Dissertation (36 Credit Hours)

Students must complete a Dissertation that involves creative, research-oriented work within the field of petroleum geosciences, under direct supervision of a full-time faculty advisor from the Petroleum Geosciences Department, and at least one other full-time faculty who acts as a co-advisor. The outcome of research should demonstrate the synthesis of information into knowledge in a form that may be used by others. The research findings must be documented in a formal dissertation and defended successfully in a viva voce examination.

STUDY PLAN

A typical study plan for students enrolled in the PhD PGEG is shown below.

TYPICAL STUDY PLAN FOR FULL-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	PGEG 700 Research Methods PGEG 795 Graduate Seminar I PGEG 701 Petroleum Systems Elective Course 1	PGEG 796 Graduate Seminar II PGEG 702 or PGEG 703 Lab Techniques Elective Course 2 PGEG 797 PhD Written Qualifying Exam (WQE) PGEG 799 PhD Research Dissertation
YEAR 2	Elective Course 3 Elective Course 4 PGEG 799 PhD Research Dissertation	Elective Course 5 PGEG 798 PhD Oral Qualifying Exam (OQE) PGEG 799 PhD Research Dissertation
YEAR 3	PGEG 799 PhD Research Dissertation	PGEG 799 PhD Research Dissertation
YEAR 4	PGEG 799 PhD Research Dissertation	PGEG 799 PhD Research Dissertation PhD Research Dissertation Examination

GRADUATE PROGRAMS

COLLEGE OF ENGINEERING

MSC IN BIOMEDICAL ENGINEERING

ABOUT THE PROGRAM

The Master of Science in Biomedical Engineering (MSc BMED) program has the following main characteristics:

- Advanced Biomedical Engineering
- Clinical and Molecular Diagnostic and Therapeutic Systems
- Healthcare Innovation, Leadership and Management
- Specialized professional courses, such as Computational Biomechanics, Advanced Biosignals, Advanced Rehabilitation Engineering, Biorobotics and Algorithms in Bioinformatics, as well as the important Healthcare Leadership, Innovation and Management courses.

The degree caters to recent graduates who would like to pursue a Master's qualification before going to industry, enrolling in a professional program, such as medicine, or continuing their graduate studies at the PhD level. The program also targets engineers in full-time employment who wish to advance their knowledge base and enhance their career progression prospects.

PROGRAM EDUCATIONAL OBJECTIVES

The objectives of the MSc in Biomedical Engineering program are to produce graduates who:

1. Are able to apply their training on the interface of engineering, medicine and science in an ethical, creative, and innovative manner to solve problems related to health and healthcare that are locally and globally relevant.
2. Are recognized as leaders in their respective careers in biomedical engineering in industry, hospitals and clinical practice, government, and academia.
3. Engage in life-long learning by continuing their education in graduate or professional schools or through career development and professional training.

LEARNING OUTCOMES

MSc in Biomedical Engineering graduates will be able to:

1. Identify, formulate, and solve advanced biomedical engineering and science problems and apply current engineering and science tools and techniques.
2. Conduct interdisciplinary research; design and conduct experiments, manage, analyze, interpret data and disseminate research results.
3. Function in team environments and communicate effectively with engineering, medical and science stakeholders and communities.
4. Acquire knowledge of contemporary issues in the fields of biomedical engineering, science and medicine and develop an aptitude for innovation and entrepreneurship.
5. Understand and apply professional and ethical standards in local and global frameworks.

PROGRAM STRUCTURE AND REQUIREMENTS

Overall Program Structure

The MSc BMED consists of a minimum 36 credit hours, distributed as follows: 12 credit hours of Program Core courses, 12 credit hours of Elective courses, 12 credit hours of Master's Thesis and a zero credit Research Methods course. The components of the program are summarized in the table below:

PROGRAM COMPONENT	CREDIT HOURS
ENGR 695 Seminar in Research Methods	0
Program Core	12
Program Electives	12
BMED 699 Master's Thesis	12
Total	**36**

Program Requirements

Students seeking the degree of MSc in Biomedical Engineering must successfully complete a minimum 36 credit hours as specified in the program requirements detailed below, with a minimum CGPA of 3.0. Course selection should be made in consultation with the student's Main Advisor. All courses have a credit rating of three credits each, except ENGR 695 Seminar in Research Methods and the Master's Thesis.

PROGRAM CORE (12 CREDIT HOURS)

Students must complete the following core courses.

- ENGR 695 Seminar in Research Methods
- BMED 600 Physiological Systems
- BMED 601 Experimental Biochemistry
- BMED 602 / EMSA 617 Innovation and Creativity in Technology Organizations
- BMED 603 Multivariate Data Analysis

PROGRAM ELECTIVES (12 CREDIT HOURS)

- Students must select any four elective courses from the list below. Subject to Main Advisor approval, up to two elective courses (6 credit hours) can be taken from other MSc programs in the College of Engineering at KU.
- BMED 611 Clinical Pathology
- BMED 612 Molecular Genetics and Genome Technologies
- BMED 620 Cognitive and Computational Neuroscience
- BMED 631 Advanced Biosignal Processing
- BMED 632 Physiological Control Systems
- BMED 633 Advanced Rehabilitation Engineering
- BMED 634 / COSC 620 Algorithms in Bioinformatics
- BMED 635 / ESMA 673 Healthcare Information Systems
- BMED 640 Biomaterials for Drug Delivery
- BMED 694 Selected Topics in Biomedical Engineering
- ENGR 602 Engineering Numerical Methods

BMED 699 MASTER'S THESIS (MINIMUM 12 CREDIT HOURS)

Students must complete a Master's Thesis that involves creative, research-oriented work within the broad field of biomedical engineering, under the direct supervision of a full-time faculty advisor from the Biomedical Engineering Department, and at least one other full-time faculty who acts as a co-advisor. The outcome of research should demonstrate the synthesis of information into knowledge in a form that may be used by others. The research findings must be documented in a formal thesis and defended successfully in a viva voce examination. Furthermore, the research should lead to publishable quality scholarly articles.

STUDY PLAN

A typical study plan for students enrolled in the MSc BMED is shown below.

TYPICAL STUDY PLAN FOR FULL-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods Program Core Course 1 Program Core Course 2 Elective Course 1	Program Core Course 3 Program Core Course 4 BMED 699 Master's Thesis
YEAR 2	Elective Course 2 Elective Course 3 BMED 699 Master's Thesis	Elective Course 4 BMED 699 Master's Thesis

TYPICAL STUDY PLAN FOR PART-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods Program Core Course 1 Program Core Course 2	Program Core Course 3 Program Core Course 4
YEAR 2	Elective Course 1 BMED 699 Master's Thesis	Elective Course 2 BMED 699 Master's Thesis
YEAR 3	Elective Course 3 BMED 699 Master's Thesis	Elective Course 4 BMED 699 Master's Thesis

MSC IN CHEMICAL ENGINEERING

ABOUT THE PROGRAM

The Master of Science in Chemical Engineering (MSc CHEG) is an exciting research-led program, with a wide range of courses and a significant research component that provides an in-depth grounding in the various aspects of the broad field of chemical engineering. The program is delivered by experienced international faculty who are actively engaged in cutting-edge research. The MSc CHEG provides excellent training for those aiming to pursue a career in industry and academia as well as research and development.

PROGRAM EDUCATIONAL OBJECTIVES

The objectives of the MSc in Chemical Engineering program are to produce graduates who:

1. Advance professionally and are recognized as leaders in their chosen fields.
2. Apply their technical expertise to address the needs of society in critical, creative, ethical, and innovative manner.
3. Further develop their knowledge and skills through graduate education and professional schools.

LEARNING OUTCOMES

MSc in Chemical Engineering graduates will be able to:

1. Demonstrate advanced knowledge of sciences (mathematics, physics, chemistry) and engineering.
2. Understand and carry out safe and economic design of chemical engineering processes and systems fulfilling environmental and societal constraints.
3. Design and conduct theoretical and/or experimental work, as well as analyze and interpret data.
4. Identify, formulate, analyze and solve chemical engineering problems by applying knowledge of chemical engineering concepts.
5. Use computational and process simulation tools necessary for chemical engineering practice.
6. Communicate effectively and professionally in English (both oral and in writing).
7. Function autonomously and take responsibility for managing professional practices, work, processes or systems. Demonstrate an awareness and understanding of contemporary environmental and social issues in the regional and global context.
8. Inculcate a passion for life-long learning and self-education; learn from experiences gained in different contexts and apply new knowledge and skills into practice; demonstrate professional integrity and ethical responsibility.
9. Take responsibility and act to formulate creative solutions to complex problems.

PROGRAM STRUCTURE AND REQUIREMENTS

Overall Program Structure

The MSc CHEG consists of a minimum 36 credit hours, distributed as follows: 12 credit hours of Program Core courses, 12 credit hours of Program Elective courses, 12 credit hours of Master's Thesis and a zero credit Research Methods course. Students may organize the selection of elective courses relevant to the Master's Thesis topic with the consent of the Main Advisor. The components of the program are summarized in the table below:

PROGRAM COMPONENT	CREDIT HOURS
ENGR 695 Seminar in Research Methods	0
Program Core	12
Program Electives	12
CHEG 699 Master's Thesis	12
Total	**36**

Program Requirements

Students seeking the degree of MSc in Chemical Engineering must successfully complete a minimum 36 credit hours as specified in the program requirements detailed below, with a minimum CGPA of 3.0. Course selection should be made in consultation with the student's Main Advisor. All courses have a credit rating of three credits each, except ENGR 695 Seminar in Research Methods and the Master's Thesis.

Program Core (12 Credit Hours)

Students must complete the following core courses:

- ENGR 695 Seminar in Research Methods
- CHEG 610 Advanced Chemical Reaction Engineering
- CHEG 620 Mathematical Methods in Chemical Engineering
- CHEG 630 Advanced Chemical Engineering Thermodynamics
- CHEG 640 Transport Phenomena

Program Electives (12 Credit Hours)

Students must select four courses from the list below. Subject to approval of the Main Advisor, students can also select up to two elective courses (6 Credit Hours) from other MSc programs in the College of Engineering at KU.

- CHEG 604 / WENV 604 Desalination
- CHEG 606 / WENV 606 Wastewater Treatment Engineering
- CHEG 611 Polymer Reaction Engineering
- CHEG 621 Numerical Methods in Chemical Engineering
- CHEG 622 Process Simulation and Optimization
- CHEG 623 Systems Engineering
- CHEG 631 Statistical Thermodynamics
- CHEG 641 Multiphase Flow
- CHEG 642 Separation Processes
- CHEG 643 Colloids and Interfacial Science
- CHEG 644 Consequence Analysis of Chemical Releases
- CHEG 651 Combustion and Air Pollution Control
- CHEG 652 Advanced Process Control
- CHEG 653 Sustainable Energy Conversion Processes
- CHEG 654 Chemical Process Safety
- CHEG 655 Air Quality Management
- CHEG 656 Experimental Design
- CHEG 657 Materials Engineering and Corrosion
- CHEG 658 Polymer Properties and Processing
- CHEG 659 Engineering Design for Process Safety
- CHEG 694 Selected Topics in Chemical Engineering

CHEG 699 Master's Thesis (Minimum 12 Credit Hours)

Students must complete a Master's Thesis that involves creative, research-oriented work within the broad field of chemical engineering, under the direct supervision of a full-time faculty advisor from the Chemical Engineering Department, and at least one other full-time faculty who acts as a co-advisor.

The outcome of research should demonstrate the synthesis of information into knowledge in a form that may be used by others. The research findings must be documented in a formal thesis and defended successfully in a viva voce examination. Furthermore, the research should lead to publishable quality scholarly articles.

STUDY PLAN

A typical study plan for students enrolled in the MSc CHEG is shown below.

TYPICAL STUDY PLAN FOR FULL-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods Program Core Course 1 Program Core Course 2 Elective Course 1	Program Core Course 3 Program Core Course 4 Elective Course 2 CHEG 699 Master's Thesis
YEAR 2	Elective Course 3 Elective Course 4 CHEG 699 Master's Thesis	CHEG 699 Master's Thesis

TYPICAL STUDY PLAN FOR PART-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods Program Core Course 1 Program Core Course 2	Program Core Course 3 Program Core Course 4
YEAR 2	Elective Course 1 CHEG 699 Master's Thesis	Elective Course 2 CHEG 699 Master's Thesis
YEAR 3	Elective Course 3 CHEG 699 Master's Thesis	Elective Course 4 CHEG 699 Master's Thesis

MSC IN CIVIL AND INFRASTRUCTURAL ENGINEERING

ABOUT THE PROGRAM

The Master of Science in Civil and Infrastructural Engineering (MSc CIVE) is an exciting research-led program, with a wide range of courses and a significant research component that provides an in-depth grounding in the various aspects of the broad field of civil engineering. The program is delivered by experienced international faculty and candidates for this degree are expected to demonstrate initiative and innovation in their work.

PROGRAM EDUCATIONAL OBJECTIVES

The objectives of the MSc in Civil and Infrastructural Engineering program are to produce graduates who:

1. Are able to apply their training on the interface of engineering and science in an ethical, creative and innovative manner to solve problems related to civil and infrastructural engineering that are locally and globally relevant.
2. Are recognized as leaders in their respective careers in civil and infrastructural engineering in industry, government and academia.
3. Engage in life-long learning by continuing their education by enrolling in PhD programs or through career development and professional training.

LEARNING OUTCOMES

MSc in Civil and Infrastructural Engineering graduates will be able to:

1. Identify, formulate, and solve advanced civil and infrastructural engineering problems and apply current engineering and science tools and techniques.
2. Conduct interdisciplinary research and design, conduct experiments, manage, analyze, interpret data and disseminate research results.
3. Function in team environments and communicate effectively with engineering and science stakeholders and communities.
4. Acquire knowledge of contemporary issues in the fields of civil and infrastructural engineering.
5. Understand and apply professional and ethical standards in local and global frameworks.

PROGRAM STRUCTURE AND REQUIREMENTS

Overall Program Structure

The MSc CIVE consists of a minimum 36 credit hours, distributed as follows: 12 credit hours of Program Core courses, 12 credit hours of Program Elective courses, 12 credit hours of Master's Thesis and a zero credit Research Methods course. Students may organize the selection of elective courses relevant to the Master's Thesis topic with the consent of the Main Advisor. The components of the program are summarized in the table below:

PROGRAM COMPONENT	CREDIT HOURS
ENGR 695 Seminar in Research Methods	0
Program Core	12
Program Electives	12
CIVE 699 Master's Thesis	12
Total	36

Program Requirements

Students seeking the degree of MSc in Civil and Infrastructural Engineering must successfully complete a minimum 36 credit hours as specified in the program requirements detailed below, with a minimum CGPA of 3.0. Course selection should be made in consultation with the student's Main Advisor. All courses have a credit rating of three credits each, except ENGR 695 Seminar in Research Methods and the Master's Thesis.

Program Core (12 Credit Hours)

Students must complete the following core courses:

- ENGR 695 Seminar in Research Methods
- CIVE 630 Tensors Algebra and Applications
- CIVE 631 Dynamic Response of Civil Engineering Constructions
- CIVE 632 Highrise Building Design
- CIVE 650 Construction Cost Estimating

Program Electives (12 Credit Hours)

Students must select four courses from the list below. Subject to approval of the Main Advisor, students can also select up to two elective courses (6 Credit Hours) from other MSc programs in the College of Engineering at KU.

- CIVE 634 Design of Civil Engineering Structures for Fire Protection
- CIVE 635 Railway Geotechnics
- CIVE 636 Wind Effects on Structures
- CIVE 637 Pavement Monitoring and Rehabilitation
- CIVE 638 Transportation Systems
- CIVE 640 Soil Structure Interaction
- CIVE 641 Coastal Engineering
- CIVE 651 Sustainable Building Construction
- CIVE 652 Construction Safety
- CIVE 694 Selected Topics in Civil and Infrastructural Engineering

CIVE 699 Master's Thesis (Minimum 12 Credit Hours)

Students must complete a Master's Thesis that involves creative, research-oriented work within the broad field of civil/infrastructural engineering, under the direct supervision of a full-time faculty advisor from the Civil Infrastructure and Environmental Engineering Department, and at least one other full-time faculty who acts as a co-advisor.

The outcome of research should demonstrate the synthesis of information into knowledge in a form that may be used by others. The research findings must be documented in a formal thesis and defended successfully in a viva voce examination. Furthermore, the research should lead to publishable quality scholarly articles.

STUDY PLAN

A typical study plan for students enrolled in the MSc CIVE is shown below.

TYPICAL STUDY PLAN FOR FULL-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods CIVE 630 Tensors Algebra and Applications CIVE 650 Construction Cost Estimating Program Elective Course 1	CIVE 631 Dynamic Response of Civil Engineering Constructions Program Elective Course 2 Program Elective Course 3 CIVE 699 Master's Thesis
YEAR 2	CIVE 632 Highrise Building Design Program Elective Course 4 CIVE 699 Master's Thesis	CIVE 699 Master's Thesis

TYPICAL STUDY PLAN FOR PART-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods CIVE 630 Tensors Algebra and Applications CIVE 650 Construction Cost Estimating	CIVE 631 Dynamic Response of Civil Engineering Constructions Program Elective Course 1
YEAR 2	CIVE 632 Highrise Building Design Program Elective Course 2	Program Elective Course 3 CIVE 699 Master's Thesis
YEAR 3	Program Elective Course 4 CIVE 699 Master's Thesis	CIVE 699 Master's Thesis

MSC IN COMPUTER SCIENCE

ABOUT THE PROGRAM

The Master of Science in Computer Science (MSc COSC) follows an in-depth, balanced approach to both fundamental and advanced aspects of Computer Science such as Algorithms, Software Engineering, Artificial Intelligence and Data Science. A wide variety of courses will offer opportunities to specialize on state-of-the-art competencies such as Data Mining, Machine Learning, Information Security and Bioinformatics.

PROGRAM EDUCATIONAL OBJECTIVES

The objectives of the MSc in Computer Science program are to produce graduates who:

1. Advance professionally and be recognized as leaders in their chosen fields.
2. Apply their technical expertise to address the needs of society in critical, creative, ethical, and innovative manner.
3. Further develop their knowledge and skills through graduate education and professional schools.

LEARNING OUTCOMES

MSc in Computer Science graduates will be able to:

1. Identify, formulate, and solve advanced computer and information systems problems through the application of modern tools as well as techniques and advanced knowledge of mathematics and science.
2. Acquire knowledge of contemporary issues in the field of computer science.
3. Design and conduct experiments, as well as analyze and interpret data and make decisions.
4. Conduct research and document and defend the research results.
5. Function on teams and communicate effectively.
6. Conduct themselves in a professional and ethical manner.

PROGRAM STRUCTURE AND REQUIREMENTS

Overall Program Structure

The MSc COSC program is equivalent to 36 credit hours, distributed as follows: 12 credit hours of Program Core courses, 12 credit hours of Program Elective courses and 12 credit hours of Master's Thesis. The components of the program are summarized in the table below:

PROGRAM COMPONENT	CREDIT HOURS
ENGR 695 Seminar in Research Methods	0
Program Core	12
Program Electives	12
Master's Thesis	12
Total	36

Program Requirements

Students seeking the degree of MSc in Computer Science must successfully complete 36 credit hours as specified in the program requirements detailed below, with a minimum CGPA of 3.0. Course selection should be made in consultation with the student's Main Advisor. All courses have a credit rating of three credits each, except the Master's Thesis.

Program Core (12 Credit Hours)

Students must complete the following core courses:

- ENGR 695 Seminar in Research Methods (0 credits)
- Select at least one Engineering Mathematics Core course from the list below (3 credits):
  - ENGR 602 Engineering Numerical Methods
  - ENGR 605 Systems Optimization
- Select at least three COSC Core courses from the list below (9 credits):
  - COSC 602 Software Engineering
  - COSC 604 Artificial Intelligence
  - COSC 607 Algorithm Design Techniques
  - COSC 608 Distributed Computer Systems and Cloud Computing
  - COSC/ECCE 632 Advanced Operating Systems

Program Electives (12 Credit Hours)

Students must select four courses from the list below, or from any core courses listed above that are not used to meet the Program Core requirement. Subject to approval of the Main Advisor, students can select up to two elective courses (6 Credit Hours) from other MSc programs in the College of Engineering at KU.

- COSC 603 Multi-Agent Systems
- COSC 605 Strategic Requirements Engineering
- COSC 606 Machine Learning
- COSC 620 Algorithms in Bioinformatics
- COSC 621 Data Science
- COSC/ECCE 631 Blockchain Fundamentals and Applications
- COSC/ECCE 635 Deep Learning System Design
- COSC/ECCE 636 Human Computer Interaction
- COSC/ECCE 637 Parallel Programming
- COSC/CSEC 638 Artificial Intelligence Techniques for Cyber-Security
- COSC 694 Selected Topics in Computer Science

COSC 699 Master's Thesis (Minimum 12 Credit Hours)

Students must complete a Master's Thesis that involves creative, research-oriented work within the field of computing and information systems, under direct supervision of a faculty advisor from the Electrical Engineering and Computer Science Department, and at least one other full-time faculty who acts as a co-advisor.

The outcome of research should demonstrate the synthesis of information into knowledge in a form that may be used by others. The research findings must be documented in a formal thesis and defended successfully in a viva voce examination. Furthermore, the research should lead to publishable quality scholarly articles.

CONCENTRATION IN SPACE SYSTEMS AND TECHNOLOGY

The Space Systems and Technology concentration is part of a collaboration with satellite industry leaders Yahsat and Orbital ATK. The objective of this concentration is to foster advanced research areas in space science and technology for the development of the UAE national space program and provide the space industry with human resources and infrastructure.

In addition to program specific core courses, students who opt for the Space Systems and Technology concentration must complete all four spacecraft core courses (9 Credit Hours) and a thesis that includes challenges and scientific research opportunities in space science and technology. Students will also engage in designing, building, integration, testing and operation of a small satellite such as a CubeSat.

The Space Systems and Technology concentration core courses are:

- SSCC 601 Spacecraft Systems and Design (3 credits)
- SSCC 602 Spacecraft Systems Lab 1 (2 credits)
- SSCC 603 Spacecraft Systems Lab 2 (2 credits)
- SSCC 604 Spacecraft Systems Lab 3 (2 credits)

Note that a student who opts for the Space Systems and Technology concentration should take SSCC 601 in the first semester of study. This will allow the student to complete the sequence of laboratory-based courses (SSCC 602, 603 and 604), which take the place of program electives. The concentration will be specified on the student's official transcript.

CONCENTRATION IN ARTIFICIAL INTELLIGENCE

In addition to program specific core courses, students who opt for the Artificial Intelligence concentration must complete a minimum of three courses (9 Credit Hours) from the list below and a thesis in the general domain of artificial intelligence. The concentration will be specified on the student's official transcript.

- COSC 603 Multi-agent Systems (3 credits)
- COSC 606 Machine Learning (3 credits)
- COSC 621 Data Science (3 credits)
- COSC/ECCE 635 Deep Learning System Design (3 credits)
- COSEC/CSEC 638 Artificial Intelligence Techniques for Cyber-Security (3 credits)

STUDY PLAN

A typical study plan for students enrolled in the MSc COSC is shown below.

TYPICAL STUDY PLAN FOR FULL-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods Engineering Mathematics Core Course Program Core Course 1 Program Core Course 2	Program Core Course 3 Elective Course 1 COSC 699 Master's Thesis
YEAR 2	Elective Course 2 Elective Course 3 COSC 699 Master's Thesis	Elective Course 4 COSC 699 Master's Thesis

TYPICAL STUDY PLAN FOR PART-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods Program Core Course 1 Program Core Course 2	Engineering Mathematics Core Course Program Core Course 3
YEAR 2	Elective Course 1 COSC 699 Master's Thesis	Elective Course 2 COSC 699 Master's Thesis
YEAR 3	Elective Course 3 COSC 699 Master's Thesis	Elective Course 4 COSC 699 Master's Thesis

MSC IN CYBER SECURITY

ABOUT THE PROGRAM

The Master of Science in Cyber Security (MSc CSEC) program targets students with diverse backgrounds, including graduates of Computer Science, Computer Engineering, Electronic Engineering, Communication Engineering, Information Technology, Mathematics, or other pertinent specializations. The program is designed to develop the student's ability to think critically and make informed decisions when it comes to infrastructure attacks on company's hardware and software. Students will be trained in how to assess the level of risk within an enterprise and to improve its security.

PROGRAM EDUCATIONAL OBJECTIVES

The objectives of the MSc in Cyber Security program are to produce graduates who:

1. Advance professionally and be recognized as leaders in their field.
2. Apply their technical expertise to address the needs of society in critical, creative, ethical, and innovative manner.
3. Further develop their knowledge and skills through graduate education and professional schools.

LEARNING OUTCOMES

MSc in Cyber Security graduates will be able to:

1. Identify, formulate, and solve advanced Cyber Security problems through the application of modern tools and techniques and advanced knowledge of mathematics and science.
2. Acquire, review and integrate knowledge of contemporary issues in the field of Cyber Security, developing autonomous judgements.
3. Design and conduct experiments, taking responsibility of interpreting results and making decisions based on them.
4. Conduct research projects, document the research methodology and defend the project outcome.
5. Manage individual activities and lead team work in Cyber Security professional context.
6. Consistently and sensibly manage ethical issues emerging in professional activities.

PROGRAM STRUCTURE AND REQUIREMENTS

Overall Program Structure

The MSc CSEC consists of a minimum 36 credit hours, distributed as follows: 12 credit hours of Program Core courses, 12 credit hours of Elective courses, 12 credit hours of Master's Thesis and a zero credit Research Methods course. The components of the program are summarized in the table below:

PROGRAM COMPONENT	CREDIT HOURS
ENGR 695 Seminar in Research Methods	0
Program Core	12
Program Electives	12
CSEC 699 Master's Thesis	12
Total	**36**

Program Requirements

Students seeking the degree of MSc in Cyber Security must successfully complete a minimum 36 credit hours as specified in the program requirements detailed below, with a minimum CGPA of 3.0. Course selection should be made in consultation with the student's Main Advisor. All courses have a credit rating of three credits each, except ENGR 695 Seminar in Research Methods and the Master's Thesis.

Program Core (12 Credit Hours)

Students must complete the following core courses:

- ENGR 695 Seminar in Research Methods (0 credits)
- CSEC 601 Cyber Physical Systems Security (3 credits)
- CSEC 602 Modern Cryptography (3 credits)
- CSEC 603 Secure Software Systems Engineering (3 credits)
- CSEC 604 Cyber-security Threats and Mitigation (3 credits)

Program Electives (12 Credit Hours)

Students must select four courses from the list below. Subject to approval of the Main Advisor, students can select up to two elective courses (6 Credit Hours) from other MSc programs in the College of Engineering at KU.

- CSEC 615 Cloud and Mobile Digital Forensics
- CSEC 618 Wireless Network and Mobile Security
- CSEC 620 Social Engineering and Human Hacking
- CSEC 621 Hardware and System Architecture Security
- CSEC 622 Penetration Testing
- COSC/CSEC 638 Artificial Intelligence Techniques for Cyber Security
- CSEC 640 Financial Cyber Security
- CSEC 694 Selected Topics in Cyber Security

CSEC 699 Master's Thesis (Minimum 12 Credit Hours)

Students must complete a Master's Thesis that involves creative, research-oriented work within the broad field of Cyber Security, under the direct supervision of a full-time faculty advisor from the Electrical Engineering and Computer Science Department, and at least one other full-time faculty who acts as a co-advisor. The outcome of research should demonstrate the synthesis of information into knowledge in a form that may be used by others. The research findings must be documented in a formal thesis and defended successfully in a viva voce examination. Furthermore, the research should lead to publishable quality scholarly articles.

STUDY PLAN

A typical study plan for students enrolled in the MSc CSEC is shown below.

TYPICAL STUDY PLAN FOR FULL-TIME STUDENTS		
	SEMESTER 1	SEMESTER 2
YEAR 1	ENGR 695 Seminar in Research Methods Program Core Course 1 Program Core Course 2 Program Core Course 3	Program Core Course 4 Elective Course 1 CSEC 699 Master's Thesis
YEAR 2	Elective Course 2 Elective Course 3 CSEC 699 Master's Thesis	Elective Course 4 CSEC 699 Master's Thesis

TYPICAL STUDY PLAN FOR PART-TIME STUDENTS		
	SEMESTER 1	SEMESTER 2
YEAR 1	ENGR 695 Seminar in Research Methods Program Core Course 1 Program Core Course 2	Program Core Course 3 Program Core Course 4
YEAR 2	Elective Course 1 CSEC 699 Master's Thesis	Elective Course 2 CSEC 699 Master's Thesis
YEAR 3	Elective Course 3 CSEC 699 Master's Thesis	Elective Course 4 CSEC 699 Master's Thesis

MSC IN ELECTRICAL AND COMPUTER ENGINEERING

ABOUT THE PROGRAM

The Master of Science in Electrical and Computer Engineering (MSc ECE) is an exciting research-led program, with a wide range of courses and a significant research component that provides an in-depth grounding in the various aspects of the broad field of electrical and computer engineering. The program is delivered by experienced international faculty who are actively engaged in cutting-edge research. The MSc ECE program provides excellent training for those aiming to pursue a career in industry and academia as well as research and development.

PROGRAM EDUCATIONAL OBJECTIVES

The objectives of the MSc in Electrical and Computer Engineering program are to produce graduates who:

1. Advance professionally and are recognized as leaders in their chosen fields.
2. Apply their technical expertise to address the needs of society in critical, creative, ethical, and innovative manner.
3. Further develop their knowledge and skills through graduate education and professional schools.

LEARNING OUTCOMES

MSc in Electrical and Computer Engineering graduates will be able to:

1. Identify, formulate, and solve advanced electrical and computer engineering problems through the application of modern tools and techniques and advanced knowledge of mathematics and engineering science.
2. Acquire knowledge of contemporary issues in the field of electrical and computer engineering.
3. Design and conduct experiments, as well as analyze, interpret data, and make decisions.
4. Conduct research and document and defend the research results.
5. Function on teams and communicate effectively.
6. Conduct themselves in a professional and ethical manner

In addition to the above Learning Outcomes, students choosing the Space Systems and Technology concentration are also expected to attain the following concentration specific outcomes:

7. Demonstrate proficiency in the aspects of space systems design and analysis
8. Design and build a small-satellite as a part of a multi-disciplinary team.

PROGRAM STRUCTURE AND REQUIREMENTS

Overall Program Structure

The MSc ECE consists of a minimum 36 credit hours, distributed as follows: 12 credit hours of Program Core courses, 12 credit hours of Program Elective courses, 12 credit hours of Master's Thesis and a zero credit Research Methods course. Students may organize the selection of elective courses and the thesis topic to follow a specialization track or concentration. The track will be noted on the student's official transcript, while the concentration will be noted on the transcript and the diploma. The components of the program are summarized in the table below:

PROGRAM COMPONENT	CREDIT HOURS
ENGR 695 Seminar in Research Methods	0
Engineering Mathematics Core	3
Program Core	9
Program Electives	12
ECCE 699 Master's Thesis	12
Total	**36**

Program Requirements

Students seeking the degree of MSc in Electrical and Computer Engineering must successfully complete a minimum 36 credit hours as specified in the program requirements detailed below, with a minimum CGPA of 3.0. Course selection should be made in consultation with the student's Main Advisor. All courses have a credit rating of three credits each, except ENGR 695 Seminar in Research Methods and the Master's Thesis.

Program Core (12 Credit Hours)

Students must complete the following core courses:

- ENGR 695 Seminar in Research Methods
- Select at least one Engineering Mathematics Core course from the list below:
  - ENGR 602 Engineering Numerical Methods
  - ENGR 605 Systems Optimization
  - ENGR 606 Advanced Engineering Mathematics
- Select at least three ECCE Core courses from the list below:
  - ECCE 610 Digital Signal Processing
  - ECCE 620 Real-Time Embedded Systems
  - ECCE 630 Advanced Computer Networks
  - ECCE 635 Deep Learning System Design
  - ECCE 650 Linear Systems
  - ECCE 660 Power System Analysis
  - ECCE 661 Power Electronics
  - ECCE 670 Micro/Nano Processing Technologies
  - ECCE 671 Fabrication of Nano Devices (if student has taken ECCE 495 Fabrication course or equivalent)
  - ECCE 672 Principles and Models of Semiconductor Devices

Program Electives and Tracks (12 Credit Hours)

Students must select any four elective courses from the list below, or from any core courses listed above that are not used to meet the Program Core requirement. Subject to approval of the Main Advisor, students can select up to two elective courses (6 Credit Hours) from other MSc programs in the College of Engineering at KU.

- COSC 604 Artificial Intelligence
- COSC 606 Machine Learning
- CSEC 630 Artificial Intelligence Techniques for Cyber-Security
- ECCE 611 Advanced Digital Signal Processing
- ECCE 612 Multimedia Processing
- ECCE 621 Digital ASIC Design
- ECCE 622 RF and Mixed-Signal Circuit Design
- ECCE 623 High-Speed Communication Circuits
- ECCE 624 Analog Integrated Circuits
- ECCE 625 Digital Integrated Circuit Design
- ECCE 626 Advanced Digital System Design
- ECCE 627 Computer-Aided Design of Microelectronic Systems
- ECCE 628 Computer Architecture
- ECCE 629 Hardware Accelerators for Artificial Intelligence
- ECCE 631 Blockchain Fundamentals and Applications
- ECCE 632 Advanced Operating Systems
- ECCE 633 Machine Vision and Image Understanding
- ECCE 636 Human Computer Interaction
- ECCE 637 Parallel Programming
- ECCE 640 Communication Systems Design
- ECCE 641 Wireless Communication Systems
- ECCE 642 Broadband Communication Networks
- ECCE 643 Radar Systems
- ECCE 644 Radio Frequency Measurements
- ECCE 645 Stochastic Processes, Detection, and Estimation
- ECCE 652 Modeling and System Identification
- ECCE 653 Advanced Digital Control Systems
- ECCE 654 Adaptive Control
- ECCE 655 Artificial Intelligence for Control Engineering
- ECCE 656 Nonlinear Control
- ECCE 657 Process Instrumentation
- ECCE 658 Autonomous Robotics Systems
- ECCE 659 Modeling and Control of Robotic Systems
- ECCE 662 Electric Drives
- ECCE 663 Distribution Systems Design and Operation
- ECCE 664 Distributed Generation
- ECCE 665 Electric Power Quality
- ECCE 666 Power System Protection
- ECCE 667 High Voltage Engineering

- ECCE 668 Electric Machines
- ECCE 669 Power System Operation
- ECCE 670 Micro/Nano Processing Technologies
- ECCE 671 Fabrication of Nano Devices
- ECCE 672 Advanced Microelectronics Devices
- ECCE 673 Fundamentals of Photonics
- ECCE 674 Semiconductor Optoelectronic Devices
- ECCE 675 Nanoscale Integrated Circuits Technology
- ECCE 694 Selected Topics in Electrical and Computer Engineering
- ENGR 610 Risk, Reliability and Uncertainty in Engineering Systems

Students wishing to complete an optional specialization track, must select at least three of the four elective courses from one of the groups listed below. The track will be noted on the student's official transcript, provided that the student fulfills the following requirements:

- Complete a minimum of three courses (9 Credit Hours) from the same track specialization; and
- Complete a Master's research thesis within the domain of the track specialization.

PROGRAM TRACKS

Artificial Intelligence

- COSC 604 Artificial Intelligence
- COSC 606 Machine Learning
- CSEC 630 Artificial Intelligence Techniques for Cyber-Security
- ECCE 633 Machine Vision and Image Understanding
- ECCE 655 Artificial Intelligence for Control Engineering
- ECCE 658Autonomous Robotics Systems

Communication and Signal Processing Systems

- ECCE 611Advanced Digital Signal Processing
- ECCE 612 Multimedia Processing
- ECCE 633 Machine Vision and Image Understanding
- ECCE 640 Communication Systems Design
- ECCE 641 Wireless Communication Systems
- ECCE 642 Broadband Communication Networks
- ECCE 645 Stochastic Processes, Detection, and Estimation

Computing Systems

- ECCE 626 Advanced Digital System Design
- ECCE 628 Computer Architecture
- ECCE 631 Blockchain Fundamentals and Applications
- ECCE 632 Advanced Operating Systems
- ECCE 633 Machine Vision and Image Understanding
- ECCE 636 Human Computer Interaction
- ECCE 63 Parallel Programming

Electrical Power Engineering

- ECCE 662 Electric Drives
- ECCE 663 Distribution Systems Design and Operation
- ECCE 664 Distributed Generation
- ECCE 665 Electric Power Quality
- ECCE 666 Power System Protection
- ECCE 667 High Voltage Engineering
- ECCE 668 Electric Machines
- ECCE 669 Power System Operation

Embedded Systems

- ECCE 621 Digital ASIC Design
- ECCE 622 RF and Mixed-Signal Circuit Design
- ECCE 623 High-Speed Communication Circuits
- ECCE 624 Analog Integrated Circuits
- ECCE 625 Digital Integrated Circuit Design
- ECCE 626 Advanced Digital System Design
- ECCE 627 Computer-Aided Design of Microelectronic Systems
- ECCE 628 Computer Architecture
- ECCE 629 Hardware Accelerators for Artificial Intelligence
- ECCE 675 Nanoscale Integrated Circuits Technology

Micro and Nano Systems

- ECCE 622 RF and Mixed-Signal Circuit Design
- ECCE 623 High-Speed Communication Circuits
- ECCE 624 Analog Integrated Circuits
- ECCE 625 Digital Integrated Circuit Design
- ECCE 670 Micro/Nano Processing Technologies
- ECCE 671 Fabrication of Nano Devices
- ECCE 672 Advanced Microelectronics Devices
- ECCE 673 Fundamentals of Photonics
- ECCE 674 Semiconductor Optoelectronic Devices
- ECCE 675 Nanoscale Integrated Circuits Technology

Robotics, Control and Autonomous Systems

- ECCE 633 Machine Vision and Image Understanding
- ECCE 652 Modeling and System Identification
- ECCE 653 Advanced Digital Control Systems
- ECCE 654 Adaptive Control
- ECCE 655 Artificial Intelligence for Control Engineering
- ECCE 656 Nonlinear Control
- ECCE 657 Process Instrumentation
- ECCE 658 Autonomous Robotic Systems
- ECCE 659 Modeling and Control of Robotic Systems

ECCE 699 Master's Thesis (Minimum 12 Credit Hours)

Students must complete a Master's Thesis that involves creative, research-oriented work within the broad field of ECE, under the direct supervision of a full-time faculty advisor from the Electrical Engineering and Computer Science Department, and at least one other full-time faculty who acts as a co-advisor. The outcome of research should demonstrate the synthesis of information into knowledge in a form that may be used by others. The research findings must be documented in a formal thesis and defended successfully in a viva voce examination. Furthermore, the research should lead to publishable quality scholarly articles.

CONCENTRATION IN SPACE SYSTEMS AND TECHNOLOGY

The Space Systems and Technology concentration is part of a collaboration with satellite industry leaders Yahsat and Orbital ATK. The objective of this concentration is to foster advanced research areas in space science and technology for the development of the UAE national space program and provide the space industry with human resources and infrastructure.

In addition to program specific core courses, students who opt for the Space Systems and Technology concentration must complete all four spacecraft core courses (9 Credit Hours) and a thesis that includes challenges and scientific research opportunities in space science and technology. Students will also engage in designing, building, integration, testing and operation of a small satellite such as a CubeSat.

The Space Systems and Technology concentration core courses are:

- SSCC 601 Spacecraft Systems and Design (3 credits)
- SSCC 602 Spacecraft Systems Lab 1 (2 credits)
- SSCC 603 Spacecraft Systems Lab 2 (2 credits)
- SSCC 604 Spacecraft Systems Lab 3 (2 credits)

Note that a student who opts for the Space Systems and Technology concentration should take SSCC 601 in the first semester of study. This will allow the student to complete the sequence of laboratory-based courses (SSCC 602, 603 and 604), which take the place of program electives. The concentration will be specified on the student's diploma and official transcript.

STUDY PLAN

A typical study plan for students enrolled in the MSc CSEC is shown below.

TYPICAL STUDY PLAN FOR FULL-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods Engineering Mathematics Core Course Program Core Course 1 Program Core Course 2	Program Core Course 3 Elective Course 1 ECCE 699 Master's Thesis
YEAR 2	Elective Course 2 Elective Course 3 ECCE 699 Master's Thesis	Elective Course 4 ECCE 699 Master's Thesis

TYPICAL STUDY PLAN FOR PART-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods Engineering Mathematics Core Course Program Core Course 1	Program Core Course 2 Program Core Course 3
YEAR 2	Elective Course 1 ECCE 699 Master's Thesis	Elective Course 2 ECCE 699 Master's Thesis
YEAR 3	Elective Course 3 ECCE 699 Master's Thesis	Elective Course 4 ECCE 699 Master's Thesis

MSC IN ENGINEERING SYSTEMS AND MANAGEMENT

ABOUT THE PROGRAM

The Master of Science in Engineering Systems and Management (MSc ESM) is an interdisciplinary program that brings together experts in engineering, design, economics, management and policy to teach and undertake research into large-scale complex systems.

The mission of the MSc ESM is to create corporate and government leaders that can effectively deal with global energy and sustainability challenges that involve large scale systems. MSc ESM graduates are trained in strategy, industrial operations, operations research, and systems thinking. As such, they will be ideally positioned to take leadership positions in the private or public sector and guide research and implementation of advanced technologies, and optimize the operations and design of complex systems.

PROGRAM EDUCATIONAL OBJECTIVES

The objectives of the MSc in Engineering and Systems Management program are to produce graduates who have an:

1. Ability to identify and respond to complex engineering systems problems (involving technical and socioeconomic components).
2. Ability to apply advanced systems analysis tools in a multi-disciplinary setting in order to bound, plan, analyze, design and implement solutions to engineering systems problems, while advancing professionally and be recognized as leaders in their chosen fields.
3. Understanding of the complex interactions between the engineering system solutions and their implications on larger scale (regional, national, global) technological, economic, societal and environmental systems with a view on long-term sustainability.
4. Understanding of the value of technical and scientific scholarship, service to society, leadership and life-long learning required to further their career aspirations in support of the needs of the community.

LEARNING OUTCOMES

MSc in Engineering and Systems Management graduates will be able to:

1. Successfully apply appropriate combinations of advanced concepts of engineering, economics, system theory, management and policy to identify, formulate and address engineering systems problems, and acquire knowledge of contemporary issues in the field of engineering systems and management.
2. Successfully use advanced system analysis, operations research methodology, data management, and design tools (e.g. optimization, simulation, architecture, statistical analysis, surveys, applied principles and heuristics etc.) to design, develop, implement, integrate and improve systems and processes, and make educated objective decisions.
3. Understand and apply the relationships between the management tasks of planning, organization, leadership, control, and the human element in production, research, and service organizations along with an understanding of and dealing with the stochastic nature of organizational systems.
4. Assess the direct and indirect impact of engineering solutions on sustainable development (e.g., economic, environmental, and social factors) with a focus on engineering systems contemporary issues such as energy and health care delivery systems, while developing an aptitude for continuous improvement.

5. Use appropriate advanced methods to design, conduct and analyze experimental studies and manage data for engineering systems with a strong sociotechnical component.
6. Communicate effectively in written and oral form, both, individually and as a member of a multidisciplinary team, while conducting research, documenting and defending the research results.

In addition to the above Learning Outcomes, students choosing the Space Systems and Technology concentration are also expected to attain the following concentration specific outcomes:

7. Demonstrate proficiency in the aspects of space systems design and analysis.
8. Design and build a small-satellite as a part of a multi-disciplinary team.

PROGRAM STRUCTURE AND REQUIREMENTS

Overall Program Structure

The MSc ESM consists of a minimum 36 credit hours, distributed as follows: 12 credit hours of Program Core courses, 12 credit hours of Program Elective courses, 12 credit hours of Master's Thesis and a zero credit Research Methods course. Students may organize the selection of elective courses and the thesis topic to follow a specialization track or concentration. The track will be noted on the student's official transcript, while the concentration will be noted on the transcript and the diploma. The components of the program are summarized in the table below:

PROGRAM COMPONENT	CREDIT HOURS
ENGR 695 Seminar in Research Methods	0
Program Core	12
Program Electives	12
ESMA 699 Master's Thesis	12
Total	**36**

Program Requirements

Students seeking the degree of MSc in Engineering and Systems Management must successfully complete a minimum 36 credit hours as specified in the program requirements detailed below, with a minimum CGPA of 3.0. Course selection should be made in consultation with the student's Main Advisor. All courses have a credit rating of three credits each, except ENGR 695 Seminar in Research Methods and the Master's Thesis.

Program Core (12 Credit Hours)

Students must complete the following core courses:

- ENGR 695 Seminar in Research Methods
- ESMA 603 Systems Optimization
- ESMA 604 System Dynamics for Business Policy or ESMA 650 Cost Engineering
- ESMA 605 System Project Management
- ESMA 610 Business Analytics, Statistics for Engineering Systems

Program Electives and Tracks (12 Credit Hours)

Students must select any four elective courses from the list below, or from any core courses listed above that are not used to meet the Program Core requirement. Subject to approval of the Main Advisor, students can select up to two elective courses (6 Credit Hours) from other MSc programs in the College of Engineering at KU.

- ESMA 601 System Architecture
- ESMA 602 Product Design and Development
- ESMA 607 Management and Entrepreneurship for Engineers
- ESMA 608 Environmental Policy and Economics
- ESMA 617 Innovation and Creativity Entrepreneurship in Technology Organizations
- ESMA 618 Strategic Management of Technology and Innovation
- ESMA 619 Advanced Quality Systems Management
- ESMA 621 Production, Operations and Inventory Management
- ESMA 623 Advanced Lean Manufacturing
- ESMA 633 System Simulation: Modelling and Analysis
- ESMA 641 Supply Chain, Logistics and Transportation Networks
- ESMA 642 Global Supply Chain Management
- ESMA 643 Warehousing and Distribution
- ESMA 671 Healthcare Operations Management
- ESMA 672 Lean Service Systems
- ESMA 673 Healthcare Information Systems
- ESMA 694 Selected Topics in Systems and Engineering Management

Students wishing to complete an optional specialization track, must select at least three of the four elective courses from one of the groups listed below. The track will be noted on the student's official transcript, provided that the student fulfills the following requirements:

- Complete a minimum of three courses (9 Credit Hours) from the same track specialization; and
- Complete a Master's research thesis within the domain of the track specialization.

ESMA 699 Master's Thesis(Minimum 12 Credit Hours)

Students must complete a Master's Thesis that involves creative, research-oriented work within the broad field of ESM, under the direct supervision of a full-time faculty advisor from the Industrial and Systems Engineering Department, and at least one other full-time faculty who acts as a co-advisor. The outcome of research should demonstrate the synthesis of information into knowledge in a form that may be used by others. The research findings must be documented in a formal thesis and defended successfully in a viva voce examination. Furthermore, the research should lead to publishable quality scholarly articles.

CONCENTRATION IN SPACE SYSTEMS AND TECHNOLOGY

The Space Systems and Technology concentration is part of a collaboration with satellite industry leaders Yahsat and Orbital ATK. The objective of this concentration is to foster advanced research areas in space science and technology for the development of the UAE national space program and provide the space industry with human resources and infrastructure.

In addition to program specific core courses, students who opt for the Space Systems and Technology concentration must complete all four spacecraft core courses (9 Credit Hours) and a thesis that includes challenges and scientific research opportunities in space science and technology. Students will also engage in designing, building, integration, testing and operation of a small satellite such as a CubeSat. The Space Systems and Technology concentration core courses are:

- SSCC 601 Spacecraft Systems and Design (3 credits)
- SSCC 602 Spacecraft Systems Lab 1 (2 credits)
- SSCC 603 Spacecraft Systems Lab 2 (2 credits)
- SSCC 604 Spacecraft Systems Lab 3 (2 credits)

Note that a student who opts for the Space Systems and Technology concentration should take SSCC 601 in the first semester of study. This will allow the student to complete the sequence of laboratory-based courses (SSCC 602, 603 and 604), which take the place of program electives. The concentration will be specified on the student's diploma and official transcript.

CONCENTRATION IN TECHNOLOGY MANAGEMENT, INNOVATION AND ENTREPRENEURSHIP

The Technology Management, Innovation and Entrepreneurship concentration allows students to conduct an in-depth study on managing the steps needed to translate new technologies into useful products and services. In addition to program specific core courses, students pursuing this concentration must successfully complete the courses listed below and a thesis in a field of research relevant to the general area of Technology Strategy, Management, Innovation and Entrepreneurship.

The concentration will be specified on the student's diploma and official transcript.

- ESMA 607 Management and Entrepreneurship for Engineers
- ESMA 617 Innovation and Creativity in Technology Organizations
- ESMA 618 Strategic Management of Technology and Innovation

STUDY PLAN

A typical study plan for students enrolled in the MSc ESM is shown below.

TYPICAL STUDY PLAN FOR FULL-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods ESMA 603 Systems Optimization ESMA 605 System Project Management ESMA 610 Business Analytics, Statistics for Engineering Systems	ESMA 604 System Dynamics for Business Policy or ESMA 650 Cost Engineering Elective Course 1 ESMA 699 Master's Thesis
YEAR 2	Elective Course 2 Elective Course 3 ESMA 699 Master's Thesis	Elective Course 4 ESMA 699 Master's Thesis

TYPICAL STUDY PLAN FOR PART-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods ESMA 603 Systems Optimization ESMA 610 Business Analytics, Statistics for Engineering Systems	Elective Course 1 Elective Course 2
YEAR 2	ESMA 605 System Project Management ESMA 699 Master's Thesis	ESMA 604 System Dynamics for Business Policy or ESMA 650 Cost Engineering ESMA 699 Master's Thesis
YEAR 3	Elective Course 3 ESMA 699 Master's Thesis	Elective Course 4 ESMA 699 Master's Thesis

MSC IN MATERIALS SCIENCE AND ENGINEERING

ABOUT THE PROGRAM

The Master of Science in Materials Science and Engineering (MSc MSEN) is an exciting research-led program, with a wide range of courses and a significant research component that provides an in-depth grounding in the various aspects of the broad field of materials science engineering. The program is delivered by experienced international faculty who are actively engaged in cutting-edge research. The MSc MSEN program provides excellent training for those aiming to pursue a career in industry and academia as well as research and development.

PROGRAM EDUCATIONAL OBJECTIVES

The objectives of the MSc in Materials Science and Engineering program are to produce graduates who will:

1. Identify and address current and future needs in various aspects of materials and devices (both active and passive) for all sorts of applications towards a sustainable and improved human well-being.
2. Apply a multi-disciplinary approach to conceive, plan, design, and implement innovations and solutions to problems and challenges that involve materials and their properties and applications.
3. Determine the potential impact of materials-based technologies and innovations on the social, economic, environmental aspects.
4. Promote science-based engineering, technical scholarship, service to society, leadership, best practice, and life-long learning.

LEARNING OUTCOMES

MSc in Materials Science and Engineering graduates will be able to:

1. Apply advanced concepts of fundamental sciences and engineering to identify, formulate and solve complex materials and devices problems.
2. Design and develop materials, devices, systems, and processes to meet desired needs of society professionally and ethically.
3. Design and conduct experiments in the area of materials and/or devices, and analyze and interpret data.
4. Be continuously aware of contemporary issues and research opportunities/challenges in the field of materials engineering as related to energy and sustainability and engage in life-long learning in the field and in the fundamentals of other related disciplines.
5. Deploy advanced materials characterization techniques, skills, and modern scientific and engineering tools.
6. Communicate effectively in written and oral form, both, individually and as a member of a multidisciplinary team.

In addition to the above, students choosing the concentration in Space Systems and Technology are also expected to attain the following concentration specific outcomes:

7. Demonstrate proficiency in the aspects of space systems design and analysis.
8. Design and build a small-satellite as a part of a multi-disciplinary team.

PROGRAM STRUCTURE AND REQUIREMENTS

Overall Program Structure

The MSc MSEN consists of a minimum 36 credit hours, distributed as follows: 12 credit hours of Program Core courses, 12 credit hours of Elective courses, 12 credit hours of Master's Thesis and a zero credit Research Methods course. The components of the program are summarized in the table below:

PROGRAM COMPONENT	CREDIT HOURS
ENGR 695 Seminar in Research Methods	0
Program Core	12
Program Electives	12
MSEN 699 Master's Thesis	12
Total	**36**

Program Requirements

Students seeking the degree of MSc in Materials Science and Engineering must successfully complete a minimum 36 credit hours as specified in the program requirements detailed below, with a minimum CGPA of 3.0. Course selection should be made in consultation with the student's Main Advisor. All courses have a credit rating of three credits each, except ENGR 695 Seminar in Research Methods and the Master's Thesis.

Program Core (12 Credit Hours)

Students must complete the following core courses:

- ENGR 695 Seminar in Research Methods
- MEEN 630 Advanced Engineering Mathematics
- MSEN 607 Thermodynamics of Materials
- MSEN 608 Kinetics of Materials
- MSEN 623 Electrical, Optical and Magnetic Properties of Crystalline Materials

Program Electives (12 Credit Hours)

Students must select four courses from the list below. Subject to approval of the Main Advisor, students can select up to two elective courses (6 Credit Hours) from other MSc programs in the College of Engineering at KU.

- MSEN 605 Structure and Properties of Polymers
- MSEN 606 Materials Processing and Manufacturing Technologies
- MSEN 611 Photovoltaic Technologies: Materials, Devices and Systems
- MSEN 612 Physics for Solid-State Application
- MSEN 619 Crystallography and Diffraction
- MSEN 621 Mechanical Properties of Materials
- MSEN 622 Electrical, Optical and Magnetic Properties of Amorphous Materials
- MSEN 624 Thermal Properties of Materials
- MSEN 694 Selected Topics in Material Science and Engineering

MSEN 699 Master's Thesis (Minimum 12 Credit Hours)
Students must complete a Master's Thesis that involves creative, research-oriented work within the broad field of MSEN, under the direct supervision of a full-time faculty advisor from the Mechanical Engineering Department, and at least one other full-time faculty who acts as a co-advisor. The outcome of research should demonstrate the synthesis of information into knowledge in a form that may be used by others. The research findings must be documented in a formal thesis and defended successfully in a viva voce examination. Furthermore, the research should lead to publishable quality scholarly articles.

CONCENTRATION IN SPACE SYSTEMS AND TECHNOLOGY

The Space Systems and Technology concentration is part of a collaboration with satellite industry leaders Yahsat and Orbital ATK. The objective of this concentration is to foster advanced research areas in space science and technology for the development of the UAE national space program and provide the space industry with human resources and infrastructure.

In addition to program specific core courses, students who opt for the Space Systems and Technology concentration must complete all four spacecraft core courses (9 Credit Hours) and a thesis that includes challenges and scientific research opportunities in space science and technology. Students will also engage in designing, building, integration, testing and operation of a small satellite such as a CubeSat.

The Space Systems and Technology concentration core courses are:
- SSCC 601 Spacecraft Systems and Design (3 credits)
- SSCC 602 Spacecraft Systems Lab 1 (2 credits)
- SSCC 603 Spacecraft Systems Lab 2 (2 credits)
- SSCC 604 Spacecraft Systems Lab 3 (2 credits)

Note that a student who opts for the Space Systems and Technology concentration should take SSCC 601 in the first semester of study. This will allow the student to complete the sequence of laboratory-based courses (SSCC 602, 603 and 604), which take the place of program electives. The concentration will be specified on the student's diploma and official transcript.

STUDY PLAN

A typical study plan for students enrolled in the MSc MSEN is shown below.

TYPICAL STUDY PLAN FOR FULL-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods MEEN 630 Advanced Engineering Mathematics Program Core Course 1 Program Core Course 2	Program Core Course 3 Elective Course 1 MSEN 699 Master's Thesis
YEAR 2	Elective Course 2 Elective Course 3 MSEN 699 Master's Thesis	Elective Course 4 MSEN 699 Master's Thesis

TYPICAL STUDY PLAN FOR PART-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods MEEN 630 Advanced Engineering Mathematics Program Core Course 1	Program Core Course 2 Program Core Course 3
YEAR 2	Elective Course 1 MSEN 699 Master's Thesis	Elective Course 2 MSEN 699 Master's Thesis
YEAR 3	Elective Course 3 MSEN 699 Master's Thesis	Elective Course 4 MSEN 699 Master's Thesis

MSC IN MECHANICAL ENGINEERING

ABOUT THE PROGRAM

The Master of Science in Mechanical Engineering (MSc MEEN) combines in-depth knowledge from core areas of mechanical engineering, including mechanics, thermodynamics, fluids, materials, manufacturing and controls. The integration of these core topics is essential for multidisciplinary threads, such as robotics, micro and nanotechnologies, production systems, and energy systems. Students will utilize modelling, computer simulation and advanced experimental techniques as tools to analyze and understand different phenomena and processes. Graduates of the MSc MEEN will have acquired the advanced level of knowledge needed to assume leading positions in industry and government, as well as continuing their studies to the Doctorate level.

PROGRAM EDUCATIONAL OBJECTIVES

The objectives of the MSc in Mechanical and Engineering program are to produce graduates who:

1. Advance professionally and be recognized as leaders in their chosen fields.
2. Apply their technical expertise to address the needs of society in critical, creative, ethical, and innovative manner.
3. Further develop their knowledge and skills through graduate education and professional schools.

LEARNING OUTCOMES

MSc in Mechanical Engineering graduates will be able to:

1. Identify, formulate, and solve advanced mechanical engineering problems through the application of modern tools and techniques and advanced knowledge of mathematics and engineering science.
2. Acquire knowledge of contemporary issues in the field of mechanical engineering.
3. Design and conduct experiments, as well as analyze, interpret data and make decisions.
4. Conduct research and document and defend the research results.
5. Function in teams and communicate effectively.
6. Conduct themselves in a professional and ethical manner.

In addition to the above Learning Outcomes, students choosing the Space Systems and Technology concentration are also expected to attain the following concentration specific outcomes:

7. Demonstrate proficiency in the aspects of space systems design and analysis.
8. Design and build a small-satellite as a part of a multi-disciplinary team.

PROGRAM STRUCTURE AND REQUIREMENTS

Overall Program Structure

The MSc MEEN consists of a minimum 36 credit hours, distributed as follows: 12 credit hours of Program Core courses, 12 credit hours of Elective courses, 12 credit hours of Master's Thesis and a zero credit Research Methods course. The components of the program are summarized in the table below:

PROGRAM COMPONENT	CREDIT HOURS
ENGR 695 Seminar in Research Methods	0
MEEN 630 Advanced Engineering Mathematics	3
Program Core	9
Program Electives	12
MEEN 699 Master's Thesis	12
Total	**36**

Program Requirements

Students seeking the degree of MSc in Mechanical Engineering must successfully complete a minimum 36 credit hours as specified in the program requirements detailed below, with a minimum CGPA of 3.0. Course selection should be made in consultation with the student's Main Advisor. All courses have a credit rating of three credits each, except ENGR 695 Seminar in Research Methods and the Master's Thesis.

Program Core (12 Credit Hours)

Students must complete the following core courses.

- ENGR 695 Seminar in Research Methods
- MEEN 630 Advanced Engineering Mathematics
- Select at least three MEEN courses from the list below:
- MEEN 601 Advanced Dynamics
- MEEN 602 Advanced Vibrations
- MEEN 603 Advanced Thermodynamics
- MEEN 604 Advanced Fluid Mechanics
- MEEN 605 Advanced Continuum Mechanics
- MEEN 606 Advanced Mechanics of Solids and Materials
- MEEN 607 Sustainable Energy

Program Electives and Tracks (12 credit hours)

Students must select any four elective courses from the list below, or from any core courses listed above that are not used to meet the Program Core requirement. Subject to approval of the Main Advisor, up to two elective courses (6 credit hours) can be taken from other MSc programs in the College of Engineering at KU.

- AERO/MEEN 611 Combustion Theory and Applications
- AERO/MEEN 612 Advanced Viscous Flow Analysis
- AERO 622 Structural Dynamics and Aeroelasticity
- AERO 630 Aerospace Materials and Structures
- AERO 631 Boundary Layer Analysis
- ECCE/MEEN 659 Modeling and Control of Robotic Systems
- MEEN 610 Applied Finite Element Analysis
- MEEN 613 Advanced Heat Transfer
- MEEN 614 Advanced Energy Conversion
- MEEN 615 Multiphase Flow Engineering
- MEEN 616 Solar Thermal Analysis, Design and Testing
- MEEN 617 Fuel Cell Systems
- MEEN 618 Computational Fluid Dynamics and Fire Modeling
- MEEN 619 Fire Dynamics Laboratory
- MEEN 620 Measurements and Instrumentation
- MEEN 621 Feedback Control
- MEEN 622 Control System Theory and Design
- MEEN 631 Fatigue and Fracture of Engineering Materials
- MEEN 632 Micro/Nanotechnology and Applications
- MEEN 633 Advanced Manufacturing Processes
- MEEN 694 Selected Topics in Mechanical Engineering

Students wishing to complete an optional specialization track, must select at least three courses from one of the groups listed below. The track will be noted on the student's official transcript, provided that the student fulfills the following requirements:

- Complete a minimum of three courses (9 credit hours) from the same track specialization; and
- Complete a Master's research thesis within the domain of the track specialization.

PROGRAM TRACKS

Aeronautical Engineering

- AERO/MEEN 611 Combustion Theory and Applications
- AERO/MEEN 612 Advanced Viscous Flow Analysis
- AERO 622 Structural Dynamics and Aeroelasticity
- AERO 630 Aerospace Materials and Structures
- AERO 631 Boundary Layer Analysis

Robotics and Autonomous Systems

- ECCE 633 Machine Vision and Image Understanding
- ECCE 658 Autonomous Robotic Systems
- ECCE/MEEN 659 Modeling and Control of Robotic Systems

MEEN 699 Master's Thesis (Mnimum 12 Credit Hours)

Students must complete a Master's Thesis that involves creative, research-oriented work within the broad field of mechanical engineering, under the direct supervision of a full-time faculty advisor from the Mechanical Engineering Department, and at least one other full-time faculty who acts as a co-advisor. The outcome of research should demonstrate the synthesis of information into knowledge in a form that may be used by others. The research findings must be documented in a formal thesis and defended successfully in a viva voce examination. Furthermore, the research should lead to publishable quality scholarly articles.

CONCENTRATION IN SPACE SYSTEMS AND TECHNOLOGY

The Space Systems and Technology concentration is part of a collaboration with satellite industry leaders Yahsat and Orbital ATK. The objective of this concentration is to foster advanced research areas in space science and technology for the development of the UAE national space program and provide the space industry with human resources and infrastructure.

In addition to program specific core courses, students who opt for the Space Systems and Technology concentration must complete all four spacecraft core courses (9 credit hours) and a thesis that includes challenges and scientific research opportunities in space science and technology. Students will also engage in designing, building, integration, testing and operation of a small satellite such as a CubeSat.

The Space Systems and Technology concentration core courses are:

- SSCC 601 Spacecraft Systems and Design (3 credits)
- SSCC 602 Spacecraft Systems Lab 1 (2 credits)
- SSCC 603 Spacecraft Systems Lab 2 (2 credits)
- SSCC 604 Spacecraft Systems Lab 3 (2 credits)

Note that a student who opts for the Space Systems and Technology concentration should take SSCC 601 in the first semester of study. This will allow the student to complete the sequence of laboratory-based courses (SSCC 602, 603 and 604), which take the place of program electives. The concentration will be specified on the student's diploma and official transcript.

STUDY PLAN

A typical study plan for students enrolled in the MSc MEEN is shown below.

TYPICAL STUDY PLAN FOR FULL-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods MEEN 630 Advanced Engineering Mathematics Program Core Course 1 Elective Course 1	Program Core Course 2 Elective Course 2 MEEN 699 Master's Thesis
YEAR 2	Program Core Course 3 Elective Course 3 MEEN 699 Master's Thesis	Elective Course 4 MEEN 699 Master's Thesis

TYPICAL STUDY PLAN FOR PART-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods MEEN 630 Advanced Engineering Mathematics Program Core Course 1	Program Core Course 2 Elective Course 1
YEAR 2	Program Core Course 3 MEEN 699 Master's Thesis	Elective Course 2 MEEN 699 Master's Thesis
YEAR 3	Elective Course 3 MEEN 699 Master's Thesis	Elective Course 4 MEEN 699 Master's Thesis

MSC IN NUCLEAR ENGINEERING

ABOUT THE PROGRAM

The Master of Science in Nuclear Engineering (MSc NUCE) was established to support the UAE's peaceful nuclear energy program. Education in Nuclear Engineering is of paramount importance for the safe construction, operation, maintenance and eventual decommissioning of nuclear reactors. The MSc NUCE targets students with various backgrounds, such as graduates of Mechanical, Nuclear or Electrical and Computer Engineering, Physics, Chemistry, Material Science, Mathematics or other pertinent specializations.

The program starts with common core courses that cover essential nuclear engineering topics, followed by a selection of specialization tracks that prepare students for project/thesis work and broaden their expertise in specific areas of nuclear technology. Students will also be required to complete a field trip component, which consists of carrying out a series of nuclear reactor experiments to consolidate theory lessons given in class as well as visiting selected nuclear facilities to gain an overall appreciation of nuclear energy technology. By necessity, the field trips will be undertaken overseas until such time that nuclear laboratories and facilities are available in the UAE. Applicants with insufficient prior academic background may be conditionally admitted and assigned remedial undergraduate courses.

PROGRAM EDUCATIONAL OBJECTIVES

The objectives of the MSc in Nuclear Engineering program are to produce graduates who:

1. Advance professionally and be recognized as leaders in their chosen fields.
2. Apply their technical expertise to address the needs of society in critical, creative, ethical, and innovative manner.
3. Further develop their knowledge and skills through graduate education and professional schools.

LEARNING OUTCOMES

MSc in Nuclear Engineering graduates will be able to:

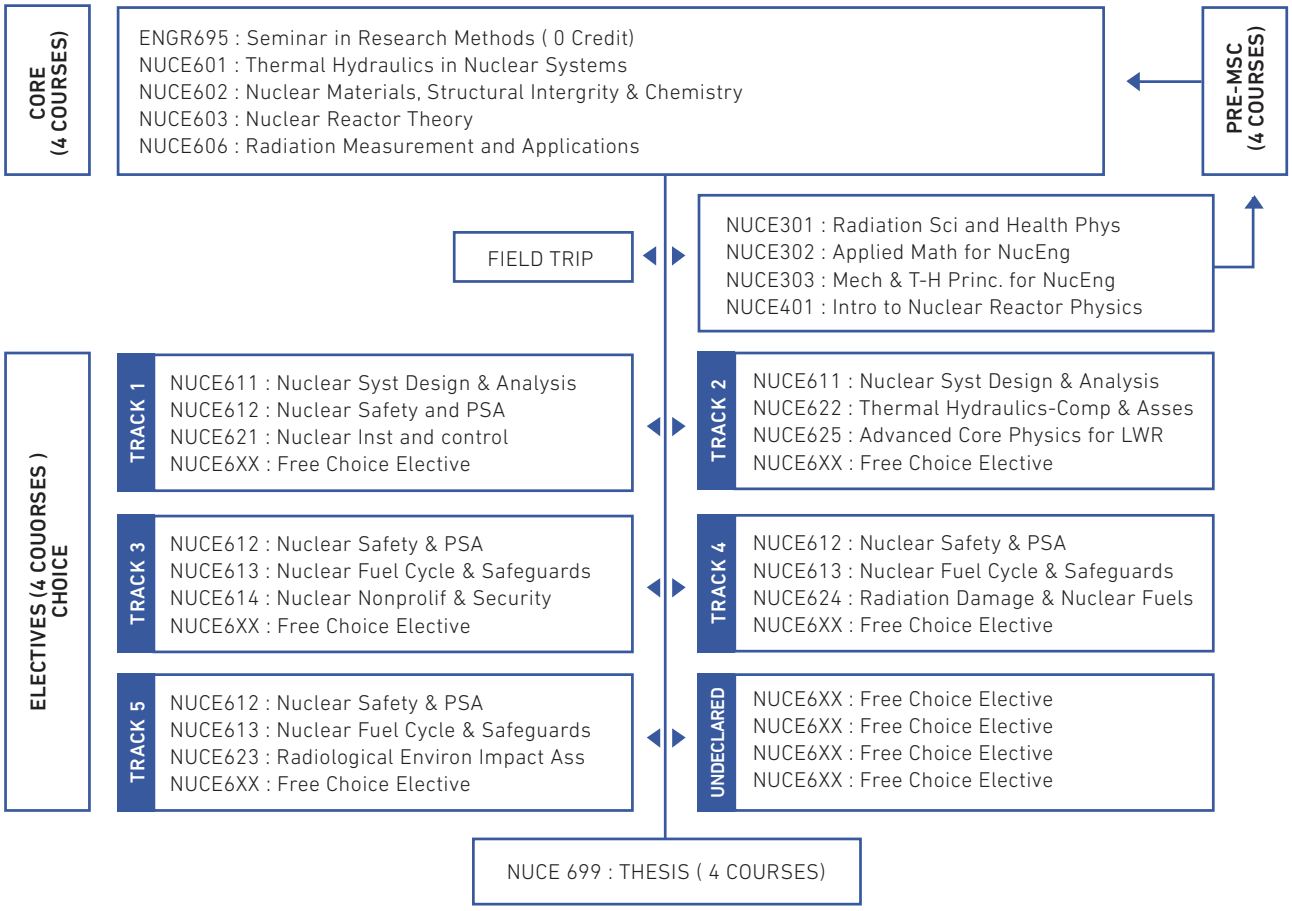
1. Identify, formulate, and solve advanced Nuclear Engineering problems through the application of modern tools and techniques and advanced knowledge of mathematics and engineering science.
2. Acquire knowledge of contemporary issues and demonstrate an advanced level of understanding in the field of Nuclear Engineering.
3. Design and conduct experiments, as well as analyze, interpret data and make decisions.
4. Conduct research in a chosen area of specialization, document and defend the research results.
5. Function on teams in design, analysis and or/safety and communicate effectively, both orally and in writing.
6. Understand legal, professional, regulatory and ethical responsibilities.

PROGRAM STRUCTURE AND REQUIREMENTS

Overall Program Structure

The MSc NUCE consists of a minimum 36 credit hours, distributed as follows: 12 credit hours of Program Core courses, 12 credit hours of Elective courses, 12 credit hours of Master's Thesis and a zero credit Research Methods course. Students must also complete a mandatory field trip component. The curriculum flowchart for the MSc NUCE is given below, followed by the program requirements.

PROGRAM COMPONENT	CREDIT HOURS
ENGR 695 Seminar in Research Methods	0
Program Core	12
Program Electives	12
NUCE 699 Master's Thesis	12
Total	**36**



Program Requirements

Students seeking the degree of MSc in Nuclear Engineering must successfully complete a minimum 36 credit hours as specified in the program requirements detailed below, with a minimum CGPA of 3.0. Course selection should be made in consultation with the student's Main Advisor. All courses have a credit rating of three credits each, except ENGR 695 Seminar in Research Methods and the Master's Thesis.

Program Core (12 Credit Hours)

Students must complete the following core courses:

- ENGR 695 Seminar in Research Methods
- NUCE 601 Thermal Hydraulics in Nuclear Systems
- NUCE 602 Nuclear Materials, Structural Integrity and Chemistry
- NUCE 603 Nuclear Reactor Theory
- NUCE 606 Radiation Measurements and Applications

Program Electives and Tracks (12 Credit Hours)

Students must select any four elective courses from the list below, or from any core courses listed above that are not used to meet the Program Core requirement. Subject to approval of the Main Advisor, up to two elective courses (6 Credit Hours) can be taken from other MSc programs in the College of Engineering at KU.

- NUCE 611 Nuclear Systems Design and Analysis
- NUCE 612 Nuclear Safety and Probabilistic Safety Assessment
- NUCE 613 Nuclear Fuel Cycle and Safeguards
- NUCE 614 Nuclear Nonproliferation and Security
- NUCE 621 Nuclear Instrumentation and Control
- NUCE 622 Thermal Hydraulics Computations and Modelling
- NUCE 623 Radiological Environmental Impact Assessment
- NUCE 624 Radiation Damage and Nuclear Fuels
- NUCE 625 Advanced Core Physics for Light Water Reactors
- NUCE 630 Biological Effects of the Exposure to Ionizing Radiation
- NUCE 694 Selected Topics in Nuclear Engineering

Students wishing to complete an optional specialization track, must select three of the four elective courses from one of the groups listed below. Other tracks may be introduced depending on demand and stakeholder requirements.

The track will be noted on the student's official transcript, provided that the student fulfills the following requirements:

- Complete a minimum of three courses (9 Credit Hours) from the same track specialization; and
- Complete a Master's research thesis within the domain of the track specialization.

PROGRAM TRACKS

Nuclear Systems and PSA

- NUCE 611 Nuclear Systems Design and Analysis
- NUCE 612 Nuclear Safety and Probabilistic Safety Assessment
- NUCE 621Nuclear Instrumentation and Control

Nuclear Reactor Design

- NUCE 611 Nuclear Systems Design and Analysis
- NUCE 622 Thermal Hydraulics Computations and Modelling
- NUCE 625 Advanced Core Physics for Light Water Reactors

Nuclear Safeguards, Security and the Fuel Cycle

- NUCE 612 Nuclear Safety and Probabilistic Safety Assessment
- NUCE 613 Nuclear Fuel Cycle and Safeguards
- NUCE 614 Nuclear Nonproliferation and Security

Nuclear Materials and Radiation Damage

- NUCE 612 Nuclear Safety and Probabilistic Safety Assessment
- NUCE 613 Nuclear Fuel Cycle and Safeguards
- NUCE 624 Radiation Damage and Nuclear Fuels

Nuclear and Radiation Safety

- NUCE 612 Nuclear Safety and Probabilistic Safety Assessment
- NUCE 613 Nuclear Fuel Cycle and Safeguards
- NUCE 623 Radiological Environmental Impact Assessment

NUCE 699 Master's Thesis (Minimum 12 Credit Hours)

Students must complete a Master's Thesis that involves creative, research-oriented work within the broad field of nuclear engineering, under the direct supervision of a full-time faculty advisor from the Nuclear Engineering Department, and at least one other full-time faculty who acts as a co-advisor. The outcome of research should demonstrate the synthesis of information into knowledge in a form that may be used by others. The research findings must be documented in a formal thesis and defended successfully in a viva voce examination. Furthermore, the research should lead to publishable quality scholarly articles.

STUDY PLAN

A typical study plan for students enrolled in the MSc NUCE is shown below.

TYPICAL STUDY PLAN FOR FULL-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods NUCE 601 Thermal Hydraulics in Nuclear Systems NUCE 602 Nuclear Materials, Structural Integrity and Chemistry NUCE 603 Nuclear Reactor Theory Elective Course 1	NUCE 606 Radiation Measurement and Applications Elective Course 2 NUCE 699 Master's Thesis
YEAR 2	Elective Course 3 Elective Course 4 NUCE 699 Master's Thesis	NUCE 699 Master's Thesis

TYPICAL STUDY PLAN FOR PART-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods NUCE 601 Thermal Hydraulics in Nuclear Systems NUCE 602 Nuclear Materials, Structural Integrity and Chemistry	NUCE 603 Nuclear Reactor Theory NUCE 606 Radiation Measurement and Applications
YEAR 2	Elective Course 1 NUCE 699 Master's Thesis	Elective Course 2 NUCE 699 Master's Thesis
YEAR 3	Elective Course 3 NUCE 699 Master's Thesis	Elective Course 4 NUCE 699 Master's Thesis

MSC IN PETROLEUM ENGINEERING

ABOUT THE PROGRAM

The Petroleum Engineering department aims to become a leading international center of excellence in education, training, research and professional service dedicated to serving the competence, training and technology development needs of the petroleum industry. The Master of Science in Petroleum Engineering (MSc PEEG) is delivered by experienced international faculty who are actively engaged in cutting-edge research and provides excellent training for students aiming to pursue a career in industry and academia, as well as research and development.

PROGRAM EDUCATIONAL OBJECTIVES

The objectives of the MSc in Petroleum Engineering program are to:

1. Provide graduates with an outstanding education and the research skills and knowledge required to further their career aspirations.
2. Provide the regional and global oil and gas industry with a pool of highly educated personnel who can utilize their in-depth knowledge of petroleum engineering to better develop business opportunities.
3. Advance the technological profile of the UAE, and the regional and global oil and gas sector.
4. Address the needs of society in a critical, creative, ethical, and innovative manner.

LEARNING OUTCOMES

MSc in Petroleum Engineering graduates will be able to:

1. Demonstrate advanced knowledge of petroleum engineering concepts.
2. Apply advanced concepts of petroleum engineering science and mathematics to the formulation and solution of complex problems.
3. Use advanced techniques to design, simulate and conduct theoretical and experimental work.
4. Publish and present effectively research findings in international conferences and peer reviewed journals.
5. Demonstrate an awareness and understanding of contemporary issues related to fossil fuels and their role in the energy mix.
6. Participate in professional organizations and learn from experiences and engage in life-long learning.

PROGRAM STRUCTURE AND REQUIREMENTS

Overall Program Structure

The MSc PEEG consists of a minimum 36 credit hours, distributed as follows: 12 credit hours of Program Core courses, 12 credit hours of Elective courses, 12 credit hours of Master's Thesis and a zero credit Research Methods course. The components of the program are summarized in the table below:

PROGRAM COMPONENT	CREDIT HOURS
ENGR 695 Seminar in Research Methods	0
Program Core	12
Program Electives	12
PEEG 699 Master's Thesis	12
Total	**36**

Program Requirements

Students seeking the degree of MSc in Petroleum Engineering must successfully complete a minimum 36 credit hours as specified in the program requirements detailed below, with a minimum CGPA of 3.0. Course selection should be made in consultation with the student's Main Advisor. All courses have a credit rating of three credits each, except ENGR 695 Seminar in Research Methods and the Master's Thesis.

Program Core (12 Credit Hours)

Students must complete the following core courses:

- ENGR 695 Seminar in Research Methods
- ENGR 602 Engineering Numerical Methods
- Select at least three PEEG courses from the list below:
  - PEEG 610 Advanced Well Test Analysis
  - PEEG 620 Advanced Drilling Engineering
  - PEEG 630 Advanced Reservoir Engineering
  - PEEG 640 Well Performance Evaluation

Program Electives (12 Credit Hours)

Students must select four courses from the list below, or from any core courses listed above that are not used to meet the Program Core requirement. Subject to Main Advisor approval, up to two elective courses (6 Credit Hours) can be taken from other MSc programs in the College of Engineering at KU.

- PEEG 621 Underbalanced Drilling
- PEEG 623 Well Stimulation
- PEEG 631 Petroleum Reservoir Simulation
- PEEG 632 Enhanced Oil Recovery
- PEEG 641 Well Completions and Workover
- PEEG 650 Advanced Petroleum Economics
- PEEG 694 Selected Topics in Petroleum Engineering

PEEG 699 Master's Thesis (Minimum 12 Credit Hours)

Students must complete a Master's Thesis that involves creative, research-oriented work within the broad field of petroleum engineering, under the direct supervision of a full-time faculty advisor from the Petroleum Engineering Department, and at least one other full-time faculty who acts as a co-advisor. The outcome of research should demonstrate the synthesis of information into knowledge in a form that may be used by others. The research findings must be documented in a formal thesis and defended successfully in a viva voce examination. Furthermore, the research should lead to publishable quality scholarly articles.

STUDY PLAN

A typical study plan for students enrolled in the MSc PEEG is shown below.

TYPICAL STUDY PLAN FOR FULL-TIME STUDENTS		
	SEMESTER 1	SEMESTER 2
YEAR 1	ENGR 695 Seminar in Research Methods ENGR 602 Engineering Numerical Methods Program Core Course 1 Elective Course 1	Program Core Course 2 Program Core Course 3 Elective Course 2 PEEG 699 Master's Thesis
YEAR 2	Elective Course 3 Elective Course 4 PEEG 699 Master's Thesis	PEEG 699 Master's Thesis

TYPICAL STUDY PLAN FOR PART-TIME STUDENTS		
	SEMESTER 1	SEMESTER 2
YEAR 1	ENGR 695 Seminar in Research Methods ENGR 602 Engineering Numerical Methods Program Core Course 1	Program Core Course 2 Program Core Course 3
YEAR 2	Elective Course 1 PEEG 699 Master's Thesis	Elective Course 2 PEEG 699 Master's Thesis
YEAR 3	Elective Course 3 PEEG 699 Master's Thesis	Elective Course 4 PEEG 699 Master's Thesis

MSC IN SUSTAINABLE CRITICAL INFRASTRUCTURE

ABOUT THE PROGRAM

The Master of Science in Sustainable Critical Infrastructure (MSc SCIN) program will be conducive to developing highly skilled researchers and workforce and attracting substantial government and industry interest. The academic program is designed to develop core capabilities, through the integration of coursework and research that is critical to the region.

Urban development will continue globally while the requirements for reducing its ecological footprint and carbon emissions in particular will be increasingly more aggressive. The Sustainable Critical Infrastructure (SCIN) Program aims at advancing research and education in integrated sustainable infrastructure development. The program is addressed to architects, urban planners and civil engineers, as well as engineers and building scientists interested in infrastructure planning.

The need for urban critical infrastructure development and maintenance will remain acute; as urbanization will be a continuing process, well into the middle of the century to accommodate the growing global population and migration waves. Infrastructures can be defined as "network[s] of independent man-made systems and processes that function collaboratively and synergistically to produce and distribute a continuous flow of essential goods and services." Typical critical infrastructure systems include:

- Transportation networks
- Logistics systems (including waste processing and reverse logistics),
- Buildings and urban components
- Energy generation and distribution systems
- Water supply and wastewater treatments systems,
- Information and communication technology (ICT) systems etc.

The efficiency and reliability of urban critical infrastructure affect many aspects of society that include the cost of food and consumer goods, health and safety of citizens, availability and reliability of power systems, reliability and speed of telecommunications, travel times. Critical infrastructures also affect the environment and natural resources.

PROGRAM EDUCATIONAL OBJECTIVES

The objectives of the MSc in Sustainable Critical Infrastructure program are to produce graduates who possess an:

1. Ability to design integrated urban infrastructure systems for new or existing developments with careful examination of environmental, social and financial requirements.
2. Ability to apply planning and design tools using multi-disciplinary inputs in order effectively generate and implement solutions to urban infrastructure problems.
3. Understanding of the complex interactions between infrastructure systems solutions and their implications on larger scale (regional, national, global) technological, economic, societal and environmental systems with a view on long-term sustainability.
4. Understanding of the value of technical and scientific scholarship, service to society, leadership and life-long learning required to further their career aspirations in support of the needs of the community.

LEARNING OUTCOMES

MSc in Sustainable Critical Infrastructure graduates will be able to:

1. Successfully apply advanced concepts of planning and engineering to identify, formulate and solve complex infrastructure planning problems, particularly as they pertain to sustainable urban infrastructure planning.
2. Successfully apply advanced concepts of infrastructure planning to the analysis, design and development of infrastructure projects, urban design, and transportation systems to meet societal needs.
3. Use advanced techniques, skills, and modern scientific and engineering software tools for planning professional practice.
4. Successfully develop integrated infrastructure plans that account for long term resource availability on one hand and the financial and social constraints on the other with a long-term sustainability objective.
5. Use an advanced approach to design and conduct surveys, and to analyze and interpret data.
6. Communicate effectively in written and oral form, both, individually and as a member of a multidisciplinary team, and thus to put forward the scientific findings at national and international levels successfully.

PROGRAM STRUCTURE AND REQUIREMENTS

Overall Program Structure

The MSc SCIN consists of a minimum 36 credit hours, distributed as follows: 12 credit hours of Program Core courses, 12 credit hours of Elective courses, 12 credit hours of Master's Thesis and a zero credit Research Methods course. The components of the program are summarized in the table below:

PROGRAM COMPONENT	CREDIT HOURS
ENGR 695 Seminar in Research Methods	0
Program Core	12
Program Electives	12
SCIN 699 Master's Thesis	12
Total	**36**

Program Requirements

Students seeking the degree of MSc in Sustainable Critical Infrastructure must successfully complete a minimum 36 credit hours as specified in the program requirements detailed below, with a minimum CGPA of 3.0. Course selection should be made in consultation with the student's Main Advisor. All courses have a credit rating of three credits each, except ENGR 695 Seminar in Research Methods and the Master's Thesis.

Program Core (12 Credit Hours)

Students must complete the following core courses.

- ENGR 695 Seminar in Research Methods
- ESMA 603 Systems Optimization or ESMA 610 Business Analytics, Statistics for Engineering Systems

- SCIN 601 Transportation Systems Analysis: Demand and Economics
- SCIN 602 Urban Design for Sustainability: Theory and Practice
- SCIN 612 Sustainable Building Science: Fundamentals, Tools, and Applications

Program Electives and Tracks (12 Credit Hours)

Students must select any four elective courses from the list below. Subject to Main Advisor approval, up to two elective courses (6 Credit Hours) can be taken from other MSc programs in the College of Engineering at KU.

- SCIN 603 Management of Infrastructure Systems
- SCIN 604 Infrastructure Finance
- SCIN 605 Planning Theory, Practice, and Ethics
- SCIN 606 Geographic Information Systems
- SCIN 607 Infrastructure and Development
- SCIN 608 Urban Planning and Design Studio
- SCIN 609 Comparative Land Use and Transportation Planning
- SCIN 610 Public Transportation Systems
- SCIN 611 Thermal Energy in Buildings
- SCIN 612 Sustainable Building Science: Fundamentals, Tools, and Applications
- SCIN 694 Selected Topics in Sustainable Critical Infrastructure

Students wishing to complete an optional specialization track, must select at least three of the four elective courses from one of the groups listed below. The track will be noted on the student's official transcript, provided that the student fulfills the following requirements:

- Complete a minimum of three courses (9 Credit Hours) from the same track specialization; and
- Complete a Master's research thesis within the domain of the track specialization.

PROGRAM TRACKS

Sustainable Urban Planning and Design

- SCIN 603 orSCIN 604 Management of Infrastructure Systems Infrastructure Finance
- SCIN 605 Planning Theory, Practice, and Ethics
- SCIN 606 Geographic Information Systems
- SCIN 607 Infrastructure and Development
- SCIN 608 Urban Planning and Design Studio

Transportation Planning

- SCIN 603 orSCIN 604 Management of Infrastructure Systems Infrastructure Finance
- SCIN 606 Geographic Information Systems
- SCIN 607 Infrastructure and Development
- SCIN 609 Comparative Land Use and Transportation Planning
- SCIN 610 Public Transportation Systems

SCIN 699 MASTER'S THESIS (MINIMUM 12 CREDIT HOURS)

Students must complete a Master's Thesis that involves creative, research-oriented work within the broad field of sustainable critical infrastructure, under the direct supervision of a full-time faculty advisor from the Industrial and Systems Engineering Department, and at least one other full-time faculty who acts as a co-advisor. The outcome of research should demonstrate the synthesis of information into knowledge in a form that may be used by others. The research findings must be documented in a formal thesis and defended successfully in a viva voce examination. Furthermore, the research should lead to publishable quality scholarly articles.

STUDY PLAN

A typical study plan for students enrolled in the MSc SCIN is shown below.

TYPICAL STUDY PLAN FOR FULL-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods ESMA 603 or ESMA 610 SCIN Core Course 1 SCIN Core Course 2	SCIN Core Course 3 Elective Course 1 SCIN 699 Master's Thesis
YEAR 2	Elective Course 2 Elective Course 3 SCIN 699 Master's Thesis	Elective Course 4 SCIN 699 Master's Thesis

TYPICAL STUDY PLAN FOR PART-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods SCIN Core Course 1 SCIN Core Course 2	SCIN Core Course 3 ESMA 603 or ESMA 610
YEAR 2	Elective Course 1 SCIN 699 Master's Thesis	Elective Course 2 SCIN 699 Master's Thesis
YEAR 3	Elective Course 3 SCIN 699 Master's Thesis	Elective Course 4 SCIN 699 Master's Thesis

MSC IN WATER AND ENVIRONMENTAL ENGINEERING

ABOUT THE PROGRAM

The Master of Science in Water and Environmental Engineering (MSc WENV) aims to provide students with a comprehensive understanding of the challenges behind one of the foundations of sustainable development – ensuring sufficient and equitable access to clean water. Furthermore, the program gives students the opportunity to deepen their knowledge in one of two specialization tracks - Water and Environmental Technologies or Water and Environmental Resources - and contribute to the process of discovery and knowledge creation through the conduct of original research. Candidates for this degree are taught and supervised by experienced faculty and are expected to demonstrate initiative in their approach and innovation in their work.

PROGRAM EDUCATIONAL OBJECTIVES

The objectives of the MSc in Water and Environmental Engineering program are to produce graduates who will have an:

1. An ability to identify and address current and future societal problems related to water, waste, and the environment within a broader framework of sustainable development.
2. An ability to apply a multi-disciplinary approach to conceive, plan, design, and implement solutions to problems in the field of water and environmental engineering.
3. An understanding of the impact of solutions to water and environmental engineering problems in a global, economic, environmental, and societal systems context.
4. An understanding of the value of technical and scientific scholarship, service to society, leadership and lifelong learning required to further their career aspirations.

LEARNING OUTCOMES

MSc in Water and Environmental Engineering graduates will be able to:

1. Successfully apply advanced concepts of fundamental sciences and engineering to identify, formulate, and solve complex water and environmental engineering problems, and understand the impact of such solutions on sustainable development.
2. Successfully apply advanced concepts of water and environmental engineering and fundamental sciences to design, analyze, and develop technologies, processes or systems to meet desired needs of society, both, professionally and ethically.
3. Use an advanced and rigorous approach to the design and execution of experiments, and to the analysis and interpretation of experimental data.
4. Be knowledgeable of contemporary issues and research challenges/opportunities related to water and environmental engineering, and engage in lifelong learning to keep abreast of such issues.
5. Use advanced techniques, skills, and modern scientific and engineering tools for problems related to professional practice in the field of water and environmental engineering.
6. Communicate effectively and professionally in written and oral form, both, individually and as a member of a multidisciplinary team.

PROGRAM STRUCTURE AND REQUIREMENTS

Overall Program Structure

The MSc WENV consists of a minimum 36 credit hours, distributed as follows: 12 credit hours of Program Core courses, 12 credit hours of Elective courses, 12 credit hours of Master's Thesis and a zero credit Research Methods course. The components of the program are summarized in the table below:

PROGRAM COMPONENT	CREDIT HOURS
ENGR 695 Seminar in Research Methods	0
Program Core	6
Track Core	6
Program Electives	12
WENV 699 Master's Thesis	12
Total	**36**

Program Requirements

Students seeking the degree of MSc in Water and Environmental Engineering must successfully complete a minimum 36 credit hours as specified in the program requirements detailed below, with a minimum CGPA of 3.0. Course selection should be made in consultation with the student's Main Advisor. All courses have a credit rating of three credits each, except ENGR 695 Seminar in Research Methods and the Master's Thesis.

Program Core (6 Credit Hours)

Students must complete the following core courses:

- ENGR 695 Seminar in Research Methods
- WENV 601 Chemicals in the Environment: Fate and Transport
- WENV 622 Data Analysis for Environmental Modeling or CHEG 620 Mathematical Methods in Chemical Engineering

Track Core (6 Credit Hours)

Students must select one of the specialization tracks listed below. To fulfill track requirements, students must complete a minimum of 6 credit hours, consisting of two track core courses.

WATER AND ENVIRONMENTAL TECHNOLOGIES TRACK

This track allows students to focus on the selection, design, and performance evaluation of technologies relevant to water production, municipal and industrial wastewater treatment, water reuse, water distribution, desalination technologies and hazardous waste treatment. It is mandatory for students to complete the following listed courses for specializing in this track:

- WENV 604 / CHEG 604 Desalination
- WENV 606 / CHEG 606 Wastewater Treatment Engineering

WATER AND ENVIRONMENTAL RESOURCES TRACK

This track in Water and Environmental Resources allows students to focus on the development, management, integration, and protection of water resources, hydrological modeling, environmental monitoring, and hydro-climatic modeling and climate change mitigation. It is mandatory for students to complete the following listed courses for specializing in this track:

- WENV 602 Industrial Ecology
- WENV 611 Hydrologic Analysis

Program Electives (12 Credit Hours)

Students must select any four elective courses from the list below, or from any core courses listed above that are not used to meet the Track Core requirement. Subject to approval of the Main Advisor, up to two elective courses (6 Credit Hours) can be taken from other MSc programs in the College of Engineering at KU.

- WENV 623 Global Climate Change: Impacts and Adaptation
- WENV 694 Selected Topics in Water and Environmental Engineering

WENV 699 Master's Thesis (Minimum 12 Credit Hours)

Students must complete a Master's Thesis that involves creative, research-oriented work within the broad field of water and environmental engineering, under the direct supervision of a full-time faculty advisor from the Civil Infrastructure and Environmental Engineering Department or the Chemical Engineering Department, and at least one other full-time faculty who acts as a co-advisor. The outcome of research should demonstrate the synthesis of information into knowledge in a form that may be used by others. The research findings must be documented in a formal thesis and defended successfully in a viva voce examination. Furthermore, the research should lead to publishable quality scholarly articles.

STUDY PLAN

A typical study plan for students enrolled in the MSc WENV is shown below.

TYPICAL STUDY PLAN FOR FULL-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods Program Core Course 1 Program Core Course 2 Elective Course 1	Track Core Course 1 Track Core Course 2 Elective Course 2 WENV 699 Master's Thesis
YEAR 2	Elective Course 3 Elective Course 4 WENV 699 Master's Thesis	WENV 699 Master's Thesis

TYPICAL STUDY PLAN FOR PART-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods Program Core Course 1 Program Core Course 2	Track Core Course 1 Track Core Course 2
YEAR 2	Elective Course 1 WENV 699 Master's Thesis	Elective Course 2 WENV 699 Master's Thesis
YEAR 3	Elective Course 3 WENV 699 Master's Thesis	Elective Course 4 WENV 699 Master's Thesis

MENG IN HEALTH, SAFETY AND ENVIRONMENTAL ENGINEERING

ABOUT THE PROGRAM

The Master of Engineering in Health, Safety and Environmental Engineering (MEng HSEG) program is designed for educational preparation of two types of professionals:

- Engineering graduates who are currently working as engineers in industry and who intend to stay in that type of job, but who want to embed HSE in their engineering functions. These graduates will have diverse capabilities in the various aspects of HSE and will use this knowledge to manage risk as they devise optimal engineering and operational solutions within the constraints of regulatory mandates and best practices.
- Engineering graduates who wish to assume varying levels of HSE responsibilities in one or more aspects of a company's HSE department/program. These graduates will have sufficient background to assume the role of a general HSE engineering practitioner/manager while possessing additional capabilities in any one of the offered HSE areas of concentrations.

PROGRAM EDUCATIONAL OBJECTIVES

The objectives of the MEng in Health, Safety and Environmental Engineering program are to produce graduates who:

1. Apply their scientific knowledge and engineering skills to develop innovative solutions to HSEG problems in occupational setting;
2. Advance professionally and are recognized as leaders in the HSEG field;
3. Communicate effectively regarding HSEG issues to management, employees and other stakeholders; and
4. Demonstrate knowledge of their ethical and professional responsibilities, as well as applicable standards and regulations.

LEARNING OUTCOMES

MEng in Health, Safety and Environmental Engineering graduates will have the ability to:

1. Anticipate, recognize, and evaluate hazardous conditions and work practices in business and industry;
2. Develop/implement engineering and administrative control strategies for identified hazardous conditions and work practices in business and industry;
3. Communicate effectively in written and oral forms at the level of professionals in HSEG positions;
4. Conduct themselves in a professional and ethical manner;
5. Function as members of teams working towards achieving solutions to defined problems; and
6. Demonstrate research skills relevant to the disciplines within HSEG.

PROGRAM STRUCTURE AND REQUIREMENTS

Overall Program Structure

The MEng in HSE Engineering program consists of a minimum 30 credit hours, distributed as follows: 12 credit hours of Program Core courses, 15 credit hours of elective courses, 3 credit hours of HSEG Graduate Project (capstone course) and a zero credit Research Methods course. The components of the program are summarized in the table below:

PROGRAM COMPONENT	CREDIT HOURS
ENGR 695 Seminar in Research Methods	0
Program Core	12
Program Electives	12
Free Technical Elective	3
HSEG 697 HSEG Graduate Project	3
Total	**30**

Program Requirements

Students seeking the degree of MEng in HSE Engineering must successfully complete a minimum of 30 credit hours as specified in the program requirements detailed below, with a minimum CGPA of 3.0. Course selection should be made in consultation with the student's Main Advisor. All courses have a credit rating of three credits each, except ENGR 695 Seminar in Research Methods.

Program Core (12 credit hours)

Students must complete the following core courses:

- ENGR 695 Seminar in Research Methods
- HSEG 601 Introduction to HSE Engineering
- HSEG 602 Industrial Hygiene Engineering
- HSEG 605 System Safety Engineering and Risk Management
- HSEG 606 Fire Protection Engineering

HSEG 697 HSEG Graduate Project (3 credit hours)

Students must complete the individual capstone project.

Free Technical Elective (3 credit hours)

Students can select any course from the Master's programs offered in the College of Engineering provided that they meet the prerequisites of that particular course.

Program Electives and Concentrations (12 credit hours)

Students must select any four elective courses from the list below, in consultation with their Main Advisor:

- HSEG 604 Hazard Control in Production Systems
- HSEG 607 Industrial Security and Disaster Preparedness
- HSEG 608 QHSE Program Management
- HSEG 610 Hazardous Waste Management
- HSEG 611 Ergonomics and Human Factors Engineering
- HSEG 613 Analysis and Design of Air Pollution Control Systems
- HSEG 694 Selected Topics in HSEG
- MEEN 611 Combustion Theory and Applications
- MEEN 613 Advanced Heat Transfer
- MEEN 618 Computational Fluid Dynamics and Fire Modeling
- MEEN 619 Fire Dynamics Laboratory
- CHEG 644 Consequence Analysis of Chemical Releases
- CHEG 655 Air Quality Management
- CHEG 659 Engineering Design for Process Safety
- NUCE 606 Radiation Measurement and Applications
- NUCE 607 Principles of Radiological Protection
- NUCE 608 Radiological Protection in Planned Exposure Situations
- NUCE 609 Radiological Protection in Existing and Emergency Exposure Situations

- NUCE 615 Radiation Dosimetry
- NUCE 616 Occupational Radiological Protection
- NUCE 623 Radiological Environmental Impact Assessment
- NUCE 625 Biological Effects of the Exposure to Ionizing Radiation
- CIVE 634 Design of Civil Engineering Structures for Fire Protection

Alternatively, students wishing to complete an optional concentration, must complete a minimum of four elective courses from one of the groups listed below. The concentration will be noted on the student's official transcript, provided that the student fulfills the following requirements:

- Complete a minimum of four courses (12 credit hours) from the same concentration; and
- Complete a HSEG Graduate Project within the domain of the concentration.

PROGRAM CONCENTRATIONS

Fire Protection Engineering

- MEEN 611 Combustion Theory and Applications
- MEEN 613 Advanced Heat Transfer
- MEEN 618 Computational Fluid Dynamics and Fire Modeling
- MEEN 619 Fire Dynamics Laboratory

Process Safety Engineering

- CHEG 644 Consequence Analysis of Chemical Releases
- CHEG 655 Air Pollution Control Engineering
- CHEG 659 Engineering Design for Process Safety
- CHEG 651 Combustion and Air Pollution Control

Radiation Protection Engineering

- NUCE 606 Radiation Measurement and Applications
- NUCE 607 Principles of Radiological Protection
- NUCE 608 Radiological Protection in Planned Exposure Situations
- NUCE 609 Radiological Protection in Existing and Emergency Exposure Situations
- NUCE 615 Radiation Dosimetry
- NUCE 616 Occupational Radiological Protection
- NUCE 623 Radiological Environmental Impact Assessment
- NUCE 625 Biological Effects of the Exposure to Ionizing Radiation

STUDY PLAN

A typical study plan for students enrolled in the MEng in HSE Engineering is shown below.

TYPICAL STUDY PLAN FOR FULL-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods HSEG 601 Introduction to HSE Engineering HSEG 602 Industrial Hygiene Engineering HSEG 605 System Safety Engineering and Risk Management	HSEG 606 Fire Protection Engineering Program Elective Course 1 Program Elective Course 2
YEAR 2	Program Elective Course 3 Program Elective Course 4 Free Technical Elective	HSEG 697 HSEG Graduate Project

TYPICAL STUDY PLAN FOR PART-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 695 Seminar in Research Methods HSEG 601 Introduction to HSE Engineering HSEG 602 Industrial Hygiene Engineering	HSEG 606 Fire Protection Engineering Program Elective Course 1
YEAR 2	HSEG 605 System Safety Engineering and Risk Management Program Elective Course 2	Program Elective Course 3 Program Elective Course 4
YEAR 3	Free Technical Elective HSEG 697 HSEG Graduate Project	

PHD IN ENGINEERING

ABOUT THE PROGRAM

The Doctor of Philosophy in Engineering (PhD ENGR) is awarded to candidates who successfully complete a program of advanced courses in engineering and conduct independent research of a specialized area within their selected discipline. Students are expected to seek novel solutions that advance the boundaries of engineering knowledge, demonstrate initiative in their approach and innovation in their work. PhD candidates prepare and present a dissertation on their chosen area. Research may be undertaken in a variety of topics corresponding to the areas of focus identified by the University.

Candidates applying to the program may opt for a PhD in Engineering with a concentration in one of the engineering areas listed below. The concentration will be specified on the student's diploma and official transcript.

- Aerospace Engineering
- Biomedical Engineering
- Chemical Engineering
- Civil Infrastructure and Environmental Engineering
- Electrical and Computer Engineering
- Engineering Systems and Management
- Material Science and Engineering
- Mechanical Engineering
- Nuclear Engineering
- Petroleum Engineering
- Robotics

Selecting a concentration is not mandatory and students who prefer to pursue a multidisciplinary form of research have the option to complete a multidisciplinary PhD in Engineering (i.e. with no one specialization). If this option is selected, only the title of the degree will be stated on the diploma and transcript of the student.

PROGRAM EDUCATIONAL OBJECTIVES

Program Educational Objectives are broad statements that describe the career and professional accomplishments that graduates are expected to attain within few years of graduation. The PhD in Engineering program aims to produce graduates with the disciplinary preparation and ability to:

1. Synthesize scientific and technical engineering knowledge to identify, formulate and solve research challenges, and effectively disseminate the results to a variety of audiences.
2. Work across multiple disciplines and develop their individual academic, professional and career focus.
3. Keep abreast of the latest advances in science and engineering that contribute to the advancement of knowledge for the benefit of society.

LEARNING OUTCOMES

Students graduating with a PhD in Engineering will have the ability to:

1. Demonstrate appropriate breadth and depth of knowledge that is at the frontier of their disciplines and areas of specialization.
2. Conduct and defend original independent research that results in significant contributions to knowledge in the field and leads to publishable quality scholarly articles.
3. Understand and value diverse methodologies and techniques for solving critical problems in research.
4. Verify, justify and evaluate the various aspects of the solution to a complex engineering problem.
5. Communicate effectively and professionally, in written and oral forms, the major tenets of their field and their work to a variety of audiences.
6. Demonstrate a commitment to ethical behavior in research and professional activities.
7. Contribute effectively in multidisciplinary collaborative environments.

ADMISSION REQUIREMENTS

In addition to satisfying the University general admission requirements, applicants for the PhD in Engineering must demonstrate that they have the appropriate technical background. Disciplines acceptable for admission to each of the PhD in Engineering concentrations include, but are not limited to, the ones listed below.

PHD CONCENTRATION	ENGINEERING DISCIPLINE
AEROSPACE ENGINEERING	• Aerospace/Aeronautical Engineering • Mechanical/Mechatronics Engineering • Electrical and Computer Engineering/Science
BIOMEDICAL ENGINEERING	• Biomedical Engineering • Bio-Engineering/Science • Mechanical/Mechatronics Engineering • Aerospace/Aeronautical Engineering • Electrical and Computer Engineering/Science
CHEMICAL ENGINEERING	• Chemical Engineering • Biomedical Engineering • Civil and Environmental Engineering • Materials Engineering/Science • Mechanical/Mechatronics Engineering • Nuclear Engineering • Industrial Systems Engineering • Petroleum Engineering
CIVIL INFRASTRUCTURE AND ENVIRONMENTAL ENGINEERING	• Civil Infrastructural Engineering • Environmental Engineering • Mechanical Engineering • Materials Engineering/Science • Chemical Engineering • Applied Mathematics • Computer Science • Bio-Sciences • Chemistry
ELECTRICAL AND COMPUTER ENGINEERING	• Electrical/Electronic Engineering • Communication Engineering • Computer Engineering • Computer Science • Software Engineering • Information Technology • Mechatronics • Robotics • Material Engineering/Science • Applied Mathematics • Applied Physics

ENGINEERING SYSTEMS AND MANAGEMENT	• Industrial Engineering • Systems Engineering • Electrical Engineering • Computer Engineering • Civil and Environmental Engineering, • Architectural Engineering • Aerospace/Aeronautical Engineering • Mechanical Engineering • Materials Engineering/Science • Nuclear Engineering • Chemical Engineering • Applied Mathematics • Computer Science • Bio-Sciences
MATERIAL SCIENCE AND ENGINEERING	• Materials Engineering/Science • Mechanical/Mechatronics Engineering • Aerospace/Aeronautical Engineering • Civil and Environmental Engineering • Chemical Engineering • Nuclear Engineering • Industrial Systems Engineering
MECHANICAL ENGINEERING	• Mechanical/Mechatronics Engineering • Aerospace/Aeronautical Engineering • Civil and Environmental Engineering • Chemical Engineering • Materials Engineering/Science • Nuclear Engineering • Industrial Systems Engineering
NUCLEAR ENGINEERING	• Nuclear Engineering • Mechanical/Mechatronics Engineering • Aerospace/Aeronautical Engineering • Electrical and Computer Engineering/Science • Chemical Engineering • Engineering/Medical Physics • Materials Engineering/Science
PETROLEUM ENGINEERING	• Petroleum Engineering • Chemical Engineering • Applied Mathematics • Hydrology • Geophysics, • Geology Engineering • Civil Engineering • Aerospace Engineering • Nuclear Engineering
ROBOTICS	• Robotics • Mechanical/Mechatronics Engineering • Aerospace/Aeronautical Engineering • Biomedical Engineering • Materials Engineering/Science • Nuclear Engineering • Electrical and Computer Engineering/Science • Information Technology

MATHEMATICS REQUIREMENTS

Mathematics is an integral element of all engineering disciplines. Therefore, the PhD in Engineering program will assess the mathematical background of the students at the admissions stage and require admitted students to pass at least two PhD level courses with a substantial mathematical component as explained below.

1. The admissions committee will assess the mathematical background of all students applying for the PhD in Engineering, taking into account mathematics courses completed at Master's and undergraduate levels, along with the mathematical skills essential for the particular PhD concentration the student would like to pursue. Depending on the committee's assessment, the student may be conditionally admitted subject to successful completion of one or two courses from an approved list of graduate-level mathematics courses. Credits from these courses do not count toward fulfillment of the PhD degree requirements and do not contribute to the student's CGPA calculation. The current list of approved graduate-level mathematics courses is:
   - ENGR 602 Engineering Numerical Methods
   - ENGR 603 Multivariate Data Analysis
   - ENGR 605 Systems Optimization
   - ENGR 606 Advanced Engineering Mathematics

2. All students must complete a minimum of 6 credit hours of PhD level technical elective courses with a substantial mathematics component. These courses count towards the PhD degree program taught course credit hour requirement and contribute to the graduation CGPA. The current list of PhD level courses with a substantial mathematics component includes:

   - AERO 701 Nonlinear Structural Dynamics
   - AERO 703 Numerical Methods in Aerofluids
   - AERO 761 Advanced Process Dynamics and Control
   - AERO 764 Optimal Control
   - BMED 711 Biomolecular and Cellular Engineering
   - BMED 712 Rehabilitation and Augmentation of Human Movement
   - BMED 713 Advanced Physiological Systems
   - BMED 716 Medical Device Innovation
   - CHEG 700 Sustainable Desalination Processes
   - CHEG 705 Membrane Technology
   - CHEG 720 Modelling and Eng. of Microbial Env. Bioprocesses
   - CHEG 745 Multicomponent Mass Transfer
   - CHEG 750 Molecular Thermodynamics
   - CHEG 760 Non-Equilibrium Thermodynamics
   - CHEG 765 Computational Fluid Dynamics for Chemical Engineers
   - CHEG 790 Dynamic Behavior of Process Systems
   - CIVE 707 Environmental Remote Sensing and Satellite Image Proc.
   - CIVE 719 Climate Dynamics
   - CIVE 721 Aquatic Chemistry
   - CIVE 750 Non-Linear Mechanics of Construction Materials

- CIVE 751 Non-Linear FE Analysis of Civil Engineering Structures
- ECCE 701 Power System Modelling and Control
- ECCE 703 Embedded Generation Operation and Control
- ECCE 706 Power Quality and FACTS Devices
- ECCE 710 Analysis of Power Systems Over-Voltages and Transients
- ECCE 711 Advanced Power System Grounding and Safety
- ECCE 714 Appl. of Heuristic Optimization Techniques to Power Systems
- ECCE 721 Analog Mixed Signal Design Techniques
- ECCE 722 Numerical Simulation of Circuits and Systems
- ECCE 732 Machine Learning and Applications
- ECCE 733 High Speed Computer Arithmetic
- ECCE 734 Advanced Computer Architecture
- ECCE 735 Advanced Computer Vision Paradigms
- ECCE 738 High Performance Computing
- ECCE 741 Advanced Digital Communications
- ECCE 742 Adv. Conc. in Stoch. Proc., Detection, and Estimation Theory
- ECCE 743 Broadband Communication Systems
- ECCE 744 Optical Wireless Communication System
- ECCE 751 Discontinuous Control Systems
- ECCE 752 Nonlinear Control Systems
- ECCE 753 Computational Prototyping of Dynamical Systems
- ECCE 754 Computational Prototyping of Partial Differential Equations
- ECCE 755 Cognitive Robotics
- ECCE 756 Robotic Perception
- ECCE 757 Control of Robotic Systems
- ECCE 772 Advanced Microsystem Design
- ECCE 773 Photonic Materials and Metamaterials Design for Engineers
- ECCE 774 Advanced Photonic Integrated Circuits
- ESMA 701 Advanced Systems Optimization
- ESMA 710 Times Series Analysis Modeling and Prediction
- ESMA 711 Advanced Business Analytics
- ESMA 720 Advanced Production and Operations Management
- ESMA 721 Stochastic Processes and Applications
- ESMA 730 Complex Network Analysis
- ESMA 781 Modeling Urban Systems Energy Flows
- MEEN 701/AERO 711 Fracture Mechanics and Fatigue
- MEEN 702 Damage Mechanics of Solids and Structures
- MEEN 703 Linear and Nonlinear Finite Element Methods
- MEEN 704 Computational Inelasticity
- MEEN 706 Theory of Plasticity
- MEEN 721 Computational Fluid Mechanics
- MEEN 722 Non-Newtonian Fluid Dynamics

- MEEN 724 Advanced Modeling of Cooling Systems
- MEEN 725 Multiphase Flow in Porous Media
- MEEN 741 Advanced Conduction and Radiation Heat Transfer
- MEEN 742 Advanced Convection Heat Transfer
- MEEN 743 Micro-Nano Energy Transport
- MEEN 761 Advanced Process Dynamics and Control
- MEEN 762 Analysis and Simulation of Mechatronics Systems
- MEEN 763 Theory and Design of Digital Control Systems
- MEEN 764 Optimal Control
- MEEN 765 Acoustics and Noise Control
- MEEN 767 Control of Robotic Systems
- MEEN 791 Estimation and Inference from Data and Models
- MSEN 740 Advances in Inv. of Intermolecular and Surface Forces
- NUCE 701 Advanced Computational Methods of Particle Transport
- NUCE 702 Nuclear Systems and Materials/Accident Analysis
- NUCE 704 The Reactor Core Design Analysis for Light Water Reactors
- NUCE 705 Nuclear Criticality Safety Assessment
- PEEG 723 Stimulation of Conventional and Unconventional Reservoirs
- PEEG 730 Fluid Flow and Transport Processes in Porous Media
- PEEG 732 Hybrid Enhanced Oil Recovery
- PEEG 733 Miscible Gas Flooding
- PEEG 746 Emerging Well Construction Technology
- PEEG 747 Horizontal and Multilateral Drilling and Completion
- PEEG 749 Characterization and Modelling of Unconv. Reservoirs
- PEEG 752 Simulation of Naturally Fractured Reservoirs

PROGRAM STRUCTURE AND REQUIREMENTS

Overall Program Structure

The PhD ENGR consists of a minimum 60 credit hours, distributed as follows: 3 credit hours of Program Core courses, 21 credit hours of Program Technical Elective courses, 36 credit hours of Dissertation research and two zero credit PhD Research Seminar courses. The technical background of the student will be assessed by a Written Qualifying Examination (WQE), followed by a Research Proposal Examination (RPE) which the student must successfully complete in order to progress further in the program. The components of the PhD program are summarized in the table below:

PROGRAM COMPONENT	CREDIT HOURS
ENGR 701 Research Methods in Engineering	3
Program Electives	21
ENGR 703 PhD Research Seminar I	0
ENGR 704 PhD Research Seminar II	0
ENGR 795 Written Qualifying Examination (WQE)	0
ENGR 796 Research Proposal Examination (RPE)	0
ENGR 799 PhD Research Dissertation	36
Total	60

PROGRAM REQUIREMENTS

Students seeking the degree of PhD in Engineering must successfully complete a minimum 60 credit hours as specified in the program requirements detailed below, with a minimum CGPA of 3.0. Course selection should be made in consultation with the student's Main Advisor and must be aligned to the chosen area(s) of research.

All courses have a credit rating of three credits each, except ENGR 703/704 PhD Research Seminar, ENGR 795 Written Qualifying Exam, ENGR 796 Research Proposal Exam, and the PhD Dissertation.

Program Core (3 credit hours)

Students must complete the following core courses:

- ENGR 701 Research Methods in Engineering
- ENGR 703 PhD Research Seminar I
- ENGR 704 PhD Research Seminar II
- ENGR 795 PhD Written Qualifying Exam (WQE)
- ENGR 796 PhD Research Proposal Exam (RPE)

Program Electives and Concentrations (21 credit hours)

Students must complete a minimum of seven technical elective courses from the list below. At least two of these electives (6 credit hours) must be PhD level courses with a substantial mathematical component, as outlined in the 'Mathematics Requirements' section above.

Subject to approval of the Main Advisor, up to two elective courses (6 credit hours) can be taken from relevant MSc programs in the College of Engineering at KU, provided that the student has not previously used those courses to satisfy the requirement of his/her Master's degree. A copy of the student's MSc transcript must be provided when a request is made to take MSc level courses.

Students wishing to complete a PhD in Engineering with a concentration in a given area, must select at least four (12 credit hours) of the seven technical elective courses from one of the groups

listed below. All selected concentration courses must be at PhD level. The concentration will be noted on the student's diploma and official transcript provided that the student fulfills the following requirements:

- Complete a minimum of four PhD level courses (12 credit hours) from the same concentration; and
- Complete a PhD research dissertation within the domain of the concentration.

For a PhD in Engineering without a concentration in a given area, the selected technical elective courses must be aligned to the interdisciplinary/multidisciplinary research the student will be conducting towards the PhD dissertation. The courses must be selected in close consultation with the student's Main Advisor.

The PhD elective courses are listed below under the various engineering concentration fields supported by the program. Students must take into account the above points when choosing their electives.

PHD IN ENGINEERING CONCENTRATIONS

Aerospace Engineering

- AERO 701 Nonlinear Structural Dynamics
- AERO 702 Advanced Composite Materials and Structures
- AERO 703 Numerical Methods in Aerofluids
- AERO 711 / MEEN 701 Fracture Mechanics and Fatigue
- AERO 712 / MEEN 702 Damage Mechanics of Solis and Structures
- AERO 723 / MEEN 723 Advanced Combustion
- AERO 761 / MEEN 761 Advanced Process Dynamics and Control
- AERO 764 / MEEN 764 Optimal Control
- AERO 794 Selected Topics in Aerospace Engineering

Biomedical Engineering

- BMED 711Biomolecular and Cellular Engineering
- BMED 712Rehabilitation and Augmentation of Human Movement
- BMED 713Advanced Physiological Systems
- BMED 716Medical Device Innovation
- BMED 794 Selected Topics in Biomedical Engineering

Chemical Engineering

- CHEG 700 / CIVE 714 Sustainable Desalination Processes
- CHEG 703 Applied Nanotechnology
- CHEG 705 / CIVE 717 Membrane Technology
- CHEG 708 Phase Equilibria

- CHEG 710 Kinetics and Mechanisms
- CHEG 712 Physical and Chemical Treatment of Waters
- CHEG 715 Biological Wastewater Treatment
- CHEG 720 Modelling and Engineering of Microbial Environmental Bioprocesses
- CHEG 730 Experimental Techniques and Instrumentation
- CHEG 735 Electrochemical Engineering
- CHEG 745 Multicomponent Mass Transfer
- CHEG 750 Molecular Thermodynamics
- CHEG 760 Non-Equilibrium Thermodynamics
- CHEG 765 Computational Fluid Dynamics for Chemical Engineers
- CHEG 770 Heterogeneous Catalysis
- CHEG 790 Dynamic Behavior of Process Systems
- CHEG 794 Selected Topics in Chemical Engineering

Civil Infrastructure and Environmental Engineering

- CIVE 703 Ground Water Hydrology
- CIVE 707 Environmental Remote Sensing and Satellite Image Processing
- CIVE 712 Remediation Engineering
- CIVE 714 / CHEG 700 Sustainable Desalination Processes
- CIVE 717 / CHEG 705 Membrane Technology
- CIVE 718 Advanced Topics in Applied Environmental Chemistry
- CIVE 719 Climate Dynamics
- CIVE 720 Nanotechnology in Water Purification
- CIVE 721 Aquatic Chemistry
- CIVE 722 Solid and Hazardous Waste Management
- CIVE 730 Public Transit Operations and Planning
- CIVE 750 Non-Linear Mechanics of Construction Materials
- CIVE 751 Non-Linear FE Analysis of Civil Engineering Structures
- CIVE 755 Geotechnical Natural Hazards Mitigation
- CIVE 756 Chemo-Mechanical Modelling and Design of Flexible Pavements
- CIVE 760 Construction Procurement
- CIVE 761 Productivity Improvement in Construction
- CIVE 762 Advanced Building Info Management
- CIVE 794 Selected Topics in Civil Infrastructural and Environmental Engineering

Electrical and Computer Engineering

- ECCE 701 Power System Modelling and Control
- ECCE 703 Embedded Generation Operation and Control
- ECCE 706 Power Quality and FACTS Devices

- ECCE 710 Analysis of Power Systems Over-Voltages and Transients
- ECCE 711 Advanced Power System Grounding and Safety
- ECCE 714 Application of Heuristic Optimization Techniques to Power Systems
- ECCE 721 Analog Mixed Signal Design Techniques
- ECCE 722 Numerical Simulation of Circuits and Systems
- ECCE 723 High Speed Communication Circuits
- ECCE 730 Advanced Deep Learning
- ECCE 731 Distributed Computing
- ECCE 732 Machine Learning and Applications
- ECCE 733 High Speed Computer Arithmetic
- ECCE 734 Advanced Computer Architecture
- ECCE 735 Advanced Computer Vision Paradigms
- ECCE 736 Advanced Topics in IoT and Blockchain
- ECCE 737 Network and Information Security
- ECCE 738 High Performance Computing
- ECCE 741 Advanced Digital Communications
- ECCE 742 Advanced Concepts in Stochastic Processes, Detection, and Estimation Theory
- ECCE 743 Broadband Communication Systems
- ECCE 744 Optical Wireless Communication Systems
- ECCE 751 Discontinuous Control Systems
- ECCE 752 Nonlinear Control Systems
- ECCE 753 Computational Prototyping of Dynamical Systems
- ECCE 754 Computational Prototyping of Partial Differential Equations
- ECCE 755 Cognitive Robotics
- ECCE 756 Robotic Perception
- ECCE 771 Advanced Integrated Circuits Technology
- ECCE 772 Advanced Microsystem Design
- ECCE 773 Photonic Materials and Metamaterials Design for Engineers
- ECCE 774 Advanced Photonic Integrated Circuits
- ECCE 778 Physics and Manufacturability of Advanced Micro and Nano Devices
- ECCE 781 The Physics of Solar Cells
- ECCE 794 Selected Topics in Electrical and Computer Engineering

Engineering Systems and Management

- ESMA 701 Advanced Systems Optimization
- ESMA 710 Times Series Analysis Modeling and Prediction
- ESMA 711 Advanced Business Analytics
- ESMA 720 Advanced Production and Operations Management
- ESMA 721 Stochastic Processes and Applications
- ESMA 722 Technology Strategy

- ESMA 730 Complex Network Analysis
- ESMA 740 Sustainable Development and Policy
- ESMA 741 Advanced Modeling for Energy Planning
- ESMA 742 Energy Economics Finance and Policy
- ESMA 743 Engineering Energy and Poverty Solutions
- ESMA 780 Advanced Urbanism: Urban Design Ideals and Action
- ESMA 781 Modeling Urban Systems Energy Flows
- ESMA 794 Selected Topics in Engineering Systems and Management

Material Science and Engineering

- MSEN 701 Electrochemical Processes and Devices
- MSEN 710 Advanced Solid State Physics
- MSEN 712 Imaging of Materials: Scanning Electron Microscopy and X-ray Microanalysis
- MSEN 715 Advanced Imaging of Materials: Transmission Electron Microscopy
- MSEN 730 Science and Engineering of Thin Films, Surfaces and Interfaces
- MSEN 740 Advances in Investigation of Intermolecular and Surface Forces
- MSEN 750 High Efficiency Silicon Solar Cells: Designs and Technologies
- MSEN 760 Thin Film Solar Cells: From Design to Applications
- MSEN 794 Selected Topics in Materials Science and Engineering

Mechanical Engineering

- MEEN 701 / AERO 711 Fracture Mechanics and Fatigue
- MEEN 702 / AERO 712 Damage Mechanics of Solis and Structures
- MEEN 703 Linear and Nonlinear Finite Element Methods
- MEEN 704 Computational Inelasticity
- MEEN 705 Micromechanics of Materials
- MEEN 706 Theory of Plasticity
- MEEN 721 Computational Fluid Mechanics
- MEEN 722 Non-Newtonian Fluid Dynamics
- MEEN 723 AERO 723 Advanced Combustion
- MEEN 724 Advanced Modeling of Cooling Systems
- MEEN 725 Multiphase Flow in Porous Media
- MEEN 741 Advanced Conduction and Radiation Heat Transfer
- MEEN 742 Advanced Convection Heat Transfer
- MEEN 743 Micro-Nano Energy Transport
- MEEN 744 Interfacial Transport and Phase Change Heat Transfer
- MEEN 745 Concentrated Solar Power and Thermal Energy Storage
- MEEN 761 AERO 761 Advanced Process Dynamics and Control
- MEEN 762 Analysis and Simulation of Mechatronics Systems
- MEEN 763 Theory and Design of Digital Control Systems

- MEEN 764 AERO 764 Optimal Control
- MEEN 765 Acoustics and Noise Control
- MEEN 766 MEMS Theory and Applications
- MEEN 781 Materials Selection in Mechanical Design
- MEEN 782 Materials Characterization Techniques
- MEEN 791 Estimation and Inference from Data and Models
- MEEN 792 Advanced Nanomaterials and Their Mechanical Applications
- MEEN 794 Selected Topics in Mechanical Engineering

Nuclear Engineering

- NUCE 701 Advanced Computational Methods of Particle Transport
- NUCE 702 Nuclear Systems and Materials/Accident Analysis
- NUCE 703 Aging Management of Nuclear Materials
- NUCE 704 The Reactor Core Design Analysis for Light Water Reactors
- NUCE 705 Nuclear Criticality Safety Assessment
- NUCE 794 Selected Topics in Nuclear Engineering

Petroleum Engineering

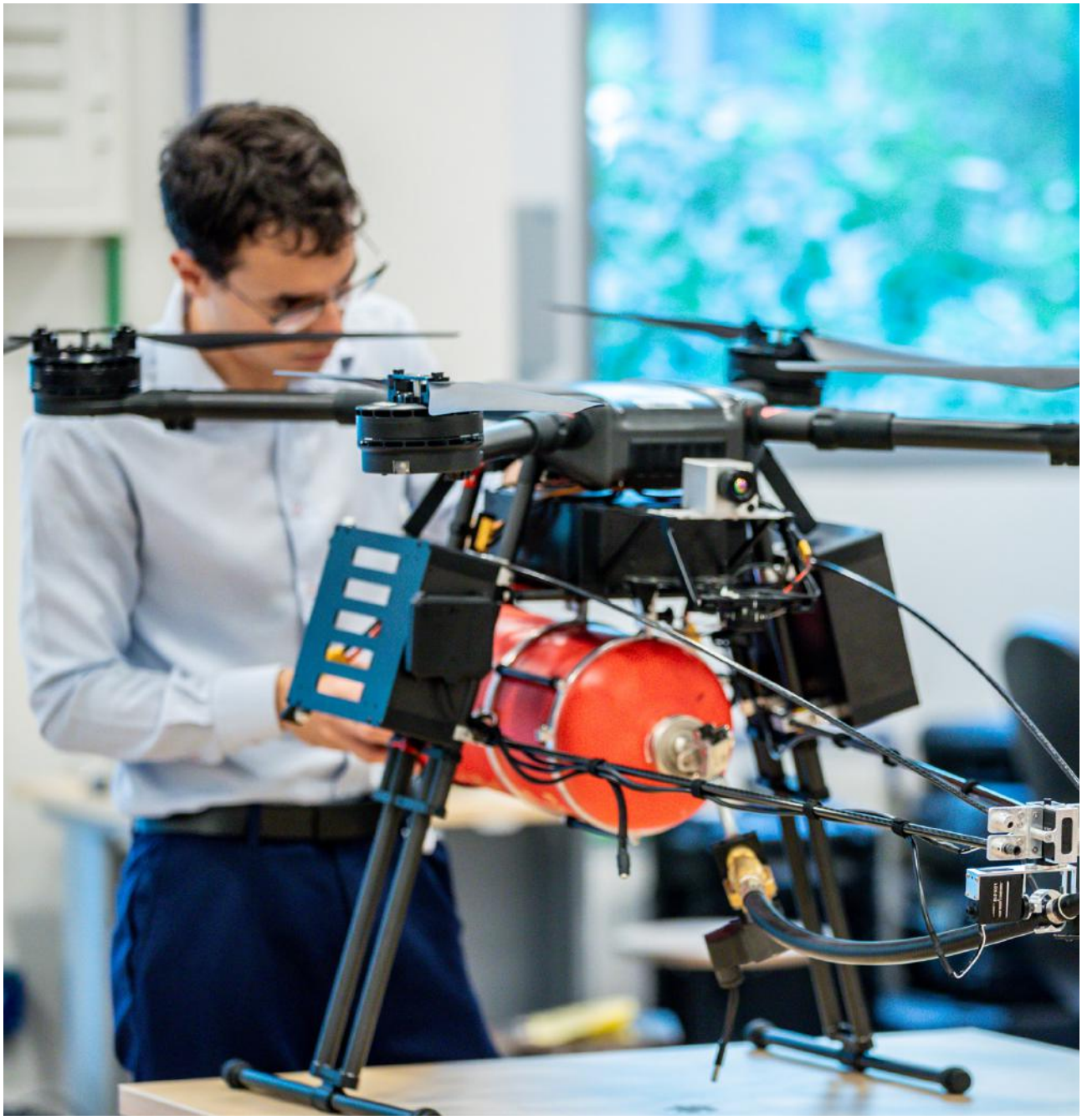
- PEEG 723 Stimulation of Conventional and Unconventional Reservoirs
- PEEG 730 Fluid Flow and Transport Processes in Porous Media
- PEEG 732 Hybrid Enhanced Oil Recovery
- PEEG 733 Miscible Gas Flooding
- PEEG 746 Emerging Well Construction Technology
- PEEG 747 Horizontal and Multilateral Drilling and Completion
- PEEG 749 Characterization and Modelling of Unconventional Reservoirs
- PEEG 752 Simulation of Naturally Fractured Reservoirs
- PEEG 794 Selected Topics in Petroleum Engineering

Robotics

- ECCE 732 Machine Learning and Applications
- ECCE 735 Advanced Computer Vision Paradigms
- ECCE 755 Cognitive Robotics
- ECCE 756 Robotic Perception
- MEEN 761 / AERO 761 Advanced Process Dynamics and Control
- MEEN 762 Analysis and Simulation of Mechatronics Systems
- MEEN 763 Theory and Design of Digital Control Systems
- MEEN 764 / AERO 764 Optimal Control
- MEEN 765 Acoustics and Noise Control
- MEEN 767 / ECCE 757 Control of Robotic Systems

ENGR 799 PhD Research Dissertation (Minimum 36 Credit Hours)

Students must complete a PhD Research Dissertation that involves novel, creative, research-oriented work under the direct supervision of at least one full-time faculty advisor from the College of Engineering, and at least one other full-time faculty who acts as a co-advisor. The Main Advisor of a student who opts for a PhD with a concentration must be a faculty member in the Department offering that particular concentration. The outcome of research should demonstrate the synthesis of information into knowledge in a form that may be used by others. The research findings must be documented in a formal Dissertation and defended successfully in a viva voce examination. Furthermore, the research must lead to publishable quality scholarly journal articles.



STUDY PLAN

A typical study plan for students enrolled in the PhD in Engineering is shown below.

TYPICAL STUDY PLAN FOR FULL-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 701 Research Methods in Eng. Technical Elective 1 Technical Elective 2	Technical Elective 3 ENGR 795 PhD Written Qualifying Examination (WQE) ENGR 799 PhD Research Dissertation
YEAR 2	Technical Elective 4 Technical Elective 5 ENGR 799 PhD Research Dissertation	Technical Elective 6 ENGR 796 PhD Research Proposal Examination (RPE) ENGR 799 PhD Research Dissertation
YEAR 3	Technical Elective 7 ENGR 703 PhD Research Seminar I ENGR 799 PhD Research Dissertation	ENGR 704 PhD Research Seminar II ENGR 799 PhD Research Dissertation
YEAR 4	ENGR 799 PhD Research Dissertation	ENGR 799 PhD Research Dissertation

TYPICAL STUDY PLAN FOR PART-TIME STUDENTS		
	SEMESTER 1	**SEMESTER 2**
YEAR 1	ENGR 701 Research Methods in Eng. Technical Elective 1	Technical Elective 2 Technical Elective 3
YEAR 2	Technical Elective 4 ENGR 799 PhD Research Dissertation	ENGR 795 PhD Written Qualifying Examination (WQE) ENGR 799 PhD Research Dissertation
YEAR 3	Technical Elective 5 ENGR 799 PhD Research Dissertation	ENGR 796 PhD Research Proposal Examination (RPE) ENGR 799 PhD Research Dissertation
YEAR 4	Technical Elective 6 ENGR 703 PhD Research Seminar I ENGR 799 PhD Research Dissertation	Technical Elective 7 ENGR 799 PhD Research Dissertation
YEAR 5	ENGR 704 PhD Research Seminar II ENGR 799 PhD Research Dissertation	ENGR 799 PhD Research Dissertation
YEAR 6	ENGR 799 PhD Research Dissertation	ENGR 799 PhD Research Dissertation

TOPICAL AREAS FOR WRITTEN QUALIFYING EXAMINATION (WQE)

Achieving PhD candidacy is contingent upon successfully passing a two-stage qualifying examination which is composed of a Written Qualifying Exam (WQE), followed by a Research Proposal Examination (RPE). For further details, please refer to the "PhD Research Milestones" section of this catalog.

The primary objective of the PhD Written Qualifying Exam (WQE) is to ensure that students pursuing a Doctoral degree in a particular concentration have graduate level understanding of the fundamentals of that concentration and evaluates the student's ability to apply them to solve problems in three topical exam areas. The syllabi for the topical exam areas are taken from undergraduate courses in the College of Engineering at Khalifa University.

Students must register for ENGR 795 PhD WQE before the end of the Add/Drop period of the semester in which they plan to take the WQE. The student must choose three exam topical areas from an approved list, in consultation with his/her Main Advisor. Students enrolled in the PhD with a concentration must select at least two of the three topical areas from the list specific to their concentration. Students pursuing a multidisciplinary PhD must select topical areas relevant to their particular fields of research.

The exams are coordinated by the Associate Dean for Graduate Studies and the Chair of the relevant Department (or designee) and held twice per year over a one-week period. The duration of each exam is three hours. A minimum score of 73 percent is required to pass the exam for each topical area. Failing any topical area of the WQE will result in the student failing the entire WQE and placing him/her on Academic Probation Level 1. A failed WQE can be retaken only once and passed upon the next offering. If the student repeats the WQE, then he/she will be required only to retake the exams in the topical areas that he/she failed during the WQE at the first attempt. The student may opt to retake the exams in topical areas other than those he/she failed in at the first attempt. PhD students who fail the WQE at the second attempt will be placed on Academic Probation Level 2 and will be subject to dismissal from the PhD program.

The list of topical exam areas for each of the PhD in Engineering concentrations and their corresponding undergraduate course syllabi are given below. This list will be updated as needed.

AEROSPACE ENGINEERING	
TOPICAL EXAM AREA	**UNDERGRADUATE COURSES**
Aerodynamics	AERO 335, AERO 336
Aerospace Materials and Manufacturing	AERO 220, AERO 415
Astronautics	AERO 465, AERO 485, AERO 495
Dynamics and Control	AERO 201, AERO 350, AERO 450
Mechanics of Solids and Structures	AERO 225, AERO 321
Thermodynamics and Propulsion	AERO 240, AERO 440

BIOMEDICAL ENGINEERING	
TOPICAL EXAM AREA	**UNDERGRADUATE COURSES**
Biochemistry	CHEG 210
Biomaterial Sciences and Engineering	BMED 411
Biomechanics	BMED 321, BMED 322
Biomedical Signals	BMED 352
Genomics	BMED 413
Molecular Biology	BMED 341 (or the former BMED 341/342)
Physiology and Anatomy	BMED 212, BMED 211
Transport Phenomena	BMED 331

CHEMICAL ENGINEERING	
TOPICAL EXAM AREA	**UNDERGRADUATE COURSES**
Chemical Engineering Thermodynamics	CHEG 332, CHEG 230
Mass Transport Phenomena	CHEG 324, CHEG 485
Momentum and Heat Transport Phenomena	CHEG 335, CHEG 232
Reaction Engineering	CHEG 443
Chemical Engineering Process Control	CHEG 412

CIVIL INFRASTRUCTURE AND ENVIRONMENTAL ENGINEERING	
TOPICAL EXAM AREA	**UNDERGRADUATE COURSES**
Atmospheric Pollution	CIVE 469
Behavior and Analysis of Structures	CIVE 225, CIVE 340
Building Design	CIVE 341, CIVE 442
Construction Project Management	CIVE 332, CIVE 484
Environmental Engineering	CIVE 370
Fluid Mechanics	CIVE 335
Geotechnical and Foundation Engineering	CIVE 338, CIVE 470
Hydrology	CIVE 465
Pavement Engineering	CIVE 472
Transportation Engineering	CIVE 380
Water and Wastewater Treatment Technologies	CIVE 463

ELECTRICAL AND COMPUTER ENGINEERING	
TOPICAL EXAM AREA	**UNDERGRADUATE COURSES**
Artificial Intelligence	COSC 330, COSC 430, ECCE 454
Communication Systems	ECCE 360, ECCE 362, ECCE 460
Computer Architecture and Networks	ECCE 350, ECCE 356, ECCE 450
Computer and Network Security	ECCE 444, ECCE 446
Control Systems	ECCE 323, ECCE 428, ECCE 429
Digital System Design	ECCE 408, ECCE 410
Electromagnetic Waves and Propagation	ECCE 320, ECCE 470
Electronic Devices and Circuits	ECCE 312, ECCE 411, ECCE 423
Integrated Microelectronic Devices and Technology	ECCE 326, ECCE 495
Power Systems and Electrical Machines	ECCE 322, ECCE 421, ECCE 425
Signal Processing	ECCE 302, ECCE 402

ENGINEERING SYSTEMS AND MANAGEMENT	
TOPICAL EXAM AREA	**UNDERGRADUATE COURSES**
Applied Statistics and Quality Control	ISYE 311, ISYE 431, MATH 242
Engineering Economics	ISYE 200, ISYE 362, BUSS 201
Operations Research and Optimization	ISYE 251, ISYE 451, ISYE 430
Production and Facilities Planning	ISYE 475, ISYE 341, ISYE 351

MATERIAL SCIENCE AND ENGINEERING	
TOPICAL EXAM AREA	**UNDERGRADUATE COURSES**
Synthesis and Characterization of Materials	MEEN 225, MEEN 423
Thermal and Mechanical Properties of Materials	MEEN 325, MEEN 343
Thermodynamics and Kinetics of Materials	MEEN 240, CHEG 324

MECHANICAL ENGINEERING	
TOPICAL EXAM AREA	**UNDERGRADUATE COURSES**
Control and Mechatronics	MEEN 356, MEEN 484
Dynamics and Vibrations	MEEN 201, MEEN 350
Engineering Mathematics	MATH 204, MEEN 206, MEEN 231
Fluid Mechanics and Heat Transfer	MEEN 335, MEEN 343
Solid Mechanics and Strength of Materials	MEEN 325, MEEN 420
Thermodynamics	MEEN 240, MEEN 441

NUCLEAR ENGINEERING	
TOPICAL EXAM AREA	**UNDERGRADUATE COURSES**
Reactor Systems Design and Analysis	NUCE 303, NUCE 401, NUCE 402
Nuclear Material Science Engineering	NUCE 303, NUCE 401
Radiation Safety in the Environment	NUCE 301, NUCE 401

PETROLEUM ENGINEERING	
TOPICAL EXAM AREA	**UNDERGRADUATE COURSES**
Reservoir Engineering	PEEG 331, PEEG 334
Drilling Engineering	PEEG 322, PEEG 326
Production Engineering	PEEG 442, PEEG 443

ROBOTICS	
TOPICAL EXAM AREA	**UNDERGRADUATE COURSES**
Control and Mechatronics	MEEN 356, MEEN 484
Signal Processing	ECCE 302, ECCE 402
Computer Architecture and Networks	ECCE 350, ECCE 356, ECCE 450

GRADUATE PROGRAMS:

COLLEGE OF MEDICINE AND HEALTH SCIENCES

PRE-MEDICINE BRIDGE PROGRAM

ABOUT THE PROGRAM

The Pre-Medicine Bridge (PMB) Program at Khalifa University is designed to enable college graduates interested in pursuing careers in medicine to enhance their knowledge and skills and improve their applications to the institution's Doctor of Medicine (MD) degree program.

The mission of the College of Medicine and Health Sciences is to enhance the healthcare ecosystem of Abu Dhabi and the United Arab Emirates through outstanding education, research, and healthcare services for the community. The College's vision is to be a leader in transforming the UAE healthcare ecosystem for a healthier nation. This unique academic bridging program supports the College of Medicine and Health Science's mission and vision by serving as a pipeline program to enhance the pool of qualified applicants for medical school admission and ultimately increase the number and quality of locally trained physicians serving the nation.

PROGRAM EDUCATIONAL OBJECTIVES

The goal of the PMB Program is to help students, primarily of Emirati nationality, acquire the knowledge, skills, and competencies required to transition to the MD program at Khalifa University. The program established the following objectives to achieve its goal:

1. Fill gaps in students' preparedness for and transition to the Khalifa University MD degree program;
2. Prepare students to obtain an admissible Medical College Admission Test (MCAT) score through intense instruction in key performance areas on this medical school entrance exam;
3. Coach students on test-taking strategies, with the support of Kaplan, Inc., and give them opportunities to complete various practice exams;
4. Provide research and clinical experiences to enhance the competitiveness of students' MD applications; and
5. Support the recruitment efforts of the MD program by providing a pipeline of qualified candidates.

DOCTOR OF MEDICINE

ABOUT THE PROGRAM

The 4-year course of study leading to the Doctor of Medicine (MD) degree employs leading-edge learning and clinical experiences to enable students to gain the competencies expected of all physicians, with an emphasis on providing technology enhanced personalized, preventive and community care. The program prepares students for postgraduate study in any specialty, for licensure, and for future medical practice. KU's Doctor of Medicine program incorporates innovative curricular design that promotes scientific inquiry, critical thinking and comprehensive clinical expertise in preparing physicians to be life-long adaptive learners. Overall, the program evolves medical education in such a way as to prepare physicians for the next 20 years and beyond.

PROGRAM EDUCATIONAL OBJECTIVES

The goals of the Khalifa University CMHS Doctor of Medicine degree program are to:

1. Provide an integrated clinical and research experience in a singular postgraduate level medical education program;
2. Educate and inspire a diverse workforce of physicians who understand the needs of patients, are able to communicate across cultures, and collaborate with diverse teams;
3. Prepare physicians who are able to seamlessly integrate technology into areas such as personalized and preventative care, artificial intelligence, population health, augmented reality and nanotechnology;
4. Prepare medical students and residents to serve as specialty physicians and to practice evidence-based medicine in the healthcare and hospital systems of Abu Dhabi and the United Arab Emirates;

5. Attract and retain a diverse and talented faculty dedicated to providing outstanding medical education and supporting the professional development of medical students;
6. Respond to stakeholder and government needs for medical education leading to clinicians who can serve the healthcare needs of the United Arab Emirates; and

Be an essential contributor to the development, enhancement and completion of the existing healthcare ecosystem of Abu Dhabi.

COMPETENCY DOMAINS

The four-year course of study leading to the Doctor of Medicine degree at Khalifa University is based on development of competencies across ten domains. These competencies provide a summary of what graduates of the program are expected to demonstrate in the workplace after graduation, as residents, fellows, and clinical practitioners. They are based on the needs of the program's constituencies. The ten domains are:

- Patient Care (CD1)
- Knowledge for Practice (CD2)
- Practice-based learning and improvement (CD3)
- Interpersonal and communication skills (CD4)
- Professionalism (CD5)
- Systems-based practice (CD6)
- Inter-professional collaboration (CD7)
- Personal and professional development (CD8)
- Technology enhanced healthcare (CD9)
- Social Accountability (CD10)

ENTRUSTABLE PROFESSIONAL ACTIVITIES

Entrustable Professional Activities (EPAs) for Entering Residency provide expectations for both learners and teachers that include 13 activities that all medical students should be able to perform upon entering residency, regardless of their future career specialty. EPAs offer a practical approach to assessing competence in real-world settings. During your time as a student, your competency in performing the EPAs is documented in an e-portfolio that can be shared with residency directors to provide clear demonstration that you can successfully perform the activities required for entrance into residency.

The 13 core EPAS are:

- EPA 1 Gather a history and perform a physical examination.
- EPA 2 Prioritize a differential diagnosis following a clinical encounter.
- EPA 3 Recommend and interpret common diagnostic and screening tests.
- EPA 4 Enter and discuss orders and prescriptions.
- EPA 5 Document a clinical encounter in the patient record.
- EPA 6 Provide an oral presentation of a clinical encounter.
- EPA 7 Form clinical questions and retrieve evidence to advance patient care.
- EPA 8 Give or receive a patient handover to transition care responsibility.
- EPA 9 Collaborate as a member of an inter-professional team.
- EPA 10 Recognize a patient requiring urgent or emergent care and initiate evaluation and management.
- EPA 11 Obtain informed consent for tests and/or procedures.
- EPA 12 Perform general procedures of a physician.
- EPA 13 Identify system failures and contribute to a culture of safety and improvement.

LEARNING OUTCOMES

Program Learning Outcomes (PLOs) are comprehensive, broad statements pertinent to the knowledge, skills and aspects of competence that a learner is expected to know and be able to do by the time of graduation. As a medical student, you will acquire these as you progress through the program.

Upon successful completion of the Doctor of Medicine program, the graduate will be able to:		Related EPA
PLO1	Illustrate established and evolving principles of the biomedical sciences foundational to the practice of medicine.*	6,7
PLO2	Explain normal physiologic responses to internal and external stimuli, including genetic, metabolic, developmental, autoimmune, environmental and infectious challenges.	6,7
PLO3	Summarize the processes utilized by cells, organs, and organ systems to maintain homeostasis, and explain how alterations of these processes can result in disease.	6,7
PLO4	Apply established and emerging bio-physical scientific principles fundamental to health care for patients and populations.*	3,6,7
PLO5	Demonstrate interpersonal and communication skills that result in the effective exchange of information and collaboration with patients, their families, professional interpreters, and other health professionals.*	1,3,5,6,8,9
PLO6	Perform and document an appropriately complete medical history and physical examination.*	1,5,6,7
PLO7	Develop and carry out patient management plans for acute life-threatening situation.*	2,3,4,5,6,10
PLO8	Develop and carry out patient management plans for chronic disease.*	2,3,4,5,6
PLO9	Develop and justify differential diagnoses based on patient information, up-to-date scientific evidence, and clinical judgment.	2,3,4,5,6,7,10
PLO10	Perform all medical, diagnostic, and surgical procedures considered essential for the area of practice.*	1,2,3,5,11
PLO11	Maintain comprehensive, timely, and legible medical records.*	4,5,7,8
PLO12	Make informed decisions about diagnostic and therapeutic interventions based on patient information and preferences, up-to-date scientific evidence, and clinical judgment.*	3,7,13
PLO13	Apply the scientific method to analyze, evaluate, create and answer research questions.	7
PLO14	Illustrate components of the UAE healthcare ecosystem and evaluate their impact on the delivery of healthcare to the community.	13
PLO15	Explain the personal and systems-level processes that promote continuous quality improvement and patient safety, and demonstrate the use of standard precautions in the health care setting.	13
PLO16	Demonstrate knowledge of established and evolving concepts involving complementary and alternative medicine, as well as the application of this knowledge to patient care.	7
PLO17	Explain end-of-life issues from the patient's and physician's perspectives.	
PLO18	Demonstrate insight and understanding about emotions and human responses to emotions that allow one to develop and manage interpersonal interactions.*	2,9
PLO19	Demonstrate knowledge of established and evolving epidemiological and social-behavioral sciences, as well as the application of this knowledge to patient care.*	2,5

PLO20	Evaluate and devise strategies to improve community health by addressing social determinants of health through engagement, collaboration and reflection.	13
PLO21	Develop patient-centered counseling skills that promote disease prevention, judicious use of healthcare resources, and patient satisfaction.	5,11
PLO22	Communicate with other health professionals in a responsive and responsible manner that supports the maintenance of health and the treatment of disease in individual patients and populations.*	6,5,8,9
PLO23	Demonstrate a commitment to carrying out professional responsibilities and an adherence to ethical principles in clinical care and research.*	
PLO24	Demonstrate the qualities required to sustain lifelong personal and professional growth.*	

* Adapted from the Associate of American Medical Colleges (AAMC) Physician Competency Reference Set (PCRS): https://www.aamc.org/initiatives/cir/establishci/348808/aboutpcrs.html

PROGRAM STRUCTURE AND REQUIREMENTS

Overall Program Structure

The Khalifa University College of Medicine and Health Sciences (CMHS) is committed to providing an innovative and challenging curriculum taught by the best clinical and research faculty in the UAE. The KU Doctor of Medicine (MD) degree curriculum is a systems based program that integrates basic and clinical science instruction into each curricular year. The curriculum is designed to provide content of sufficient breadth and depth to prepare the medical student for entry into any residency program and for the subsequent contemporary practice of medicine. There are five strands that run throughout the program, namely:

- Biomedical Science
- Clinical Medicine
- Physicianship
- Medicine and Society
- Research, Technology and Innovation

The MD program is delivered as a full-time program. The minimum period of study is four years from the date of first matriculation as a degree student, with a maximum period of study of six years. Study is considered to commence from first enrollment in degree courses as a fully admitted (matriculated) medical student. The duration of the entire program will never be less than 130 weeks. Courses and clerkships are delivered either at the Main Campus medical program facilities of Khalifa University (Buildings A and B), or at affiliated clinics or hospitals.

PROGRAM REQUIREMENTS

The learning pathway for the Doctor of Medicine degree is presented in Table 1. The curriculum is divided into four periods of study, comprising foundations of medicine (Period 1), integrated organ systems (Period 2), core clinical clerkships (Period 3), and advanced clinical rotations (Period 4). Coursework is multidisciplinary and features a case-based format in which biomedical sciences are delivered to the students in a clinical context. Clinical experiences in primary care and

emergency settings begin in the first period of study with coordinated opportunities for practical application of basic knowledge, skills, and reasoning (the Physicianship strand). Students participate in the Abu Dhabi health sector to engage with the community in a program to enhance medical and preventative health practices, the Balsam Community Health Learning Program (Balsam - Barnamij L-Ta'leem Sehat al-Mujtama (بَلسمْ - برنامج لتعليم صحة المجتمع)).

PERIOD 1

Period 1 focuses on the study of the foundations of medicine. The period starts with Transitions I, which includes an orientation to medical education and the practice of medicine. Students are welcomes into their learning community, meet with a learning specialist to identify their learning styles, and are introduced to the diverse educational pedagogies used in the MD program, such as team-based learning and the flipped classroom. The Biomedical Science strand covers foundational topics in molecular and cellular biology; human genetics; human anatomy, histology and embryology; physiology and immunology; pathology; microbiology and infectious disease; and, pharmacology and therapeutics. An introduction to clinical skills in the Clinical Medicine strand focuses on doctor–patient communication, history-taking, general physical examination skills and basic clinical procedures. Clinical skills training includes simulation, standardized patient, and real-world experiences, including half day rotations in primary-care clinics and emergency departments. The Medicine and Society strand introduces students to healthcare systems, social determinants of health, and the roles physicians hold in society. The strand also prepares students to participate in Balsam during Period 2 (explained below). The Physicianship strand focuses on professional identity formation, medical professionalism and ethics, career selection, and personal health and wellness. During the Research, Technology and Innovation strand, students review the basics of medical research, human subjects research, epidemiology and biostatistics, and evidence-based medicine. Students undergo CITI training and are paired with a research mentor to identify a required research project which will continue throughout the four years of study. The period concludes with a comprehensive assessment of each student's progress to date, and a formative Objective Structured Clinical Evaluation (OSCE).

PERIOD 2

Period 2 focuses on the in-depth study of human biology, disease, illness, and injury organized by the major organ-systems; specifically, the cardiovascular, respiratory, hematopoietic, lymphoreticular, endocrine, reproductive, musculoskeletal, integumentary, gastrointestinal, renal, nervous and behavioral systems. Clinical correlations tie the biomedical sciences to medical practice. In the Clinical Medicine strand, students build upon their clinical skills by performing targeted histories and physical exams, developing differential diagnoses, and formulating evidenced-based diagnostic and therapeutic strategies. They also continue to participate in half-day rotations at outpatient clinics and emergency rooms. The Medicine and Society strand focuses on systems of care, healthcare policy and advocacy, medical jurisprudence, interprofessional healthcare, community-based healthcare, and end-of-life care. During Period 2, students begin their service-learning study with participation in the Balsam Community Health Learning Program (Balsam - Barnamij L-Ta'leem Sehat al-Mujtama (بَلسمْ - برنامج لتعليم صحة المجتمع), a service-learning program that focuses on home-based healthcare. In the Physicianship Strand, students identify potential career pathways while continuing to explore their own personal and professional development. Students move forward with their research projects during Period 2. At the conclusion of the Period, students complete comprehensive assessments and a formative OSCE.

PERIOD 3

Period 3 begins the intensive clinical training phase and consists of eight (8) core clerkships: Surgery, Internal Medicine, Neurology, Medical Imaging, Family Medicine, Obstetrics and Gynecology, Pediatrics, and Psychiatry. All students take these same core clerkships although not in the same order. During these clerkships, students spend the majority of the week at affiliated hospitals and clinics, gaining experience in both inpatient and outpatient areas. They work with faculty preceptors, residents, fellows, and other healthcare professionals. One day each week, students participate in formal lectures, case-based small group sessions and/or simulation training as part of the Core Concepts in Medicine course. These experiences provide students a third opportunity to integrate learning objectives from the core biomedical with the practice of clinical medicine. Students continue to participate in the Balsam Community Health Learning Program during Period 3, work or complete their required research project, and further explore career opportunities and pathways to specialty training. At the conclusion of Period 3, students are required to take the United States Medical Licensing Examination® (USMLE) Step 1, pass all third-year rotations, and successfully complete a comprehensive OSCE in order to be promoted to

PERIOD 4

Period 4 builds on the clerkship experiences and prepares students to enter their chosen field of specialization after graduation. All students must complete rotations in Emergency Medicine and Geriatrics, as well as Advanced Medicine and Sub-Internship experiences in a specific discipline. Advanced Medicine (Internal Medicine, Surgery or Pediatrics) provides the students progressively greater responsibilities, while the Sub-internship rotation requires students to take on the role of intern under direct supervision by faculty, residents, and other healthcare providers. Additional selective and elective rotations (two selectives, four electives) give students the latitude to follow a pathway of emphasis, consistent with their long-term career goals, or to explore other areas of interest. At the end of Period 4, all students participate in a four-week clinical medicine capstone that is intended to prepare them for their chosen residency. Students continue to participate in the Balsam Community Health Learning Program throughout Period 4. Finally, students must complete their research project, and must take the USMLE Step 2 CK and Step 2CS to be eligible to graduate.

PROGRAM CORE

The curriculum includes required core content from the biomedical, behavioral, and socioeconomic sciences to support the medical student's mastery of contemporary scientific knowledge and concepts and the methods fundamental to applying them to the health of individuals and populations. Table 1 on the following page provides a list of core courses that are offered in the Doctor of Medicine program at KU.

CLINICAL EXPERIENCE

The clinical experience is integral to the curriculum. Students begin clinical training (the Clinical Medicine strand) early in the first year by encountering basic medical conditions in outpatient settings; clinical training advances progressively to include exposure to more complex cases and conditions in hospital settings, and culminates in subinternship experiences. The Period 3 curriculum includes clinical experiences in both inpatient and ambulatory settings appropriate for the achievement of required clinical experiences. Each medical student participates in at least one

clinical clerkship in a health care setting in which s/he works with a resident physician currently enrolled in an accredited program of graduate medical education. More detailed information about clerkship requirements can be found in the Clerkship Handbook.

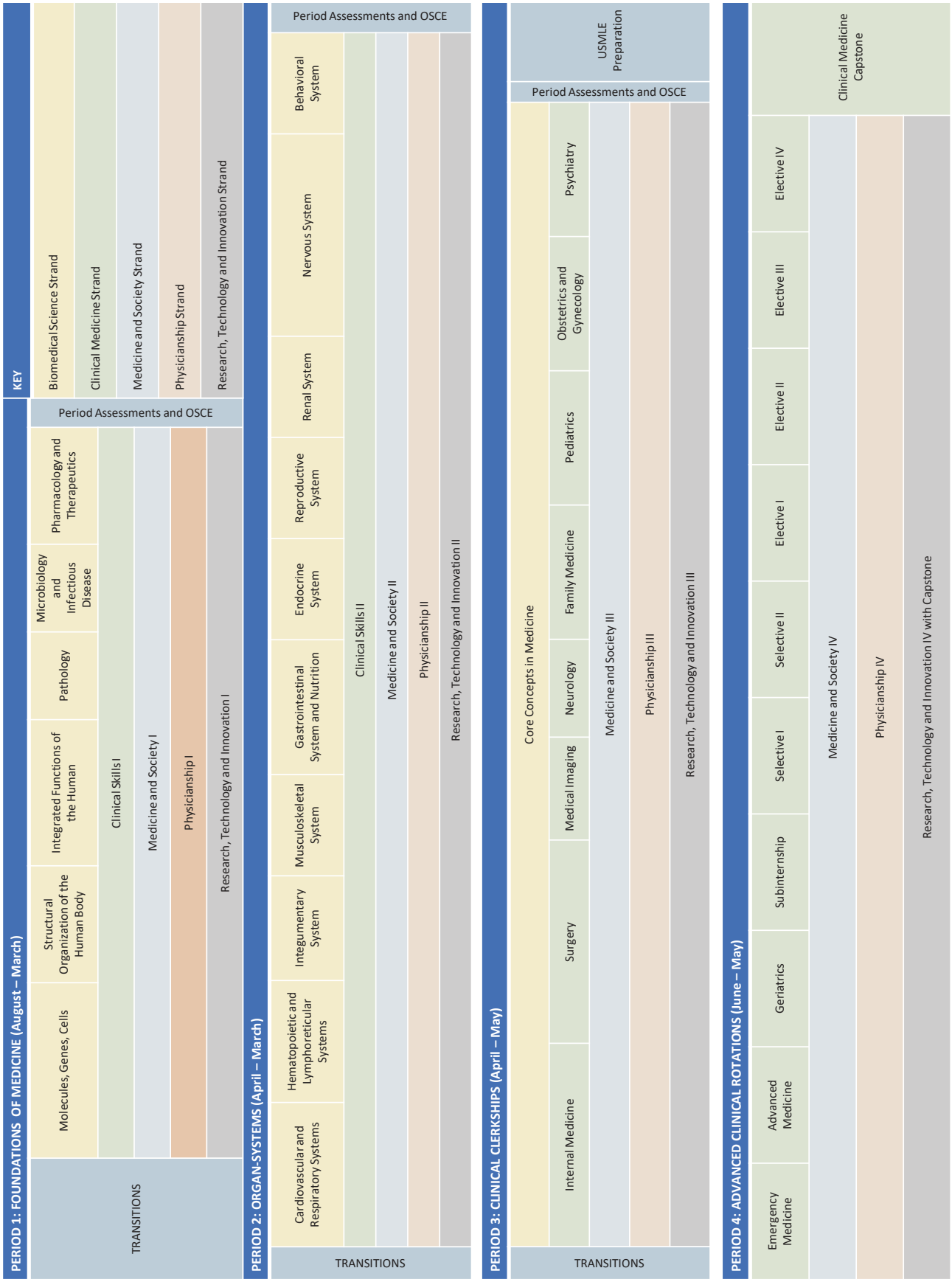
PROGRAM ELECTIVES (PATHWAYS)

Independent scholarship and broad elective and selective opportunities in the third and fourth years encourage students to explore personal interests and build competency through pathways in preparation for advanced postgraduate study and practice in a specialty area. Differentiation in training occurs during Period 4 when students choose four electives that conform to the AAMC Global Health Learning opportunities and participate in a subinternship (see Period 4 description above). Khalifa University sponsored electives and selectives may be chosen from a list of over 100 choices.

Required

- MDCM 900 Emergency Medicine
- MDCM 901 Advanced Medicine, Advanced Surgery, Advanced Pediatric Medicine or Advanced Pediatric Surgery
- MDCM 902 Geriatrics
- MDCM 903 One (1) Subinternship
- MDCM 904 Four (4) Electives, e.g. Internal Medicine, Neurology, Surgery
- MDCM 905 Two (2) Selectives, e.g. Rural Healthcare, Immersion in Medical Education
- MDCM 999 Clinical Medicine Capstone

TABLE 1: KU MD PROGRAM CURRICULUM LEARNING PATHWAY



STUDY PLAN

A typical study plan for a Doctor of Medicine degree student is shown below. The number of credits assigned for each course in Periods 1 and 2 is determined based on workload expectations, where one credit is equivalent to approximately 15 hours of formal instruction. The total workload expectation per credit is equivalent to approximately 45 hours, including instruction, study, and assessments. A 3- to 4-hour laboratory, case-based, or clinic session is quantitatively equivalent to one formal instructional hour and presumes that the activity time includes most of the study or preparation normally associated with 1 hour of lecture. The limit for formal instruction during Periods 1 and 2 is 25 hours weekly, which results in a weekly workload of up to 75 hours.

COLOR KEY FOR TABLES:

- BIOMEDICAL SCIENCE
- CLINICAL MEDICINE
- MEDICINE AND SOCIETY
- PHYSICIANSHIP
- RESEARCH, TECHNOLOGY AND INNOVATION

PERIOD 1 COURSES (August – March)

CODE	COURSE/CLERKSHIP TITLE	CREDITS	DURATION
MDPS 600	Transitions I	0	3 weeks
MDBS 601	Molecules, Genes and Cells	6	6 weeks
MDBS 602	Structural Organization of the Human Body	4	4 weeks
MDBS 603	Integrated Functions of the Human Body	5	5 weeks
Winter Break : 2 weeks			
MDBS 604	Pathology	3	3 weeks
MDBS 605	Microbiology and Infectious Diseases	3	3 weeks
MDBS 606	Pharmacology and Therapeutics	4	4 weeks
MDCM 600	Clinical Skills I	5	26 weeks
MDMS 600	Medicine and Society I	3	26 weeks
MDPS 601	Physicianship I	3	26 weeks
MDRT 600	Research, Technology and Innovation I	3	26 weeks
Period 1 Assessments and OSCE			
Spring Break: 1 week			

PERIOD 2 COURSES (April – March)

CODE	COURSE/CLERKSHIP TITLE	CREDITS	DURATION
MDBS 701	Cardiovascular and Respiratory Systems	6	6 weeks
MDBS 702	Hematopoietic and Lymphoreticular Systems	3	3 weeks
Summer Break : 6 weeks			
MDBS 703	Integumentary System	2	2 weeks
MDBS 704	Musculoskeletal Systems	3	3 weeks
MDBS 705	Gastrointestinal System and Nutrition	4	4 weeks
MDBS 706	Endocrine System	3	3 weeks
MDBS 707	Reproductive System	3	3 weeks
MDBS 708	Renal System	3	3 weeks
Winter Break : 3 weeks			
MDBS 709	Nervous System	6	6 weeks
MDBS 710	Behavioral System	3	3 weeks
MDCM 700	Clinical Skills II	5	38 weeks
MDMS 700	Medicine and Society II	3	38 weeks
MDPS 700	Physicianship II	3	38 weeks
MDRT 700	Research, Technology and Innovation II	3	38 weeks
Period 2 Assessments and OSCE			
Spring Break : 1 week			

Student workload during Periods 3 and 4 is designed to ensure an appropriate balance between formal teaching and service. All medical students rotating through clerkships, electives, selectives, and subinternships are required to comply with established limitations on duty hours. Duty hours should be limited to 80 hours per week, averaged over a 4-week period and inclusive of all in-house call activities. Continuous on-site duty, including in-house call, should not exceed 24 consecutive hours. Students may remain on duty for up to six additional hours to participate in didactic activities, transfer care of patients, conduct outpatient clinics, and maintain continuity of medical and surgical care.

Students must be provided with one day in seven free from all educational and clinical responsibilities, averaged over a 4-week period and inclusive of call. Students must be provided adequate time for rest and personal activities. This should optimally be a 10-hour time period between all daily duty periods and after in-house call. Each student is expected to choose electives and selectives for Period 4 in consultation with her/his academic advisor.

PERIOD 3 CLERKSHIPS (April – March)

CODE	COURSE/CLERKSHIP TITLE	CREDITS	DURATION
MDCM 801	Internal Medicine	8	8 weeks
MDCM 802	Surgery	8	8 weeks
MDCM 803	Medical Imaging	4	4 weeks
MDCM 804	Neurology	4	4 weeks
MDCM 805	Obstetrics and Gynaecology	6	6 weeks
MDCM 806	Pediatrics	6	6 weeks
	Winter Break : 3 weeks		
MDCM 807	Psychiatry	6	6 weeks
MDCM 808	Family Medicine	6	6 weeks
MDBS 800	Core Concepts in Medicine	3	48 weeks
MDMS 800	Medicine and Society III	3	48 weeks
MDPS 800	Physicianship III	3	48 weeks
MDRT 800	Research, Technology and Innovation III	3	48 weeks
	Period 3 Assessments and OSCE		
	USMLE Preparation		

Period 4 Advanced Clinical Rotations (April – May)
Sample Study Plan for a Student Specializing in Internal Medicine

CODE	COURSE/CLERKSHIP TITLE	CREDITS	DURATION
MDCM 900	Emergency Medicine	4	4 weeks
MDCM 901	Advanced Medicine	4	4 weeks
MDCM 902	Geriatrics	2	2 weeks
MDCM 903	Sub-Internship: Internal Medicine	4	4 weeks
MDCM 904	Elective 1: Cardiology	4	4 weeks
MDCM 904	Elective 2: Nephrology	4	4 weeks
Winter Break : 3 weeks			
MDCM 904	Elective 3: Medical Intensive Care Unit	4	4 weeks
MDCM 904	Elective 4: Anatomy	4	4 weeks
MDCM 905	Selective 1: Healthcare Administration	4	4 weeks
MDCM 905	Selective 2: Rural Health	4	4 weeks
MDMS 900	Medicine and Society IV with Capstone	3	38 weeks
MDPS 900	Physicianship IV	3	38 weeks
MDRT 900	Research, Technology and Innovation IV with Capstone	3	38 weeks
MDCM 999	Transitions V and Capstones	2	4 weeks
Period 3 Assessments and OSCE			
USMLE Preparation			

GRADUATE COURSE DESCRIPTIONS

AEROSPACE ENGINEERING (AERO)

AERO 611 Combustion Theory and Applications (3-0-3)
Prerequisite: Undergraduate thermodynamics, fluid mechanics, and heat transfer or equivalents.

Combustion thermo-chemistry of different fuels, adiabatic flame temperature and combustion products composition, chemical kinetics and important combustion chemical mechanisms, ideal flow reactors, laminar premixed flames, diffusion flames including liquid droplet and solid particle combustion, turbulent premixed and non-premixed flames, pollutant emissions and control. All of the above are treated with emphasis on a wide variety of practical applications that motivate or relate to the various theoretical concepts and current research interests.

AERO 612 Advanced Viscous Flow Analysis (3-0-3)
Prerequisite: Undergraduate Fluid Mechanics (MECH 340) or equivalent.

This course focuses on viscous flow concepts and theory. It introduces the fundamentals necessary for the analysis of incompressible Newtonian viscous flows, incompressible boundary-layers and free shear flows in the laminar and turbulent regime. It aims to develop skills required by engineers working in Thermofluids and prepares for advanced courses in Turbulence and its modeling, Computational Fluid Dynamics, Multiphase Flows and Convective Heat Transfer.

AERO 622 Structural Dynamics and Aeroelasticity (3-0-3)
Prerequisite: Undergraduate knowledge of dynamic systems and control (or equivalent).

To develop an understanding and skills for performing an accurate dynamic analysis (time and frequency response, mode shapes and resonance frequencies) for dynamical structures that give the student a strong engineering sense for the real life applications. In addition, the course will give the student the ability of understanding the interaction between the elastic structure with the static and the aerodynamic forces that influence the aircraft performance and stability.

AERO 630 Aerospace Materials and Structures (3-0-3)
Prerequisite: Undergraduate knowledge of aerospace structures (or equivalent). Graduate level course with advanced treatment in aircraft structures and aerospace materials. Topics include loads on aircraft, functions of structural components, bending of beams with non-symmetrical cross-sections, bending and torsion of thin-walled structures, structural idealization, multi-cell beams and tapered beams, and recent developments in aerospace materials.

AERO 631 Boundary Layer Analysis (3-0-3)
Prerequisite: Undergraduate knowledge of fluid mechanics and advanced continuum mechanics (or equivalents).

Introduction to Boundary Layer concept, Review of Navier-Stokes Equations; Integral Equations and Solutions for Laminar Flows; Differential Equations of Motion for Laminar Flow; Exact and Numerical Solutions for Laminar, Incompressible Flows; Compressible Laminar Boundary Layers: Transformations, Exact and Numerical Solutions; Transition to Turbulent Flow: Re-Theta, Hydrodynamic Stability Theory, the eN method; Wall Bounded, Incompressible Turbulent Flows; Free Shear Flows: Jets and Wakes.

AERO 701 Nonlinear Structural Dynamics (3-0-3)
Prerequisite: Graduate level course in advanced dynamics is required; graduate level course in vibrations is recommended; familiarity with MATLAB and with numerical integration of ordinary differential equations are required.

Basics of Linear Vibrations: Development of model nonlinear systems: Nonlinear Response Phenomena in Structural Vibratory Systems (combined lectures and student reading of current literature): Reduced Order Modeling for Nonlinear Multi-DOF Systems: Experimentation, data analysis, and simulation (combined lecturing and student reading of current literature).

AERO 702 Advanced Composite Materials and Structures (3-0-3)
Prerequisite: Graduate level courses in Solid Mechanics, Composites and/or Aerospace Structures.

This course will introduce students with advanced fiber reinforced composite materials and structures used in modern aircraft and spacecraft. The focus will be on novel reinforcements and matrices, sandwich materials, advanced manufacturing techniques, analysis of aerospace monolithic and sandwich structures, fracture and failure theories, void analysis, joining and repair technologies used in advanced aerospace composites.

AERO 703 Numerical Methods in Aerofluids (3-0-3)
Prerequisite: Proficiency in a computer programming language (e.g. FORTRAN, C++, or MATLAB), graduate level knowledge of incompressible and compressible viscous fluid dynamics.

Governing Equations. Computational Grids. Discrete Modeling. Numerical Solution of Elliptic Equations. Solution of 1-D, Unsteady Parabolic and Hyperbolic Equations. Solution of the 2-D, Unsteady Euler Equations. Boundary Condition Treatment.

AERO 711 Fracture Mechanics and Fatigue / Cross-Listed with MEEN 701 (3-0-3)
Prerequisite: Advanced mechanics of solids and materials.

Concept of linear elastic fracture mechanics, stress intensity factor, Griffith energy balance, determination of the elastic field at a sharp crack tip, J integrals analysis, experimental determination of fracture toughness, elastic plastic fracture mechanics, fatigue crack growth, elastic-plastic crack tip fields, critical crack sizes and fatigue crack propagation rate prediction. Fracture mechanisms and fracture modes associated with failure of engineering materials.

AERO 712 Damage Mechanics of Solids and Structures / Cross-Listed with MEEN 702 (3-0-3)
Prerequisite: Graduate level course in continuum mechanics.

This course aims to teach students the basic mechanisms of damage (degradation) and fracture (cracking) and how to develop theoretical models and computational algorithms that can be used in simulating and understanding damage evolution, fracture, and ultimate failure of various engineering materials, composites, and structural systems and devices. Damage and fracture in various brittle and ductile materials and their engineering implications will be studied. Formulation of time-independent and time-dependent damage and fracture models taking into consideration linear and nonlinear material behavior will be discussed in this course. Modeling of damage and fracture due to various loading conditions

(e.g., mechanical, thermal, chemical, electrical, fluid) will be presented. Also, the capabilities and limitations of well-known damage and fracture models for various applications will be assessed.

AERO 723 Advanced Combustion / Cross-Listed with MEEN 723 (3-0-3)
Prerequisite: Combustion theory and applications.

Extend the combustion theory and applications course and draws the connection between reactive flow, combustion fundamentals, combustion engineering, flames, and aerodynamics interactions. The main topics will focus on the following areas: Reactive flow transport phenomena, chemical kinetics, preferential-diffusion and flame stretch interaction, reaction mechanism reduction, combustion engineering, Biofuel combustion characterization, hydrodynamic and aerodynamic flame stability, oxygen enhanced combustion, combustion driven acoustics and vibration, fire dynamic simulation, combustion mechanisms in spark ignition and compression ignition engines, flamelet models for CFD combustion. A wide variety of practical models and applications related to the various concepts as well as experimental methods and diagnostics will be covered in lab and through literature survey.

AERO 761 Advanced Process Dynamics and Control / Cross-Listed with MEEN 761 (3-0-3)
Prerequisite: Graduate level courses in dynamics and control, and advanced engineering mathematics.

This course aims to provide multidisciplinary fundamentals and solid mathematical foundation of modern energy process systems engineering. It presents a systematic framework for physics-based and empirical dynamic process modeling, transient analysis, feedback control and optimization. This course is particularly dedicated to the most popular advanced control strategy in energy process industries - model predictive control (MPC). Other optimal control approaches are also introduced to deal with plant disturbances, uncertainties, nonlinearities, instabilities and constraints. This course emphasizes the use of advanced math tools to develop dynamic models and design advanced controllers for energy process systems.

AERO 764 Optimal Control / Cross-Listed with MEEN 764 (3-0-3)
Prerequisite: Graduate level course in advanced engineering mathematics.
This course is designed to teach students methods of optimal control and parameter estimation using Linear Quadratic Gaussian design approach, optimal control theory of non-deterministic systems, optimal control of nonlinear and time-varying systems with known inputs, as well as parameters and state estimation.

AERO 794 Selected Topics in Aerospace Engineering (3-0-3)
Prerequisite: Will be specified according to the particular topics offered under this course number.

This course covers selected contemporary topics in electrical and computer engineering. The topics will vary from semester to semester depending on faculty availability and student interests. Proposed course descriptions are considered by the Department of Aerospace Engineering on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the Graduate Studies Committee. The Course may be repeated once with change of contents to earn a maximum of 6 credit hours.

APPLIED CHEMISTRY (ACHE)

CHEM 620 Computational Chemistry (3-0-3)
Prerequisite: Graduate standing and instructor consent for non-chemistry major.

The course presents fundamental principles in molecular modeling, simulation and theoretical chemistry, links microscopic phenomena and interactions with macroscopic properties and also models complex chemical systems. Students will use state-of-the art molecular simulation tools and will perform simulations of real oil and gas industry systems as well as performing energy minimization and mechanism-testing calculations.

CHEM 623 Applied Inorganic Chemistry (3-0-3)
Prerequisite: Graduate standing and instructor consent for non-chemistry major.

The course covers the chemistry of main group elements, transition metals and f-block elements that are important in the petroleum industry, and presents various significant areas such as group theory, MO theory, ligand field theory and coordination chemistry related to applications and instrumental characterization in advanced inorganic chemistry.

CHEM 625 Applied Organic Chemistry and Instrumental Analysis (3-0-3)
Prerequisite: Graduate standing and instructor consent for non-chemistry major.

This course applies advanced instrumental methods to analyze and characterize oil and gas components. It also focuses on a scientific study of the properties and behavior of hydrocarbons and their derivatives associated with the petroleum industry.

CHEM 630 Advanced Industrial Catalysis (3-0-3)
Prerequisites: Graduate standing and instructor consent for non-chemistry major.

The course covers fundamental aspects of homogeneous and heterogeneous catalysis including catalyst manufacturing and characterization and their most representative industrial applications for both chemical commodities and fine chemicals, respectively.

CHEM 640 Advanced Organometallics and Applications (3-0-3)
Prerequisites: Graduate standing and instructor consent for non-chemistry major.

The course covers the chemistry of organometallic compounds that are important in the petroleum industry, and presents various significant areas such as ligand substitution, reductive elimination, migratory insertion and olefin polymerization related to applications in advanced organometallic chemistry.

CHEM 650 Spectrochemical Studies (2-3-3)
Prerequisites: Graduate standing and instructor consent for non-chemistry major.

This course covers the application of spectroscopic methods to determine the structure of organic molecules. Structure determination is approached through problem solving using a variety of spectroscopic methods. Hands-on experience is achieved through the laboratory component.

CHEM 655 Petroleum Production and Process Chemistry (3-0-3)
Prerequisites: Graduate standing and instructor consent for non-chemistry major.

This course covers those areas of the oil and gas industry where chemicals play a key role in solving production, process and refining issues. The course provides advanced knowledge on the understanding and use of chemicals to prevent production problems, improve production/efficiency and extend the life of the oil well, reservoir and equipment.

CHEM 660 Environmental Science and Water Technology (3-0-3)
Prerequisites: Graduate standing and instructor consent for non-chemistry major.

This course links significant environmental phenomena to chemical pollution and describes methods to combat it. Analysis of minor and trace levels of pollution will be presented. Topics offered will include: handling oil spills, treatment of soil/water/air contamination, trace analysis of toxic gases as well as low-level organic, inorganic and radioactive pollution.

CHEM 665 Fuels and Alternative Energy Sources (3-0-3)
Prerequisites: Graduate standing and instructor consent for non-chemistry major.

This course provides an overview of the role of energy within the sustainable development paradigm. Following an introduction to the energy sector and sustainability indicators, the course divides into two main areas. The first area considers conventional (fossil) fuels along with methodologies, such as carbon capture and sequestration, to reduce environmental impacts associated with their use. In the second area the potential for various alternative energy technologies is presented within a sustainability context.

CHEM 666 Construction Materials and Green Chemicals (3-0-3)
Prerequisites: Graduate standing and instructor consent for non-chemistry major.

This course gives a basic introduction to drilling technology, and provides a background in the oilfield chemicals market. Principles of oil well cementing, cement slurry design and accompanying testing are covered as well as major chemical admixtures in construction chemistry. A lab component, related to the construction field, will be offered. The course is expected to guide the students towards technology development in the field of environmentally friendly oilfield and construction chemicals.

CHEM 668 Corrosion Science and Advanced Physical Chemistry (3-0-3)
Prerequisites: Graduate standing and instructor consent for non-chemistry major.

This course imparts the essential knowledge to apply thermodynamics/statistical thermodynamics and kinetics to problems in the oil and related industries. The course provides detailed knowledge of corrosion control in the oil and gas industry, primarily corrosion under insulation (CUI), microbial corrosion (MIC) and the use of corrosion inhibitors.

CHEM 670 Polymers and Nanomaterials Chemistry (3-0-3)
Prerequisites: Graduate standing and instructor consent for non-chemistry major.

This course presents information essential to an understanding of polymers and nanomaterials chemistry e.g. chain and step growth polymerization, properties of polymers, polymer manufacturing processes, chemical and physical analysis of polymers, solid state chemistry, semiconducting materials, nanomaterials and materials characterization.

CHEM 695 Graduate Seminar I (1-0-1)
Prerequisites: Graduate standing and instructor consent for non-chemistry major.

In this course students attend seminars given by faculty, visiting scholars and fellow graduate students, and present at least one seminar on an appropriate research topic.

CHEM 696 Graduate Seminar II (1-0-1)
Prerequisites: CHEM 695
In this course students attend seminars given by faculty, visiting scholars and fellow graduate students, and present at least one seminar on an appropriate research topic.

CHEM 699 Master of Science Thesis (12 Credit Hours)
Prerequisite: Minimum of 8 credit hours of graduate course work.

The student, under the supervision of a graduate faculty member, undertakes and completes a research topic that comprises an in-depth investigation of a specific problem in Applied Chemistry culminating in a thesis to be approved by the Research Supervisory Committee.

BIOMEDICAL ENGINEERING (BMED)

BMED 600 Physiological Systems (3-0-3)
Prerequisite: Undergraduate knowledge of molecular and cellular physiology, and biotransport phenomena (or equivalent).

This course introduces human physiology to a wide range of graduate students with diverse backgrounds and varying biological experience. This course is designed to provide students with the mechanism of body function, regulation and a brief overview of anatomic structure. Course content will include the basic physical and chemical laws, homeostatic control of nervous system, musculoskeletal, circulatory, and respiratory systems. In addition to the foundation material, a related case study or research topic will be discussed.

BMED 601 Experimental Biochemistry (3-0-3)
Prerequisite: Undergraduate courses in organic chemistry and inorganic chemistry.

This course explores the chemical and physical properties of the cell and its building blocks including structures of proteins and principles of catalysis. Topics include the chemistry of organic/inorganic cofactors required for chemical transformations within the cell, basic principles of metabolism and regulation in pathways, including glycolysis, photosynthesis, fatty acid synthesis/degradation, Krebs cycle and oxidative phosphorylation.

BMED 602 Innovation and Creativity in Technology Organizations / Cross-Listed with ESMA 617 (3-0-3)
Prerequisite: Undergraduate knowledge of microeconomics.

This course will explore two terms used frequently in today's business world to describe companies or projects that go beyond conventional thinking: business "innovation" and "creativity." Many young jobseekers with an engineering background seek jobs with technology organizations that are innovative in the way that they define their business, structure their operations and workplace rules, build their products and compete in the marketplace. These innovative businesses – whether "intrapreneurial" projects within large technology organizations or small entrepreneurial startups – and their inspiring leaders are highly valued in today's market. The course will address questions like: where do the best ideas come from? How do organizations capture, develop, embrace, and harness these ideas? How do founders, leaders and other team members bring creative individualism to the project? How can creativity and innovation be increased without leading to chaos?

BMED 603 Multivariate Data Analysis (3-0-3)
Prerequisite: Undergraduate knowledge of linear algebra, differential equations and statistics.

Introductory graduate level course in Multivariate Data Analysis. This course focuses on the some of the most important techniques of data reduction and analysis of qualitative data, especially encountered in Biomedical Engineering.

BMED 611 Clinical Pathology (3-0-3)
Prerequisite: Undergraduate knowledge of biochemistry.

This course is intended to develop an understanding of the basic mechanisms of disease processes including the nature of cellular injury, inflammation, infection, repair, regeneration, neoplasia and abnormal vascular reactions.

BMED 612 Molecular Genetics and Genome Technologies (3-0-3)
Prerequisite: Undergraduate knowledge of biochemistry.

This course will cover concepts of genetics and genomics to advance the understanding of complex systems from the level of DNA and other molecules, through to cellular networks, tissues, to the whole organisms and interaction populations of organisms. The human genome is the primary focus of the course with other genomes used for comparative purposes. Applications of these disciplines of science will incorporate disease association studies, population genetics, diagnostic and precision medicine and gene editing.

BMED 620 Cognitive and Computational Neuroscience (3-0-3)
Prerequisite: Undergraduate course in Physiology or Physiological Systems (or equivalent).

This course will introduce graduate students to cognitive and computational neuroscience and its association with genetics, biochemistry, neurophysiology and signal processing in health and disease. Students will gain mathematical and experimental understanding of modelling from a functional and structural perspective, including; imaging technology and EEG, fNRS multisignal processing.

BMED 631 Advanced Biosignal Processing (3-0-3)
Prerequisite: Undergraduate knowledge of biomedical systems and signal processing (or equivalent).

Application of signal processing and modeling techniques in real world Bio signals (Electrocardiography (ECG), Electromyography (EMG) and Electroencephalography (EEG), Blood Pressure and heart Sound). MATLAB based physiological experiments, analysis and demonstration.

BMED 632 Physiological Control Systems (3-0-3)
Prerequisite: Undergraduate knowledge of biomedical systems, signal processing and control systems (or equivalent).

This course will expose graduate students to the design "secrets" of a variety of physiological control systems from an engineering viewpoint. How states of "health" versus "disease" can be explained in terms of physiological control system function (or dysfunction) will be considered. Examples of physiological control systems to be explored include: control of muscle tone, posture and locomotion; determinants and control of heart rate and blood pressure, body temperature regulation, respiratory mechanics and control, renal function and its regulation.

BMED 633 Advanced Rehabilitation Engineering (3-0-3)
Prerequisite: Undergraduate knowledge of human physiology and systems engineering.

This is a course that focuses via lectures, literature search and experimental work, on the rehabilitative and neural aspects of biomedical engineering, including human performance measurement and analysis, nerve stimulation, motor control and robotically assisted rehabilitation. Case studies from state of the art clinical platforms are also presented and discussed, including the Berkeley Lower Extremity Exoskeleton (BLEEX), the KineAssist and the Lokomat systems.

BMED 634 Algorithms in Bioinformatics / Cross-Listed with COSC 620 (3-0-3)
Prerequisite: Undergraduate level knowledge of bioinformatics.

This course focusses on algorithms to explore the many types of data produced in the Life Sciences, while combining theory and practice. Given the interdisciplinary nature of Bioinformatics, the course highlights the major mechanisms in genetics to an extend that enables formal, algorithmic approaches to process the heterogeneous data from genomics- and proteomics-based technologies: DNA sequence assembly and alignment, functional gene annotation, biological relational databases, metabolic network analysis, comparative genomics, phylogenetics, gene expression analysis and structural bioinformatics. They are coupled with fundamental algorithmic techniques including graph algorithms, dynamic programming, Statistics/Machine Learning, hierarchical clustering, classification and Bayesian methods. We will combine programming (mainly BioPython) and state-of-the- art analysis tools and apply it to Bioenergy, Metagenomics and Biomedicine.

BMED 635 Healthcare Information Systems / Cross-Listed with ESMA 673 (3-0-3)
Prerequisite: Knowledge of business analytics or equivalent.

This course provides a detailed overview of healthcare information systems for professionals who will work at the interface of clinical care, information technology, and the healthcare system. Topics include evidence-based care, clinical workflow analysis, unintended consequences of systems, and life- cycle management of complex clinical computing systems.

BMED 640 Biomaterials for Drug Delivery (3-0-3)
Prerequisite: Undergraduate course in Organic Chemistry or Biochemistry (or equivalent) and an undergraduate course in Molecular Science (Biological or Material or Physical or Chemical) (or equivalent).

This course focuses on the principles of engineering controlled release systems for targeted drug delivery. The course integrates topics in polymer chemistry, biomaterials, pharmacokinetics, and pharmaceutics formulation.

BMED 694 Selected Topics in Biomedical Engineering (3-0-3)
Prerequisite: Will be specified according to the particular topics offered under this course number.

This course covers selected contemporary topics in biomedical engineering. The topics will vary from semester to semester depending on faculty availability and student interests. Proposed course descriptions are considered by the Department of Biomedical Engineering on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the College of Engineering Graduate Studies Committee. The course may be repeated once with change of contents to earn a maximum of 6 credit hours.

BMED 699 Master's Thesis (minimum 12)
Corequisite: ENGR 695 Seminar in Research Methods, approval of the Department Chair and the Associate Dean for Graduate Studies.
In the Master's Thesis, the student is required to independently conduct original research-oriented work related to important biomedical engineering problems under the direct supervision of a main advisor, who must be a full-time faculty in the Biomedical Engineering Department, and at least one other full-time faculty who acts as co-advisor. The outcome of

the research should demonstrate the synthesis of information into knowledge in a form that may be used by others and lead to publications in suitable journals/conferences. The student's research findings must be documented in a formal thesis and defended through a viva voce examination. The student must register for a minimum of 12 credit hours of Master's Thesis.

BMED 711 Biomolecular and Cellular Engineering (3-0-3)
Prerequisite: Prior coursework and/or research experience in molecular and/or cellular biology and in engineering systems.

This course covers in-depth and critical understanding of genetic engineering in molecular and cellular level and application to tissue regeneration and drug delivery.

BMED 712 Rehabilitation and Augmentation of Human Movement (3-0-3)
Prerequisite: Prior coursework and/or research experience in human physiology and in systems engineering.

In the course human movement will be addressed from both biomechanical and neural perspectives, focusing on pathophysiology associated with movement and on technological aids in rehabilitation and augmentation of human movement.

BMED 713 Advanced Physiological Systems (3-0-3)
Prerequisite: Prior course work and/or research experience in human physiology and in systems engineering.

To provide advanced knowledge of physiological systems and emerging tools and approaches for modeling complex systems and analyzing high dimension datasets found in biology and medicine.

BMED 716 Medical Device Innovation (3-0-3)
Prerequisite: Prior coursework and/or research experience in human physiology and in systems engineering.

Medical Device Innovation is a "real world" course in creating successful medical devices. The course is composed of frontal lectures, practical training, and a guided project.

BMED 794 Selected Topics in Biomedical Engineering (3-0-3)
Prerequisite: Will be specified according to the particular topics offered under this course number.

This course covers selected contemporary topics in electrical and computer engineering. The topics will vary from semester to semester depending on faculty availability and student interests. Proposed course descriptions are considered by the Department of Biomedical Engineering on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the Graduate Studies Committee. The Course may be repeated once with change of contents to earn a maximum of 6 credit hours.

CHEMICAL ENGINEERING (CHEG)

CHEG 604 / WENV 604 Desalination (3-0-3)
Prerequisite: Undergraduate courses in heat transfer, mass transfer and fluid mechanics.
This course introduces the fundamental science and technology of water desalination to overcome water scarcity and ensure sustainable water supplies. It will cover in-depth the commonly adapted thermal and membrane based desalination technologies. This includes reverse osmosis, electrodialysis, flash-related desalination processes, and evaporation- related desalination processes. Renewable energy technologies coupled with desalination processes will be also presented. Additionally, fouling/scaling, corrosion, materials used and environmental impacts related issues will be covered. Finally, environmental, sustainability and economic factors of desalination systems for fresh water production and reuse will be presented.

CHEG 606 / WENV 606 Wastewater Treatment Engineering (3-0-3)
Prerequisite: None.
This course is an overview of engineering approaches to protecting water quality with an emphasis on the application of fundamental principles. Theory and conceptual design of systems for treating municipal and industrial wastewater are discussed. These include reactor theory, models, (bio)reaction stoichiometry and kinetics. Physical, chemical and biological processes are also studied.

CHEG 610 Advanced Chemical Reaction Engineering (3-0-3)
Prerequisite: Undergraduate level reaction engineering.

This course examines theory and practice on chemical reaction systems with an emphasis on the advanced application of mass and heat transfer and fluid mechanics in real reactors. The subject starts with the review of ideal reactors with different reactions and under different operation conditions, then focus on the steady/unsteady/multiple reactions with external energy exchange (start-up and run-away); modelling of heterogeneous catalytic reaction processes with various control steps; residence time distribution and mixing kinetic models for the design of real reactor; real reactors with multiphase reaction systems.

CHEG 611 Polymer Reaction Engineering (3-0-3)
Prerequisite: Undergraduate level polymer reaction engineering.

This course provides an introduction to the chemistry of polymerization and the polymer manufacturing process. It begins with basic concepts about polymers and polymerization and covers each major type of polymerization with relevant kinetics. The qualitative effect of reactor design on polymer manufacture is discussed as well as actual polymer manufacturing processes including those taking place in the UAE.

CHEG 620 Mathematical Methods in Chemical Engineering (3-0-3)
Prerequisite: Undergraduate level courses in mathematics.

Formulation and solution of mathematical models of a range of chemical processes with an emphasis on differential balances and incorporation of uncertainty.

CHEG 621 Numerical Methods in Chemical Engineering (3-0-3)
Prerequisite: Undergraduate level courses in mathematics.

Engineering applications of numerical methods. Numerical integration, solution of algebraic equations, matrix algebra, ordinary differential equations, and special emphasis on partial differential equations. Emphasis on the application of numerical methods to chemical engineering problems which cannot be solved by analytical methods. This course focuses both on the models and the algorithms that are used to solve these problems together with the readily available tools such as COMSOL, MATLAB etc.

CHEG 622 Process Simulation and Optimization (3-0-3)
Prerequisite: Undergraduate knowledge of optimization techniques.

Techniques of optimization, including the formulation of optimization problems, one-dimensional search techniques, analytical methods, n-dimensional search techniques, linear programming, and mixed integer programming. Advanced applications of the principles and theory to the synthesis of chemical processes and systems. Use of software packages for process optimization, synthesis, and analysis.

CHEG 623 Systems Engineering (3-0-3)
Prerequisite: Undergraduate chemical engineering courses in thermodynamics, transport phenomena and reaction engineering / instructor consent.

The course introduces students to process systems engineering and its application in chemical engineering practice. Emphasis is placed on developing skills in problem formulation, system design, use of analytical tools, and group dynamics. The topics include systems analysis, process simulation software (Aspen Plus), experimental design, applied optimization, and data analytics. Applications of these tools will be illustrated with a series of case studies involving steady-state process simulation, and product and process design.

CHEG 630 Advanced Chemical Engineering Thermodynamics (3-0-3)
Prerequisite: Undergraduate Thermodynamic course.

In this course, the principles, concepts, and laws of classical and statistical thermodynamics will be used for applications that require quantitative knowledge of thermodynamic properties from a molecular to a macroscopic level. Different models for phase equilibria calculations are presented in the form of equations of state and activity coefficient models for gases and liquids. An introduction to statistical mechanics is given, providing the link to molecular physics, intermolecular forces and macroscopic properties. Classical and molecular methods will be applied to high-pressure phase equilibria, interfacial properties, polymers and electrolyte solutions. In addition, advanced chemical and combined chemical/phase equilibria will be discussed.

CHEG 631 Statistical Thermodynamics (3-0-3)
Prerequisite: Undergraduate course on thermodynamics.

Statistical ensembles and relations to thermodynamic properties. Ideal mono- and diatomic gas. Mono-atomic crystals. Chemical equilibrium in ideal gas mixtures. Classical statistical mechanics. Equation of state for imperfect gases: Virial coefficients. Perturbation theory of liquids. Dilute electrolyte solutions. Polymer solutions. Transport properties of gases.

CHEG 640 Transport Phenomena (3-0-3)
Prerequisite: Undergraduate level transport phenomena or heat transfer, mass transfer, fluid mechanics.

The course focuses on unified treatment of heat transfer, mass transfer and fluid mechanics with application to chemical processes. Emphasis are on formulating models and obtaining solutions through analytical methods. It includes, conduction and diffusion, laminar flow regimes, convective heat and mass transfer and simultaneous heat and mass transfer with chemical reaction.

CHEG 641 Multiphase Flow (3-0-3)
Prerequisite: Undergraduate level numerical methods and fluid mechanics.

Continuum equations for conservation of momentum, heat and mass, averaging and combined phase equations. Motion of single particles, bubbles and ensembles. Bubble growth and cavitation. Gas-liquid, gas-solid and gas-liquid-solid flows, multiphase flow in chemical reactors. Flow through porous media.

CHEG 642 Separation Processes (3-0-3)
Prerequisite: Undergraduate courses in engineering thermodynamics, transport phenomena, mass transfer or equivalent.
The emphasis of the course will be on the understanding of the different separation processes concepts, theories and design. In addition, the separation method selection, operational behavior and design will be covered. This course will contain intensive separation process theories and mathematical work and calculations. The course will cover different levels of separation processes including gas/liquid, liquid/liquid, liquid/solid and gas/solid operations.

CHEG 643 Colloids and Interfacial Science (3-0-3)
Prerequisite: Undergraduate level numerical methods and fluid mechanics. Structure of solid surface sites. Instrumentation for surface characterization. Interaction of molecules in the gas phase with surfaces. Adsorption isotherms and adsorption coupled with surface reactions. Mechanisms of heterogeneous catalysis. Thermodynamics of interfaces. Solid–liquid interfaces and interfacial tension. Surfaces in contact with aqueous media, the electrical double layer, and adsorption from solution. Self-assembly of surfactant aggregates. Surface modification with surfactants.

CHEG 644 Consequence Analysis of Chemical Releases (3-0-3)
Prerequisite: None.

This course provides technical information on how to conduct a consequence analysis to satisfy the safety requirement and analysis for chemical engineering processes according to HSE regulations and policies. It covers quantifying the size of a release, dispersion of vapor clouds to an endpoint concentration, outcomes for various types of explosions and fires, and the effect of the release on people and structures.

CHEG 651 Combustion and Air Pollution Control (3-0-3)
Prerequisite: Undergraduate level heat transfer, mass transfer and fluid mechanics.

This course present air pollution impact on the environment, the hydrocarbon fuel energy, the different combustion devices and systems, pollutant emission predictions from chemical equilibrium and ideal flow reactors, design of flues and chimneys, atmospheric dispersion models, air pollution sampling and measurement, and air pollution control methods and equipment.

CHEG 652 Advanced Process Control (3-0-3)
Prerequisite: Undergraduate level process dynamic control.

This course covers regulatory and supervisory control, multivariable control loops, time-delay systems, complex variable interactions, and the principles of industrial model predictive control. The course also covers multivariate data-driven process monitoring techniques for fault detection and diagnosis. Application studies involving relevant examples in the chemical industry.

CHEG 653 Sustainable Energy Conversion Processes (3-0-3)
Prerequisite: Undergraduate knowledge of reaction engineering.

The objective of this course is to understand Fischer-Tropsch chemistry and reaction engineering, as well as gas-to-liquids (GTL) technology and its applications in the area of energy systems engineering. Fuel cell technology and systems will be examined critically and analytically. Utilization and chemical engineering aspects of energy production from nonconventional hydrocarbons energy sources, such as coal, oil shale, oil sands, and synthetic gas and liquid fuel will be discussed. The course will also cover topics including chemistry and engineering aspects of improved/enhanced oil recovery, and applications of chemical engineering fundamentals in solar energy resources and technology.

CHEG 654 Chemical Process Safety (3-0-3)
Prerequisite: Undergraduate level heat transfer, mass transfer, fluid mechanics.

To understand inter relationship among occupational health, plant safety and environmental protection. To become familiar with various source models to estimate the possible damage distances in case of accidental

release of liquids and gases from process plants. To study methods and techniques used to assess process plant safety, during design and in operations.

To understand chemical reaction hazards and safety aspects for the design of process plant equipment. To evaluate and learn from detailed accident case studies.

CHEG 655 Air Quality Management (3-0-3)
Prerequisite: Graduate standing.

The objective of this course is to understand the gravity of the problem of air pollution, its sources, and the industrial practices to reduce pollutant emission to ambient air. The course involves the design of air pollution mitigation systems adopted for different types of pollutants. The sampling and measurement techniques for ambient air and for industrial stacks will be discussed. Engineering control and best management practices for different types of equipment will be examined. Environmental impact and the technical and economic feasibility of emission control technologies will also be addressed.

CHEG 656 Experimental Design (3-0-3)
Prerequisite: Students taking this course should have successfully completed CHEG 331 or equivalent.

The course presents a methodology for product and process improvement by i) defining customer goals and customer deliverables, ii) measuring current process or product performance to define improvement opportunities, iii) defining root causes of problems, iv) improving processes using statistical and experimental methods, and iv) applying controls to ensure long-term stability of improvements.

CHEG 657 Materials Engineering and Corrosion (3-0-3)
Prerequisite: Undergraduate knowledge of thermodynamics and kinetics.
Corrosion thermodynamics and kinetics. Types of corrosion. Corrosion control with cathodic protection, inhibition and coatings. Materials selection based on corrosion criteria. Typical petroleum exploration and production, and petroleum refining applications. Electrochemical methods for studying corrosion including direct-current electrochemical methods, electrochemical impedance measurements, electrochemical noise techniques.

CHEG 658 Polymer Properties and Processing (3-0-3)
Prerequisite: Graduate standing.
Study of various polymer properties (mechanical, morphological, barrier, thermal, viscoelastic etc.) related to their structure and contributing to their applications. Introduction to various polymer processing methods (mixing, extrusion, injection molding, blow molding, spinning, compression molding etc.). Extension of polymer processing to the conventional composites and nanocomposites technology.

CHEG 659 Engineering Design for Process Safety (3-0-3)
Prerequisite: Graduate standing.
The objective of this course is to learn the variety of potential solutions for identified concerns using the conventional hazard identification check list for large variety of chemical process equipment's. The course would serve to identify opportunities for inherent and passive safety feature to be considered in the design, fully understand all the hazards and resulting risk associate with design alternatives and use risk based approach to process safety system specification.

CHEG 694 Selected Topics in Chemical Engineering (3-0-3)
Prerequisite: Will be specified according to the particular topics offered under this course number.

This course covers selected contemporary topics in chemical engineering. The topics will vary from semester to semester depending on faculty availability and student interests. Proposed course descriptions are considered by the Department of Chemical Engineering on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the College of Engineering Graduate Studies Committee. The course may be repeated once with change of contents to earn a maximum of 6 credit hours.

CHEG 699 Master's Thesis (minimum 12)
Co-requisite: ENGR 695 Seminar in Research Methods, approval of the Department Chair and the Associate Dean for Graduate Studies.

In the Master's Thesis, the student is required to independently conduct original research-oriented work related to important chemical engineering problems under the direct supervision of a main advisor, who must be a full-time faculty in the Chemical Engineering Department, and at least one other full-time faculty who acts as co-advisor. The outcome of the research should demonstrate the synthesis of information into knowledge in a form that may be used by others and lead to publications in suitable journals/conferences. The student's research findings must be documented in a formal thesis and defended through a viva voce examination. The student must register for a minimum of 12 credit hours of Master's Thesis.

CHEG 700 Sustainable Desalination Processes / Cross-Listed with CIVE 714 (3-0-3)
Prerequisite: Graduate level course on desalination (or equivalent).

The course introduces key issues related to promoting sustainable desalination operations in today's desalination industry. The course analyzes developments in the desalination industry using the three elements of sustainability: cost, society, and the environment.

CHEG 703 Applied Nanotechnology (3-0-3)
Prerequisite: Graduate level course on advance materials courses (or equivalent).
Discussion on the principles driving the advantages of nanotechnology over the conventional systems. The course will also focus on the application of nanotechnology in various engineering sectors. Topics include: nano-architecture, nano-composites, nano-biotechnology, nano-devices and nano-fabrication.

CHEG 705 Membrane Technology / Cross-Listed with CIVE 717 (3-0-3)
Prerequisite: Graduate level course on desalination or equivalent.

The course will describe in details membrane separation technology in the context of wide range of applications, especially in desalination, filtration and wastewater treatment. The course covers: global water shortages and need for membrane technology, Microfiltration, ultrafiltration, nanofiltration (NF), membrane distillation (MD), membrane bioreactors (MBR) and reverse osmosis (RO) membrane processes. It also discusses operational issues of membrane-based systems, their limitations and system configuration and design.

CHEG 708 Phase Equilibria (3-0-3)
Prerequisite: Graduate level course on advanced chemical engineering thermodynamics (or equivalent).

The purpose of this course is to educate all consequences of the Gibbs phase rule in understanding phase behavior and its practical

applications in constructing and calculation of phase diagrams. As an additional feature, knowledge of phase transformation theory leads to the understanding how phases may transform into each other. Also it will be discussed how certain types of phase behavior are interrelated to each other.

CHEG 710 Kinetics and Mechanisms (3-0-3)
Prerequisite: Graduate level course on reaction engineering (or equivalent).

The course provides an advanced overview of chemical kinetics, statistical theories of reaction rates, and the microscopic aspects of chemical reaction dynamics with an emphasis on determination of rate parameters using computational chemistry and ab-initio methods. Topics include kinetics of gas, liquid, and surface reactions; quantum chemistry; transition state theory; surface adsorption, diffusion, and desorption processes; complex reaction networks; mechanism formulation, sensitivity analysis and Chemistry of catalytic reactions.

CHEG 712 Physical and Chemical Treatment of Waters (3-0-3)
Prerequisite: Graduate level course on wastewater treatment engineering (or equivalent).

Theory and design of specific processes used for the physical and/or chemical purification of waters and wastewaters, including mixing, flocculation, sedimentation, flotation, filtration, disinfection, adsorption, ion exchange, aeration, and membrane filtration.

CHEG 715 Biological Wastewater Treatment (3-0-3)
Prerequisite: Graduate level course on wastewater treatment engineering (or equivalent).

This course is about population kinetics of microorganisms and their role in the various waste treatment processes. Unit processes for wastewater treatment, such as suspended-growth, attached-growth processes, sludge treatment, and nutrient removal are presented.

CHEG 720 Modelling and Engineering of Microbial Environmental Bioprocesses (3-0-3)
Prerequisite: Graduate level course on reaction engineering or wastewater treatment engineering (or equivalent).

The course covers in detail the modelling of the physical, chemical and biological principles involved in microbial bioprocesses. Fundamentals of microbial metabolism, stoichiometry, energetics, ecology and kinetics as well as bioreactor modelling and optimisation. The mathematical modelling and design of microbial bioreactors for environmental and industrial applications is emphasized.

CHEG 730 Experimental Techniques and Instrumentation (3-0-3)
Prerequisite: Graduate standing.

This course is to train students with theories and skills in the advanced methods for Chemical Engineering analysis and materials characterization in order that they can select the most suitable one for analyzing and characterizing the properties of a specific system, for example, the in depth characterization of a material at a nanoscale. The students have access to the available advanced testing equipment in PI, to perform several practical and laboratorial works which will be presented as scientific reports.

CHEG 735 Electrochemical Engineering (3-0-3)
Prerequisite: Graduate level courses on advanced chemical reaction engineering and advanced thermodynamics (or equivalent).
Fundamentals on energy storage devices and electrodes; Electrochemical energy conversion; Circuit analysis; Principles of thermodynamics relevant to electrochemical engineering; Governing equations and reactions; Description of fuel cells and lead acid/Li-ion batteries; Principles of polarization, conductivity, and transport (diffusion and convection) in cells; Electrostatics and electrokinetics. Phase conversions.

CHEG 745 Multicomponent Mass Transfer
Prerequisite: Graduate level course on transport phenomena (or equivalent).

This course is about the diffusion and mass transfer processes that are really important, including: those with three or more species (the 'multicomponent') mixtures, those with more than one driving force, including electrical or pressure gradients, and those with a solid matrix such as a polymer or a porous medium.

CHEG 750 Molecular Thermodynamics (3-0-3)
Prerequisite: Graduate level course on advanced chemical engineering thermodynamics (or equivalent).

This course aims to transfer detailed knowledge and understanding on the thermodynamics of a wide variety of systems of industrial importance. After a short refreshing of basic thermodynamic tools like chemical potential and fugacity, this course offers a treatment of modern thermodynamic models commonly in use for complex fluids as to be met in the oil and gas industry. Furthermore, attention will be given to the thermodynamics of polymer solutions, electrolyte and polydisperse systems. Also understanding of criticality will be presented. As computer simulations are an important tool to retrieve useful thermodynamic information, the course will offer an introduction to Monte Carlo and Molecular Dynamics simulations. Finally, a short introduction to non-equilibrium thermodynamics will be offered.

CHEG 760 Non-Equilibrium Thermodynamics (3-0-3)
Prerequisite: Graduate level course on advanced chemical engineering thermodynamics (or equivalent).

A thermodynamic description is applied in terms of excess densities, developed by Gibbs for equilibrium, to non-equilibrium systems. The treatment is restricted to transport into and through the surface. Using local equilibrium together with the balance equations for the surface, expressions for the excess entropy production of the surface are derived.

CHEG 765 Computational Fluid Dynamics for Chemical Engineers (3-0-3)
Prerequisite: Graduate level course on computational methods and fluid mechanics (or equivalent).

This course gives an introduction to CFD simulations of turbulence, mixing, reaction, combustion and multiphase flows. The emphasis on understanding the physics of these flow systems helps the students to select appropriate models with which to obtain reliable simulations. Besides presenting the equations involved, the basics and limitations of the models are explained and discussed. The students will be given hands-on experience of drawing, meshing and simulation. The tutorials cover different flow systems that serve the interest of many engineering disciplines (Chemical, Mechanical, Nuclear, Aerospace, and Environmental Engineering).

CHEG 770 Heterogeneous Catalysis (3-0-3)
Prerequisite: Graduate level courses on advanced chemical engineering thermodynamics and transport phenomena. Study on pore structure and surface area follow, with details on experimental determination of porosity and surface area, along with hysteresis cases. Infrared and thermogravimetric characterization of catalyst represent the final part of the course, which ends with a session of lab trainings on characterization of different catalyst samples. Applications are emphasized through extensive problem work relating to practical cases.

CHEG 790 Dynamic Behavior of Process Systems (3-0-3)
Prerequisite: Graduate level course on systems engineering (or equivalent).

The overall objective of this course is to teach students how to develop, in a systematic manner, correct, complete and mathematically well-behaved models of the transient behavior of process equipment. The course focuses on first-principles mathematical models derived from an understanding of the fundamental process physics, and on the interactions between physics, mathematical formulations and mathematical/numerical solution methods. Ultimately, students should be able to apply these concepts to build and execute detailed models of process equipment using state-of-the-art modelling tools.

CHEG 794 Selected Topics in Chemical Engineering (3-0-3)
Prerequisite: Will be specified according to the particular topics offered under this course number.

This course covers selected contemporary topics in electrical and computer engineering. The topics will vary from semester to semester depending on faculty availability and student interests. Proposed course descriptions are considered by the Department of Chemical Engineering on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the Graduate Studies Committee. The Course may be repeated once with change of contents to earn a maximum of 6 credit hours.

CIVIL INFRASTRUCTURE AND ENVIRONMENTAL ENGINEERING (CIVE)

CIVE 630 Tensors Algebra and Applications (3-0-3)
Prerequisite: Undergraduate level calculus, differential equations and linear algebra or permission of the instructor.

The course focuses on a detailed exposition of tensor calculus and algebra as tools in the study of non-linear continuum mechanics principles and techniques necessary for the derivation, analysis, algorithmic development and critical evaluation of constitutive models and system solution procedures suitable for the analysis and the simulation of the response of civil and infrastructural engineering materials and systems.

CIVE 631 Dynamic Response of Civil Engineering Constructions (3-0-3)
Prerequisite: Undergraduate level structural analysis.

This course is to introduce the basic concepts and techniques for structural dynamics and their practical applications to structural engineering. Students will learn the response of single degree of freedom (SDOF) and multi degree of freedom (MDOF) systems due to free vibration and forced (harmonic, periodic, arbitrary, pulse) vibration, and the earthquake response of elastic and inelastic buildings. Modal analysis, response spectrum analysis, and time-stepping methods for structural systems will be briefly covered.

CIVE 632 Highrise Building Design (3-0-3)
Prerequisite: Undergraduate knowledge of structural analysis, structural dynamics, constitutive modelling, design of concrete and steel members.

The course introduces the students to the various types of structural systems for tall buildings, their analysis and design. It addresses in detail aspects of the inelastic response of reinforced concrete and steel members and response spectrum analysis and time-stepping methods necessary for the inelastic analysis of the response of reinforced concrete and steel structures. Capacity design of the reinforced concrete and steel structures will be covered.

CIVE 634 Design of Civil Engineering Structures for Fire Protection (3-0-3)
Prerequisite: Undergraduate level courses on concrete and steel materials and design or permission of the instructor.

The course introduces the concepts of fire science and provides an outline of the key stages in ignition, fire growth and combustion products as they relate to fires in civil engineering constructions. Detailed methodologies for material selection, containment, fire resistant design, fire severity and post fire damage evaluation are presented and related to the requirements of various modern building codes. The course addresses issues faced by architects, fire safety engineers, civil engineers and building code regulators in controlling the effects of fire on civil engineering constructions and the available techniques, materials and design methodologies.

CIVE 635 Railway Geotechnics (3-0-3)
Prerequisite: Undergraduate level calculus, geotechnical engineering and foundation engineering, constitutive modelling, or permission of the instructor.

This course provides in-depth understanding of railroad track geotechnical engineering concepts, which include track component and system design, construction, evaluation, maintenance, load distribution, and wheel/rail interaction. The course will include field trip(s) to observe railway tracks and their components.

CIVE 636 Wind Effects on Structures (3-0-3)
Prerequisite: Undergraduate level courses on calculus, differential equations, structural analysis, concrete and steel materials and fluid mechanics or permission of the instructor.

This course utilizes principles and techniques from meteorology, aerodynamics, structural dynamics and aeroelasticity to describe and quantify the mechanisms of wind action on structures and the procedures used in the design of highrise buildings, towers, suspension bridges and industrial plants and the utilization of wind tunnels as design evaluation tools.

CIVE 637 Pavement Monitoring and Rehabilitation (3-0-3)
Prerequisite: Undergraduate level civil engineering materials, pavement design, and construction project management or permission of the instructor.

The course focuses on the engineering concepts needed to maintain and rehabilitate pavement and their implications on flexible and rigid pavement performance over the infrastructure service life. On the basis of project evaluation, testing and analysis, the design of rigid and flexible overlays is examined, as well as rehabilitation alternatives. The effects of maintenance and rehabilitation activities are evaluated in terms of pavement performance and life cycle costs.

CIVE 638 Transportation Systems (3-0-3)
Prerequisite: Undergraduate level course on an introductory transportation engineering course.

This course focuses on the efficient integration of different modes of transportation via multi-modal points in an urban area. An individual's trip consists of a combination of various modes of transportation including, auto (driver), auto (passenger), public transit (bus, rail, air), active modes (bike, walk), and other emerging modes. In order to implement such integration, it is essential to understand the mode-specific characteristics, associated utility, and logic models. It is also necessary to determine which intermodal points are suitable for the mode-pair transfers and when and how the transfers are to be executed.

CIVE 640 Soil-Structure Interaction (3-0-3)
Prerequisite: Undergraduate level calculus, geotechnical engineering and foundation engineering or permission of the instructor.
The course focuses on the effects of soil-structure interactions (SSI) to understand the realistic response of structures on flexible foundation soils. Characterization of elastic and plastic soil behavior under static and dynamic loads, ground response analysis with linear and nonlinear soil properties, structural influence on ground response, ground deformation by seismic loads are studied. Kinematic and inertial SSI are covered regarding the structural embedment into soils, dynamic structural responses and soil deformations. Numerical modeling of soil-structure systems is studied including visco-elastic halfspace media, Winkler model, and finite element analysis.

CIVE 641 Coastal Engineering (3-0-3)
Prerequisite: Undergraduate level calculus, differential equations and linear algebra or permission of the instructor.

This course provides in-depth understanding of wave mechanics, mechanisms of wave generation, coastal waves' variations, coastal sedimentary processes and the design and verification of coastal protection structures.

CIVE 650 Construction Cost Estimating (3-0-3)
Prerequisite: None.

This course will provide students with knowledge of the principles and practices of construction cost estimating. The course covers techniques used in estimating including: the principles of the estimating process, creating unit costs for labor and equipment resources, range estimating, estimating earthwork and excavation, highways and pavements, concrete and steel structures, and masonry. Students will learn how to convert estimated costs to the bid estimate incorporating subcontractors' bids, overhead and profit, and contingency estimation based on risk analysis. Each topic is introduced with a detailed explanation of the techniques and methods involved with hands on estimating exercises.

CIVE 651 Sustainable Building Construction (3-0-3)
Prerequisite: Undergraduate level courses on Construction Engineering, Management and Environmental Engineering or permission from the instructor.

This course will provide students with knowledge of the principles and practices of sustainability in construction while exploring the cutting edge of sustainable construction. The course covers topics including: UAE green building rating systems (Estidama and Al Safat), proper site selection, energy and water efficiency, material reuse, indoor air quality and cutting edge technologies and practices of sustainable construction. Each topic is introduced with a detailed explanation of the techniques and methods involved with hands on exercises.

CIVE 652 Construction Safety (3-0-3)
Prerequisite: Undergraduate level knowledge of fundamentals of Construction Engineering and Management or permission from the instructor.

This course addresses the vital issue of construction site safety from a management perspective while introducing students to local safety regulations. Students gain insight into the challenges of accident prevention and techniques for managing safe and secure construction projects. Covered topics include: a history of construction safety, accident causation theory, recognition, avoidance, abatement, and prevention of safety and health hazards, hazard control procedures, insurance and risk management, behavior-based safety initiatives, occupational safety and health management systems in construction firms.

CIVE 694 Selected Topics in Civil and Infrastructural Engineering (3-0-3)
Prerequisite: Will be specified according to the particular topics offered under this course number.

This course covers selected contemporary topics in civil and infrastructural engineering. The topics will vary from semester to semester depending on faculty availability and student interests. Proposed course descriptions are considered by the Department of Civil Infrastructure and Environmental Engineering on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the College of Engineering Graduate Studies Committee. The course may be repeated once with change of contents to earn a maximum of 6 credit hours.

CIVE 699 Master's Thesis (minimum 12)
Corequisite: ENGR 695 Seminar in Research Methods, approval of the Department Chair and the Associate Dean for Graduate Studies.

In the Master's Thesis, the student is required to independently conduct original research-oriented work related to important civil and infrastructural engineering problems under the direct supervision of a main advisor, who must be a full-time faculty in the Civil Infrastructure and Environmental Engineering Department, and at least one other full-time faculty who acts as co-advisor. The outcome of the research should demonstrate the synthesis of information into knowledge in a form that may be used by others and lead to publications in suitable journals/conferences. The student's research findings must be documented in a formal thesis and defended through a viva voce examination. The student must register for a minimum of 12 credit hours of Master's Thesis.

CIVE 703 Groundwater Hydrology (3-0-3)
Prerequisite: Graduate level course on hydrologic analysis (or equivalent).

Fundamentals of subsurface flow and transport, emphasizing the role of groundwater in the hydrologic cycle, the relation of groundwater flow to geologic structure, and the management of contaminated groundwater. Topics include: D'Arcy equation, flow nets, mass conservation, the aquifer flow equation, heterogeneity and anisotropy, storage properties, regional circulation, unsaturated flow, recharge, stream-aquifer interaction, well hydraulics, numerical models, groundwater quality, geochemistry, contaminant transport processes, dispersion, decay, and adsorption.

CIVE 707 Environmental Remote Sensing and Satellite Image Processing (3-0-3)
Prerequisite: Linear algebra, probability and statistics, or consent of the instructor. Graduate level course on environmental data analysis (or equivalent).

This course provides a theoretical and practical understanding of technology and applications of satellite remote sensing and Geographic Information System (GIS) in forecasting, mapping, and monitoring the natural environment. It covers a range of remote sensing and GIS tools and techniques used to address environmental issues at local, regional and global scales, with hands-on experience in satellite data analysis, digital image processing, generation of maps and manipulation of layers of spatial information, and analysis of field data and ground-based measurement. Technical topics include radiometric correction, geometric correction, atmospheric and ground effects, multi-spectral and multi-temporal analysis, supervised and unsupervised classification, and change detection. All topics are accompanied by lab assignments using various image processing software systems. In addition, students will have the opportunity to work on applied GIS projects where spatial data are used to address real world problem.

CIVE 712 Remediation Engineering (3-0-3)
Prerequisite: Graduate level course on chemicals in the environment: fate and transport (or equivalent).

An advanced course on the remediation or cleanup of contaminants present in the subsurface (i.e. vadose zone soils and aquifers). Topics will include: (i) Subsurface characterization (i.e., determining porous media properties and contaminant delineation); (ii) Setting remediation endpoints based on environmental risk; (iii) Predicting natural attenuation of groundwater contaminants using bioenergetics models for the no-remedial-action scenario; (iv) Designing extraction-well arrays for contaminated soil vapor and groundwater recovery for pump-and-treat systems; (v) In situ treatment technologies (e.g., permeable reactive barriers (PRBs), in situ reactive zones; and (vi) Long-term monitoring, performance evaluation, and costs of site remediation.

CIVE 714 Sustainable Desalination Processes / Cross-Listed with CHEG 700 (3-0-3)
Prerequisite: Graduate level course on desalination (or equivalent).

The course introduces key issues related to promoting sustainable desalination operations in today's desalination industry. The course analyzes developments in the desalination industry using the three elements of sustainability: cost, society, and the environment.

CIVE 717 Membrane Technology / Cross-Listed with CHEG 705 (3-0-3)
Prerequisite: Graduate level course on desalination (or equivalent).

The course will describe in details membrane separation technology in the context of wide range of applications, especially in desalination, filtration and wastewater treatment. The course covers: global water shortages and need for membrane technology, Microfiltration, ultrafiltration, nanofiltration (NF), membrane distillation (MD), membrane bioreactors (MBR) and reverse osmosis (RO) membrane processes. It also discusses operational issues of membrane-based systems, their limitations and system configuration and design.

CIVE 718 Advanced Topics in Applied Environmental Chemistry (3-0-3)
Prerequisite: Graduate level course on chemicals in the environment: fate and transport or equivalent.

Provides a theoretical and practical understanding for characterizing anthropogenic organic contaminant molecules in environmental media. Topics include: (1) Theoretical basis for commonly used off-line and in-line analytical separations, such as chromatography, liquid-liquid extraction, and ion exchange; (2) instrumental methods of analysis and their detection techniques utilized for compound quantitation; and, (3) spectroscopy and spectrometry techniques employed for compound identity confirmation. Emphasis is placed on trace-level environmental contaminants that require sample pre-concentration or passive sampling techniques prior to analysis. Novel applications are discussed using recent examples from scientific literature.

CIVE 719 Climate Dynamics (3-0-3)
Prerequisite: Graduate level course on global climate change impacts and adaptation, graduate level calculus, physics, and fluid mechanics (and/or hydraulics), basic stochastic modeling, or equivalent.

Climate dynamics is an extremely young discipline in atmospheric sciences. Its basic assumption is that climate is not a quasi-static system – as mostly believed till the second half of the twentieth century – but a complex dynamical system evolving under both anthropogenic and internal forcing. The course will provide students with a quantitative understanding of atmospheric dynamics and thermodynamics, and will cover main topics in internal and anthropogenic climate variability, relying on both a dynamical (deterministic) and statistical/stochastic approach. Special emphasis will be given to the diverse uncertainty sources of future climate scenarios and to the assessment of climate variability impacts (both in terms of "average global" variability and "extreme events frequency" variability) on water resources, renewable energy harvesting and sustainable development.

CIVE 720 Nanotechnology in Water Purification (3-0-3)
Prerequisite: Graduate level course on desalination (or equivalent).

This is a multidisciplinary course. The behavior of nano-materials by employing the adsorption approach. Analytical method of using specialized instruments to characterize the nanomaterials properties, and interpret the results. Membranes and their properties. Nanomaterials and their application in adsorption, electrosorption, membrane filtration and advanced oxidation water purification processes. Nano-photocatalytic oxidation process in water treatment. Potential risks associated with using nanomaterials in water purification.

CIVE 721 Aquatic Chemistry (3-0-3)
Prerequisite: Graduate level course on chemicals in the environment: fate and transport (or equivalent).

Environmental engineering has been defined as primarily the study of the fate, transport, and effects of chemicals in the natural environment, and the formulation of options for cleaning up and reducing the effects of anthropogenic and natural wastes in the environment. This course provides essentials of the chemistry for environmental processes. The topics include general chemistry, water/wastewater chemistry, atmospheric chemistry and soil chemistry

CIVE 722 Solid and Hazardous Waste Management (3-0-3)
Prerequisite: Graduate level course on chemicals in the environment: fate and transport or equivalent.

Solid waste analysis including: sources, types and composition of solid waste; handling, storage, collection and transfers; processing and resource recovery including incineration, pyrolysis and composting; hazardous waste and sanitary landfill design and management issues.

CIVE 730 Public Transit Operations and Planning (3-0-3)
Prerequisite: Undergraduate knowledge of transportation engineering or equivalent.

This course focuses on various topics in urban public transit operations and planning. The course will help students: Learn the history of public transit, understand its role in sustainable urban development and society, State-of-art review of best-practice strategies, Analyze the transit performance and demands, Identify and solve problems both at operational level and strategic level, Transit economics of various transit modes, Design and schedule for transit networks, Review of emerging technologies and strategies.

CIVE 750 Non-Linear Mechanics of Construction Materials (3-0-3)
Prerequisite: Linear algebra, calculus and differential equations.

The course focuses on a detailed exposition of non-linear computational mechanics principles and techniques which are necessary for the derivation, analysis, algorithmic development and critical evaluation of a wide range of constitutive models suitable for the simulation of the inelastic response of civil and infrastructural engineering materials.

CIVE 751 Non-Linear FE Analysis of Civil Engineering Structures (3-0-3)
Prerequisite: Non-Linear Mechanics of Construction Materials (CIVE 750) or equivalent or instructor permission.

Standard finite element techniques and software do not capture the particularities of the highly non-linear response of civil engineering materials. The course focuses on the detailed derivation, analysis, algorithmic development and implementation and the critical evaluation of non-linear finite element techniques and algorithms suitable for the simulation of the response of civil and infrastructural engineering structures subjected to static or dynamic loading.

CIVE 755 Geotechnics for Natural Hazard Mitigation (3-0-3)
Prerequisite: Undergraduate knowledge of geotechnical engineering or equivalent, graduate level knowledge in probability and statistics.

Natural hazards and role of geotechnical engineering. Field survey technics for reconnaissance. Evaluation of laboratory experimental data and prototype modeling. Theoretical soil behaviors under various loads. Case histories – landslides, soil liquefactions. Reliability concepts. Risk-based design. Soil-structure system performance. Ground improvement for hazard mitigation. Infrastructure investment, sustainable design. The course will use numerical analysis tools to model soil responses under natural disasters.

CIVE 756 Chemo-Mechanical Modelling and Design of Flexible Pavements (3-0-3)
Prerequisite: Non-Linear Mechanics of Construction Materials (CIVE 750) or equivalent.

The course focuses on a detailed identification and the quantification of the role the chemical composition and the physical characteristics of the constituents of an asphaltic material play on determining the mechanical response of the material and its implications on flexible pavement performance. On the basis of a hierarchical approach, the physico-chemical characteristics of asphalt mix constituents at various scales are examined and the interactions between them are identified and utilised and/or manipulated for the design of asphalt mixes with material response characteristics optimized for the particular pavement design application.

CIVE 760 Construction Procurement Management (3-0-3)
Prerequisite: Graduate level knowledge of management of construction development process, supply chain management within the construction industry and construction project procurement routes.

This course introduces the project procurement concept and relevant management and implementation mechanisms to help students apply these when developing a construction project. This course is primarily focused upon how project leaders can make and influence procurement decisions to realize a project that truly delivers value to project stakeholders for project and organizational success. Particular attention is paid to the nature of 'value for money' in this process along with the role of procurement strategies in order to achieve value for money for the client and customers.

CIVE 761 Productivity Improvement in Construction (3-0-3)
Prerequisite: Undergraduate knowledge of fundamentals of construction engineering and management or equivalent.

The objective of this course is to examine factors that impact construction productivity, the use of management tools to develop construction productivity improvement programs, methods for performing construction loss calculations, and strategies for developing productivity improvement programs for the construction environment. Higher productivity drives greater profitability by improving cost and schedule performance. Throughout the course, emphasis will be placed on techniques and methods that can manage and increase the efficiency of cost and schedule parameters. This course is designed to provide guidance to students, future owner, contractor, subcontractor, or construction manager on methods and processes by which construction productivity can be effectively managed and increased.

CIVE 762 Advanced Building Information Modeling (3-0-3)
Prerequisite: Graduate level courses in building life cycle analysis, construction project management and control, planning and scheduling.

This course addresses emerging technologies in the context of Project Management and Integrated Delivery, and includes modeling, visualization, 3D clash detection, digital site layout, 4D modeling, as-built model generation, and digital information management. This course will first introduce basic Virtual Design and Construction (VDC) and BIM concepts and review industry examples of how these concepts play out on design and construction projects. Students will learn advanced concepts of BIM through formal lectures, but they will also have the opportunity, through hands-on group projects, to apply the theoretical knowledge to development of a building project from conceptual design, through engineering and cost analyses, to detailed design and fabrication of models using rapid prototyping technology.

CIVE 794 Selected Topics in Civil Infrastructural and Environmental Engineering (3-0-3)
Prerequisite: Will be specified according to the particular topics offered under this course number.

This course covers selected contemporary topics in electrical and computer engineering. The topics will vary from semester to semester depending on faculty availability and student interests. Proposed course descriptions are considered by the Department of Civil Infrastructural and Environmental Engineering on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the Graduate Studies Committee. The Course may be repeated once with change of contents to earn a maximum of 6 credit hours.

COMMUNICATION STUDIES (COMM)

COMM 601 Scientific and Technical Writing (3-0-3)
Prerequisite: None

This course imparts the essential knowledge and skills of academic, technical and scientific writing. It includes an examination of academic articles in Engineering and Applied Science and drafting practice in a variety of required genres such as proposal drafting.

COMPUTER SCIENCE (COSC)

COSC 602 Software Engineering (3-0-3)
Prerequisite: Undergraduate course in Software Engineering (or equivalent).

This course is an advanced course on software engineering, which deals with the advanced topics in quality requirements for mission-critical

systems, large-scale software architecture, and data mining of software engineering repositories and artifacts. Topics include mission critical non-functional requirements safety, security, privacy, and trust; large-scale software architecture patterns and re-structuring; data mining error logs, and other selected topics.

COSC 603 Multi-Agent Systems (3-0-3)
Prerequisite: Undergraduate course in artificial intelligence (or equivalent).

This course is an advanced course on multi-agent systems, which deals with the analysis and design of distributed entities that interact with each other in both cooperative and non-cooperative domains. Topics include: cooperative and non-cooperative game theory, social choice, mechanism design, auctions, repeated games, distributed optimization, multi-agent learning and teaching, and other selected topics.

COSC 604 Artificial Intelligence (3-0-3)
Prerequisite: Undergraduate course in artificial intelligence.

This course is a graduate-level introduction to the field of artificial intelligence (AI). It aims to give students a solid understanding of the main abstractions and reasoning techniques used in AI. Topics include: representation and inference in first-order logic; modern deterministic and decision-theoretic planning techniques; Bayesian network inference and (Deep) Reinforcement Learning.

COSC 605 Strategic Requirements Engineering (3-0-3)
Prerequisite: Undergraduate course in software engineering (or equivalent).

This is an interdisciplinary graduate-level course on requirements engineering and the application of requirements engineering principles and techniques to the development of complex socio-technological systems. The course puts particular emphasis on the integration of economic, strategic, social, and technological requirements, and the analysis of their impact on the future evolution of the system.

COSC 606 Machine Learning (3-0-3)
Prerequisite: Undergraduate course in machine learning (or equivalent).

This course will cover graduate-level materials on machine learning in both theory and practice by building upon the undergraduate-level course on "Introduction to Machine Learning". The topics include statistical learning theory, ensemble learning, probabilistic learning, dimension reduction, recommender systems, advanced clustering, semi-supervised learning, transfer learning, etc.

COSC 607 Algorithm Design Techniques (3-0-3)
Prerequisite: Undergraduate course in design and analysis of algorithms (or equivalent).

Algorithms constitute the core of Computer Science and algorithm design is crucial for the performance of real-world software systems. This is an advanced algorithms course, focusing on techniques for the design and analysis of efficient algorithms, emphasizing methods useful in practice. Topics include average case analysis of search trees and hashing; amortized analysis; competitive analysis; parallel algorithms; approximation algorithms for hard optimization problems, algorithms for problems arising in computational geometry and number theoretic algorithms.

COSC 608 Distributed Systems and Cloud Computing (3-0-3)
Prerequisite: Undergraduate courses in computer networks and parallel and distributed computing (or equivalent).

This course teaches in-demand technologies for distributed and parallel computation as well as storing and processing large amounts of data using cloud computing technologies. While underlying network and architecture issues are discussed to the extent that enables a basic understanding, particular focus is on the data science aspects of Cloud computing and cloud applications complementary to other Computer Science courses related to the realm of Data Science and Artificial Intelligence. It introduces general concepts and deploys the state-of-the-art systems from public cloud systems, but also instructs how to use locally available clouds.

COSC 620 Algorithms in Bioinformatics / Cross-Listed with BMED 634 (3-0-3)
Prerequisite: Undergraduate course in bioinformatics and genomic data science (or equivalent).

This course focusses on algorithms to explore the many types of data produced in the life sciences, while combining theory and practice. The course teaches the students how to deal with DNA and protein sequence data algorithmically. We will develop software to find disease causing mutations in cancer etc., to understand what genes do and to elucidate human ancestry. Towards those goals, we deal with functional gene annotation, biological databases, comparative genomics, phylogenetics, forensics and structural bioinformatics.

COSC 621 Data Science (3-0-3)
Prerequisite: Undergraduate course in data analytics (or equivalent).

This graduate-level course on data science builds upon the undergraduate course on "Data Analytics". It covers the topics of big data methods, decision theory, data streams and online learning, time-series forecasting, and data science in different domains like string/sequence, text, image/video, and graph/network.

COSC 631 Blockchain Fundamentals and Applications / Cross-Listed with ECCE 631 (3-0-3)
Prerequisite: Undergraduate knowledge of Computer Networks or Communications Networks (or equivalent).

Introduction to cryptocurrencies, wallets, and Blockchain; Blockchain key features, benefits, and popular use cases; Blockchain fundamentals, protocols, algorithms, and underlying infrastructure Building Ethereum and Hyberledger blockchains; Decentralized applications (DApps); Smart contracts; Trusted Oracles; Decentralized storage; Designing and architecting blockchain-enabled systems and solutions for applications in IoT, AI, Supply Chain Management and Logistics, Healthcare, Smart Grids, 5G networks, Telecommunication, etc. Cost and Security Analysis; Limitations and open research challenges in Blockchain.

COSC 632 Advanced Operating Systems / Cross-Listed with ECCE 632 (3-0-3)
Prerequisite: Undergraduate course in operating systems.

The course presents the main concepts of advanced operating systems (parallel processing systems, distributed systems, real time systems, network operating systems, and open source operating systems), including the hardware and software features that support these systems.

COSC 635 Deep Learning Systems Design / Cross-Listed with ECCE 635 (3-0-3)
Prerequisite: Undergraduate knowledge of artificial intelligence (or equivalent).
High level introduction to deep learning concepts and essential contexts, deep learning computational framework, system implementation practicalities, machine learning workflow, practical classification problems for different data modalities, state of the art deep learning models.

COSC 636 Human Computer Interaction / Cross-Listed with ECCE 636 (3-0-3)
Prerequisite: Undergraduate knowledge of software engineering.

This course covers the principles of human-computer interaction, the design and evaluation of user interfaces. Topics include an overview of users' needs and how cognitive aspects affect the design of user interfaces; the principles and guidelines for designing usable user interfaces, with emphasis on the different and novel interactions and trends in HCI; the interaction evaluation methodologies and techniques that can be used to measure the usability of software. Other topics may include World Wide Web design principles and tools, crowdsening/sourcing, speech and natural language interfaces, and virtual reality interfaces.

COSC 637 Parallel Programming / Cross-Listed with ECCE 637 (3-0-3)
Prerequisite: Undergraduate knowledge of programming in C, C++, Java or similar, data structures and algorithms, and basic computer architecture.

This course is a hands-on introduction to parallel computing for MSc students with emphasis on the most common and accessible parallel architecture, namely, the Graphics Processing Unit (GPU). The course will introduce students to modern GPU architectures and the fundamental concepts of parallel computing, including data parallelism, scalable execution, memory and data locality, multithreading, and synchronization. The course will also cover some of the most common parallel patterns such as convolution, prefix sum, graph search, and sparse matrix multiplications, along with their GPU implementations. The case study of deep convolutional neural networks will be covered in detail. NVIDIA's CUDA programming environment will be used throughout the course for homework assignments and the course project.

COSC 638 Artificial Intelligence Techniques for Cyber Security / Cross-Listed with CSEC 638 (3-0-3)
Prerequisite: Undergraduate course in artificial intelligence.

This course provides student with a basic understanding of cybersecurity techniques incorporating Artificial Intelligence (AI) and Machine Learning (ML) technologies. Also, it outlines security and privacy issues of those systems.

COSC 694 Selected Topics in Computer Science (3-0-3)
Prerequisite: Will be specified according to the particular topics offered under this course number.

This course covers selected contemporary topics in Computer Science. The topics will vary from semester to semester depending on faculty availability and student interests. Proposed course descriptions are considered by the Department of Electrical and Computer Science on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the Graduate Studies Committee. The Course may be repeated once with change of contents to earn a maximum of 6 credit hours.

COSC 699 Master's Thesis (minimum 12)
Corequisite: ENGR 695 Seminar in Research Methods, approval of the Department Chair and the Associate Dean for Graduate Studies.

In the Master's Thesis, the student is required to independently conduct original research-oriented work related to important computer science problems under the direct supervision of a main advisor, who must be a full-time faculty in the Electrical Engineering and Computer Science Department, and at least one other full-time faculty who acts as co-advisor. The outcome of the research should demonstrate the synthesis of information into knowledge in a form that may be used by others and lead to publications in suitable reputable journals/conferences. The student's research findings must be documented in a formal thesis and defended through a viva voce examination. The student must register for a minimum of 12 credit hours of Master's Thesis.

CYBER SECURITY (CSEC)

CSEC 601 Cyber Physical Systems Security (3-0-3)
Prerequisites: Undergraduate knowledge of information security.

This course provides working knowledge of the security issues relating to various cyber-physical systems including industrial control systems and critical infrastructure systems. The course starts with the foundations of Cyber Physical System (CPS) Security, starting with Industrial network architectures, industrial control systems and operations. It deals with techniques for securing and protecting privacy in Cyber Physical Systems.

CSEC 602 Modern Cryptography (3-0-3)
Prerequisites: Undergraduate knowledge of cryptography.

This course investigates advanced topics in cryptography. It will cover number theory and basic theory of Galois fields used in cryptography; history of primality algorithms and the polynomial-time test of primality; discrete logarithm based cryptosystems including those based on elliptic curves; interactive protocols including the role of zero-knowledge proofs in authentication; construction of untraceable electronic cash on the net; and post-quantum cryptography. Other topics include digital watermarking, hashing, fingerprinting, and steganography.

CSEC 603 Secure Software Systems Engineering (3-0-3)
Prerequisites: Undergraduate knowledge of information security.

The course covers the security problem in software system engineering. It deals with the rise of software system security, software security measures, and open-source applications and secure software system development lifecycle. Also, the course focuses on code review tools, software systems architectural risk analysis, building knowledge of software systems security and taxonomy of coding errors.

CSEC 604 Cybersecurity Threats and Mitigation (3-0-3)
Prerequisites: CSEC 601 Cyber Physical System Security.

The course covers Cyber Security attacks, defense and mitigation technologies such as advanced malware protection, spam filtering, network analysis, and patching, providing students with a deep understanding of the cyber security processes. The course includes extensive hands-on practice using cyber-range facilities.

CSEC 615 Cloud and Mobile Digital Forensics (3-0-3)
Prerequisites: CSEC 602 Modern Cryptography.
Co-Requisites: CSEC 632 Advanced Operating Systems.

The course deals with advanced techniques for forensics in virtualized and mobile environments. It focuses on physical and touchless analysis of mobile devices, including different types of UAVs, and on identifying traces and remnants in cloud-based applications.

CSEC 618 Wireless Networks and Mobile Security (3-0-3)
Prerequisites: CSEC 601 Cyber-Physical Systems Security and CSEC 602 Modern Cryptography.

The course deals with the threat landscape and the attacks affecting wireless and mobile communication, focusing on WLAN and 5G protocol stacks. It studies security controls used to mitigate such threats and achieve confidentiality, integrity and authenticity in mobile communications.

CSEC 620 Social Engineering and Human Hacking (3-0-3)
Prerequisites: CSEC 601 Cyber Physical Systems Security.

This course deals with social engineering techniques underlying phishing and insider security attacks. Social engineering is a security attack vector that uses human factors and interactions in order to manipulate humans to help breaking normal system security procedures and best practices. Social engineering is used in many cyber security attacks as it is often easier to exploit users' weaknesses than it is to find a software, hardware, or network vulnerability. The content of this course exposes students to a comprehensive coverage of the various social security engineering attacks and countermeasures.

CSEC 621 Hardware and System Architecture Security (3-0-3)
Prerequisites: CSEC 602 Modern Cryptography.

This course provides the student with a good understanding of hardware and system architecture Security: hardware system architecture security. Topics include: Bus security and integrated networks, Memory Security, Side Channel Analysis, Fault Analysis, Physical unclonable functions, Physical Isolation and the Red/Black Architecture.

CSEC 622 Penetration Testing (3-0-3)
Prerequisites: CSEC 601 Cyber-Physical Systems Security.

This course provides the student with a good understanding of Penetration Testing (also referred to as Ethical Hacking). The course covers all aspects of the subject from ethics to social engineering and then the methodologies and tools and techniques that can be used. The course also addresses the capture of malicious software and the reporting of the results.

CSEC 638 Artificial Intelligence Techniques for Cyber Security / Cross-Listed with COSC 638 (3-0-3)
Prerequisites: Undergraduate course in artificial intelligence.

This course provides student with a basic understanding of cyber security techniques incorporating Artificial Intelligence (AI) and Machine Learning (ML) technologies. Also, it outlines security and privacy issues of those systems.

CSEC 640 Financial Cyber Security (3-0-3)
Prerequisites: CSEC 601 Cyber Physical Systems Security.

The course examines techniques to achieve security of financial systems within companies, with special reference to bank and finance organizations. Students analyze financial systems breaches, and learn common threats and frauds specifically related to financial systems. Several methods of cyber security risk assessment are explored, as well as the design of risk alleviation strategies, including choosing and designing technical and process security controls for fintech. Students analyze financial services industry regulation and discuss bank and finance compliance requirements.

CSEC 694 Selected Topics in Information Security (3-0-3)
Prerequisite: Will be specified according to the particular topics offered under this course number.

This course covers selected contemporary topics in Cyber Security. The topics will vary from semester to semester depending on faculty availability and student interests. Proposed course descriptions are considered by the Department of Electrical and Computer Science on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the Graduate Studies Committee. The Course may be repeated once with change of contents to earn a maximum of 6 credit hours.

CSEC 699 Master's Thesis (minimum 12)
Co-requisite: ENGR 695 Seminar in Research Methods, approval of the Department Chair and the Associate Dean for Graduate Studies.

In the Master's Thesis, the student is required to independently conduct original research-oriented work related to important Cyber Security problems under the direct supervision of a main advisor, who must be a full-time faculty in the Electrical Engineering and Computer Science Department, and at least one other full-time faculty who acts as co-advisor. The outcome of the research should demonstrate the synthesis of information into knowledge in a form that may be used by others and lead to publications in suitable reputable journals/conferences. The student's research findings must be documented in a formal thesis and defended through a viva voce examination. The student must register for a minimum of 12 credit hours of Master's Thesis.

ELECTRICAL AND COMPUTER ENGINEERING (ECCE)

ECCE 610 Digital Signal Processing (3-0-3)
Prerequisite: Undergraduate knowledge of digital signal processing and linear algebra.

This course is meant to be a second course in discrete-time signal processing. It provides a comprehensive treatment of signal processing methods to model discrete-time signals, design optimum digital filters, and to estimate the power spectrum of random processes. It includes topics such as signal models, parametric and nonparametric power spectrum estimation, optimal filters, the Levinson recursion, lattice filters, and Kalman filter.

ECCE 611 Advanced Digital Signal Processing (3-0-3)
Prerequisite: ECCE 610 Digital Signal Processing (or equivalent).

Statistical Signal Processing; Adaptive Filtering; Time-Frequency and Multiscale Signal Processing; ADSP Applications.

ECCE 612 Multimedia Processing (3-0-3)
Prerequisite: ECCE 610 Digital Signal Processing (or equivalent).

Audio Processing: audio fundamentals, audio filtering and effects, audio enhancement, Image Processing: image fundamentals, image manipulation, image filtering, image enhancement, quality assessment, Video Processing: video fundamentals, video editing, video filtering, video enhancement, scene analysis.

ECCE 620 Real-Time Embedded Systems (3-0-3)
Prerequisite: Undergraduate knowledge of microprocessor/microcontroller systems.

The design of embedded systems is often challenged by soft or hard timing requirements of the application and by the limited computational power of available platforms. This course addresses design aspects of real-time embedded systems and their applications.

ECCE 621 Digital ASIC Design (3-0-3)
Prerequisite: Undergraduate knowledge of digital logic design.

ASIC design flow: role of HDL in ASIC design. HDL coding style for synthesis. ASIC testing and testbench creation. Clocking in ASIC design. ASIC libraries. Constraints for synthesis. Static timing analysis (STA), statistical timing analysis and chip variation. Floor-planning. Place and Route of ASICs. Parasitics, noise, and cross talk. Chip filling and metal filing. Timing closure and tapeout. Fault models, test pattern generation and design for testability techniques. The course will use state of the art EDA (Electronic Design Automation) tools such as Cadence and Synopsys.

ECCE 622 RF and Mixed-Signal Circuits Design (3-0-3)
Prerequisite: Undergraduate knowledge of electronic circuits and devices.

The course covers most relevant topics in the design of the RF receiver architectures in CMOS technology. It also discusses issues related to the design of mixed-signal circuits. This is addressed in the context of the common wireless standards and modulation schemes.
ECCE 623 High-Speed Communication Circuits
Prerequisite: ECCE 610 Digital Signal Processing and ECCE 622 RF and Mixed-Signal Circuits Design.

This course covers circuit level design issues of high-speed communication systems, with the primary focus being placed on wireless and broadband data link applications. Specific circuit topics include transmission lines, high speed and low noise amplifiers, power amplifiers, VCO's, mixers, power amps, and phase-locked loops. In addition to learning analysis skills for the above items, students will gain a significant amount of experience in simulating RF circuits at the system level using MATLAB and CppSim and at the transistor level using SPICE.

ECCE 624 Analog Integrated Circuits (3-0-3)
Prerequisite: ECCE 672 Principles and Models of Semiconductor Devices or equivalent.

This course covers general circuit level design issues for analog integrated circuits. Techniques for achieving efficient analysis of transistor circuits are presented, along with basic analog building blocks such as single and differential amplifiers, current mirrors, operational amplifiers, samplers, and switched-capacitor networks. Non-idealities such as thermal and 1/f noise, offset variation, and mismatch are discussed, along with techniques to minimize the negative influence of such issues. The basics of higher-level building blocks such as Filters, Analog-to-Digital and Digital-to-Analog converters will also be presented. Students will gain a significant amount of experience in simulating analog circuits at the transistor level using SPICE and MATLAB.

ECCE 625 Digital Integrated Circuits Design (3-0-3)
Prerequisite: Undergraduate knowledge of digital logic design and electronic circuits and devices.

Analysis and design of digital integrated circuits. Fabrication processes, device characteristics, parasitic effects static and dynamic digital circuits for logic and memory functions. Process technology scaling and challenges, emerging technology and its impact on digital integrated circuits. Impact of process variation on circuit behavior. Design building block of digital system including memory, combinational, sequential, and IO. System integration options (TSV, SOC, SOP). Noise and noise sources in digital systems. Interconnect and its impact on digital design performance, power, and area. Synchronous and A synchronous design, clock generation and distribution. The course will use state of the art EDA (Electronic Design Automation) tools such as Cadence and Synopsys.

ECCE 626 Advanced Digital System Design (3-0-3)
Prerequisite: Undergraduate knowledge of Digital Logic Design.

This course covers lectures and labs on digital logic, flip flops, FPGAs, counters, timing, synchronization, finite-state machines, and interfacing with analog circuits to prepare students for the design and implementation of a large scale digital or mixed-signal project of their choice. The project could be related to digital filters, games, music, wireless communications, graphics, analog and/or photonic sensors, etc. Verilog is used extensively for describing and implementing digital logic designs. Students engage in extensive written and oral communication exercises.

ECCE 627 Computer-Aided Design for Microelectronic Systems (3-0-3)
Prerequisite: ECCE 621 or ECCE 626 or equivalent. Knowledge of graph algorithms will be helpful.

This course provides a graduate-level coverage of major topics in computer-aided design of microelectronic systems. Its main objective is to endow students with an up-to-date perspective on the development and implementation of methodologies and tools for the design and integration of large-scale digital and mixed-signal microelectronic systems. Its coverage spans the traditional electronic design automation (EDA) areas of logic synthesis, physical synthesis, and layout verification as well as areas that arise in the context of chip integration such as clock-tree synthesis, power-grid analysis and synthesis, and chip-package co-design. The course will also familiarize the students with the major CAD environments in the microelectronic industry and the pressing R & D issues currently facing independent EDA vendors and corporate CAD houses.

ECCE 628 Computer Architecture (3-0-3)
Prerequisite: ECCE 621 Digital ASIC Design or ECCE 626 Advanced Digital Design (or equivalent).

This course provides students with solid working knowledge of modern computer architecture and design. It covers the organization and architecture of computer systems hardware; the hardware/software interface; instruction set architectures; addressing modes; register transfer logic; processor design; pipelining; memory hierarchy; caches; virtual memory; input/output; and bus architectures.

ECCE 629 Hardware Accelerators for Artificial Intelligence (3-0-3)
Prerequisite: Undergraduate knowledge of digital logic design, microprocessor/microcontroller systems or embedded systems.

This course provides a hands-on introduction to the computational structures that are common to cognitive systems and to their hardware implementations on energy-and-area-constrained nodes. The course will explore the impact of including cognitive functions in existing devices such as low-cost microcontrollers and microprocessors as well as the design of novel constrained nodes with built-in cognitive functions.

ECCE 630 Advanced Computer Networks (3-0-3)
Prerequisite: Undergraduate knowledge of computer networks or communications networks.

Modern and popular computer network technologies, protocols and services. Next Generation Networks, Triple-play services, Network management, Firewall and Intrusion detection, Wireless ad-hoc networks. Performance analysis, modeling and simulation of computer networks.

ECCE 631 Blockchain Fundamentals and Applications (3-0-3)
Prerequisite: Undergraduate knowledge of computer networks or communications networks.

Introduction to cryptocurrencies, wallets, and Blockchain; Blockchain key features, benefits, and popular use cases; Blockchain fundamentals, protocols, algorithms, and underlying infrastructure Building Ethereum and Hyberledger blockchains; Decentralized applications (DApps); Smart contracts; Trusted Oracles; Decentralized storage; Designing and architecting blockchain-enabled systems and solutions for applications in IoT, AI, Supply Chain Management and Logistics, Healthcare, Smart Grids, 5G networks, Telecommunication, etc. Cost and Security Analysis; Limitations and open research challenges in Blockchain.

ECCE 632 Advanced Operating Systems (3-0-3)
Prerequisite: Undergraduate knowledge of operating systems.

The course presents the main concepts of advanced operating systems (parallel processing systems, distributed systems, real time systems, network operating systems, and open source operating systems), including the hardware and software features that support these systems.

ECCE 633 Machine Vision and Image Understanding (3-0-3)
Prerequisite: Undergraduate knowledge of complex variables and transforms, programming, and signals and systems (or equivalents).

The course covers the fundamental principles of machine vision and image processing techniques. This includes multiple view geometry and probabilistic techniques as related to applications in the scope of robotic and machine vision and image processing by introducing concepts such as segmentation and grouping, matching, classification and recognition, and motion estimation.

ECCE 635 Deep Learning Systems Design (3-0-3)
Prerequisite: Undergraduate knowledge of Artificial Intelligence (or equivalent).

High level introduction to deep learning concepts and essential contexts, deep learning computational framework, system implementation practicalities, machine learning workflow, practical classification problems for different data modalities, state of the art deep learning models.

ECCE 636 Human Computer Interaction (3-0-3)
Prerequisite: Undergraduate knowledge of software engineering.

This course covers the principles of human-computer interaction, the design and evaluation of user interfaces. Topics include an overview of users' needs and how cognitive aspects affect the design of user interfaces; the principles and guidelines for designing usable user interfaces, with emphasis on the different and novel interactions and trends in HCI; the interaction evaluation methodologies and techniques that can be used to measure the usability of software. Other topics may include World Wide Web design principles and tools, crowdsensing/sourcing, speech and natural language interfaces, and virtual reality interfaces.

ECCE 637 Parallel Programming (3-0-3)
Prerequisite: ECCE 316 or ECCE 341 or ECCE 342. Undergraduate knowledge of programming in C, C++, Java or similar, data structures and algorithms, and basic computer architecture.

This course is a hands-on introduction to parallel computing for MSc students with emphasis on the most common and accessible parallel architecture, namely, the Graphics Processing Unit (GPU). The course will introduce students to modern GPU architectures and the fundamental concepts of parallel computing, including data parallelism, scalable execution, memory and data locality, multithreading, and synchronization. The course will also cover some of the most common parallel patterns such as convolution, prefix sum, graph search, and sparse matrix multiplications, along with their GPU implementations. The case study of deep convolutional neural networks will be covered in detail. NVIDIA's CUDA programming environment will be used throughout the course for homework assignments and the course project.

ECCE 640 Communication Systems Design (3-0-3)
Prerequisite: Undergraduate knowledge of digital communications (or equivalent).

This course covers the main concepts in digital data transmission. The topics covered will provide the student with thorough understanding of the algorithms and techniques used to design digital transmitters and receivers to a high degree of fidelity.

ECCE 641 Wireless Communications Systems (3-0-3)
Prerequisite: Undergraduate knowledge of wireless communications (or equivalent).

This course covers advanced topics in wireless communication systems and communication theory. The goal of this course is the design and analysis of fundamental and emerging topics in wireless communication systems, e.g., multiple-input-multiple-output (MIMO) and multi-carrier systems. Further topics include, but not limited to, capacity analysis of fading channels, adaptive modulation and coding, MIMO-orthogonal frequency division multiplexing (OFDM), and cooperative communications.

ECCE 642 Broadband Communication Networks (3-0-3)
Prerequisite: Undergraduate knowledge of computer networks and/or wireless communications (or equivalent).

The course is to present the key facets of broadband communication networks. The main topics include: introduction to networks, probabilistic description of networks, queuing analysis, and layering; mobile broadband-enabling technologies; LTE-Advanced; 5G and beyond; and hybrid terrestrial/satellite networks.

ECCE 643 Radar Systems (3-0-3)
Prerequisite: Undergraduate knowledge of electromagnetics and probability and statistical inference (or equivalents).

This course covers the main concepts in radar systems design, including the physical limitations, waveform design and multimode scheduling, antenna scanning and limitations of radar tracking. The topics covered will provide the student with thorough understanding of the design and evaluation of modern radar systems.

ECCE 644 Radio Frequency Measurements (2-1-3)
Prerequisite: Undergraduate course in Electromagnetics (or equivalent).

The course covers experimental characterization of RF and high-speed digital electronics using modern frequency- and time-domain measurement techniques. Advanced RF network, spectrum, field, and noise analysis will

be covered. It offers in-depth treatment of RF measurement concepts, experimental methods, and test equipment. The course is augmented with laboratory sessions and it follows hands-on learning approach.

ECCE 645 Stochastic Processes, Detection, and Estimation (3-0-3)
Prerequisite: Undergraduate knowledge of probability and statistics, and discrete mathematics, (or equivalent).

This is a graduate-level course to introduce some fundamentals of stochastic processes, detection, and estimation involving signal models in which there is some inherent randomness. The concepts that we'll develop are extraordinarily rich, interesting, powerful, and form the basis for an enormous range of algorithms used in diverse applications. The material in this course constitutes a common foundation for work in the statistical signal processing, communication, and control areas.

ECCE 650 Linear Systems (3-0-3)
Prerequisite: Undergraduate knowledge of feedback control systems (or equivalent).

State space methods, Theory of multivariable systems, Jordan canonical forms, Transformation matrices, Realization theory, Controllability, Observability, Stability, Robust stability, State feedback controllers, Full and reduced order observers, Output feedback controllers, Compensation, Decoupling and model matching, Introduction to optimal control.

ECCE 652 Modeling and System Identification (3-0-3)
Prerequisite: Undergraduate knowledge of feedback control systems, or signals and systems (or equivalent).

Fundamentals of dynamic systems, models, and identification processes, models of linear and nonlinear time-invariant and time-variant systems, parametric estimation methods, convergence and consistency of solutions, asymptotic distribution, recursive identification methods, projection based methods, model selection and validation, applications and case studies.

ECCE 653 Advanced Digital Control Systems (3-0-3)
Prerequisite: ECCE 650 Linear Systems (or equivalent).

Classical and modern digital control system analysis and design techniques. Various discrete time controllers are designed including series compensation methods, PID-controllers, pole placement, linear quadratic optimal control, optimal state estimation and Kalman filters, Use of computer-aided analysis and design tools.

ECCE 654 Adaptive Control (3-0-3)
Prerequisite: ECCE 650 Linear Systems (or equivalent).

Introduction to various approaches to adaptive control, direct and indirect adaptive control schemes such as model reference adaptive control, auto-tuning, gain scheduling, and self-tuning regulators, benchmark comparison of adaptive control designs, convergence, stability and robustness, typical industrial applications.

ECCE 655 Artificial Intelligence for Control Engineering (3-0-3)
Prerequisite: Undergraduate knowledge of control systems and programming.

Intelligent control strategies: Fuzzy logic control, Neural networks, Optimization control techniques including Genetic algorithms, Swarm intelligence, and applications to engineering optimization problems.

ECCE 656 Nonlinear Control (3-0-3)
Prerequisite: ECCE 650 Linear Systems (or equivalent).

Introduction to nonlinear control systems by means of analysis, simulation, and synthesis. The course will include phase plane analysis and classification of equilibrium points, linearization, Lyapunov method, Passivity & input-output stability, Stability of feedback systems, feedback linearization, tracking, regulation, disturbance rejection and Observers, and Describing functions.

ECCE 657 Process Instrumentation (3-0-3)
Prerequisite: Undergraduate knowledge of Instrumentation and Measurements.

The course is to present various instrumentation systems used for field inspection (with main focus on oil and gas industry). It starts by presenting basics for field inspection using various techniques which include ultrasounds, gamma-rays, microwaves, and electrical-optical tomography. It then addresses the electronic design of the above devices which takes into consideration both the safety requirements of their corresponding applications and the real-time constraints.

ECCE 658 Autonomous Robotic Systems (3-0-3)
Prerequisite: Undergraduate knowledge of complex variables and transforms and feedback control systems (or equivalents).

The course addresses some of the main aspects of autonomous robotic systems. This includes artificial intelligence, algorithms, and robotics for the design and practice of intelligent robotic systems. Planning algorithms in the presence of kinematic and dynamic constraints, and integration of sensory data will also be discussed.

ECCE 659 Modeling and Control of Robotic Systems / Cross-Listed with MEEN 659 (3-0-3)
Prerequisite: Undergraduate knowledge of complex variables and transforms and feedback control systems (or equivalents).

The course covers the theory and practice of the modeling and control of robotic devices. This includes kinematics, statics and dynamics of robots. Impedance control and robot programming will also be covered. Different case-studies will be presented to support hands-on experiments.

ECCE 660 Power System Analysis (3-0-3)
Prerequisite: Undergraduate knowledge of power systems analysis (or equivalent).

Power system modelling; Advanced load flow techniques; Symmetric faults on generators; Single machine and Multi-Machine transient stability; Transmission line transient analysis and Power systems transients.

ECCE 661 Power Electronics (3-0-3)
Prerequisite: Undergraduate knowledge of power electronics (or equivalent).

The objectives of this course are to teach the principles of power electronics devices; introduce students to different electronics devices and converters and design of converters. The course includes: the application of electronics to energy conversion and control. Modeling, analysis and control techniques. Design of power circuits including inverters, rectifiers, and dc-dc converters.

ECCE 662 Electric Drives (3-0-3)
Prerequisite: ECCE 650 Linear Systems, ECCE 661 Power Electronics, and undergraduate knowledge of electric machines.

Selection of drives based on motor and load characteristics, modeling, simulation and control of electric drives, regenerative braking,

and power quality issues related to electric drives. High power drives and current topics in electric drives.

ECCE 663 Distribution Systems Design and Operation (3-0-3)
Prerequisite: ECCE 660 Power System Analysis (or equivalent).

Distribution feeders configurations; voltage levels; Voltage drop and power loss calculations in distribution networks; Distribution feeder modeling and analysis; Distribution Networks planning and reliability; impact of integrating distributed energy resources.

ECCE 664 Distributed Generation (3-0-3)
Prerequisite: ECCE 660 Power System Analysis (or equivalent).

The course provides up-to-date knowledge about the technical issues related to distributed generation. The course will provide an introduction to DG and their impacts on power system studies including load flow, short circuit and transient stability. The students will also learn how to perform studies, relevant to DG technology, which include protective device coordination and electricity market operation. By the end of the course, the students should have developed an understanding of some of the current challenges associated with the integration of DG in distribution systems and should be capable, through the tools presented in the course, of exploring new strategies to mitigate the impacts of DG in order to facilitate widespread integration of DG in distribution systems.

ECCE 665 Electric Power Quality (3-0-3)
Prerequisite: ECCE 660 Power Systems Analysis, ECCE 661 Power Electronics (or equivalent).

Introduction to power quality, PQ standards, causes and effects of different power quality phenomena, characteristics and definitions, electrical transients, voltage sags and swells, unbalance, flicker, and harmonics; mitigation techniques, active and passive filters; passive filter design, DSTATCOM, DVR.

ECCE 666 Power System Protection (3-0-3)
Prerequisite: ECCE 660 Power System Analysis (or equivalent).

Introduction and general philosophies of power system protection, Symmetrical components, Symmetrical and unsymmetrical fault calculation, CB sizing, Transformer protection, Generator protection, Busbar protection, Line protection, Advanced distance protection, Pilot protection system, System stability and Generator out-of-step protection.

ECCE 667 High Voltage Engineering (3-0-3)
Prerequisite: Undergraduate knowledge of electromagnetic, and high voltage engineering (or equivalent).

Materials used in high voltage insulation, including gas insulation and polymeric materials. Mechanisms of breakdown in gases, solids and liquids. Partial Discharge (PD), processes leading to insulation degradation. PD measurement and diagnosis in high voltage equipment. Overvoltages and insulation coordination in high voltage networks. High Voltage circuit breaker technologies. Monitoring of high voltage systems and numerical techniques for electric field computation. Aspects of grounding.

ECCE 668 Advanced Electric Machines (3-0-3)
Prerequisite: Undergraduate knowledge of electric machines (or equivalent).

Electromechanical energy conversion, rotating and linear electric machines. Development of analytical techniques for predicting machine characteristics: energy conversion density, efficiency; and of system interaction characteristics: regulation, stability, controllability, and response. Use of electric machines in drive systems. Example problems taken from current research.

ECCE 669 Power System Operation (3-0-3)
Prerequisite: ECCE 660 Power Systems Analysis, (or equivalent).

This course deals with modern power system operation and control issues and solution techniques. Topics covered include: Economic dispatch of thermal power generation units, Load frequency control, Unit commitment, Interchange of Power and Energy, Power System Security, Optimal Power Flow, and State Estimation in Power Systems.

ECCE 670 Micro/Nano Processing Technologies (3-0-3)
Prerequisite: Undergraduate knowledge of general chemistry and physics.

This course covers the theory and practice of semiconductor fabrication processing commonly found in the fields of MEMS, electronics and photonics: optical lithography, chemical and physical vapor deposition, spin-coating, oxidation and diffusion, layout design, plasma and wet etching, dicing and bonding.

ECCE 671 Fabrication of Nano Devices (3-0-3)
Prerequisite: ECCE 670 Micro/Nano Processing Technologies (or equivalent).

The state of the art in the microsystems device fabrication will be covered, from standard CMOS processes to niche advanced prototyping techniques of usage in new areas as photonics, MEMS, OMEMS, thin-film FETs and biosensors. Non-standard techniques such as mixed-lithography, focused ion beam milling, nanostructure self-assembly and interference lithography will also be covered.

ECCE 672 Principles and Models of Semiconductor Devices (3-0-3)
Co-requisite: ECCE 670 Micro/Nano Processing Technologies (or equivalent).

The physics of microelectronic semiconductor devices for silicon integrated circuit applications. Carrier generation, transport, recombination, and storage in semiconductors. Physical principles of operation of the p-n junction, heterojunction, metal semiconductor contact, bipolar junction transistor, MOS capacitor, MOS and junction field-effect transistors, and related optoelectronic devices such as CCDs, solar cells, LEDs, and detectors.

ECCE 673 Fundamentals of Photonics (3-0-3)
Prerequisite: Electromagnetic wave theory (or permission of instructor).

The field of Photonics describes the use of light to perform functions that are traditionally under the domain of Electronics, such as computing, data storage, information processing and telecommunications. In particular, Silicon Photonics allows the integration of optical and electronic devices on the same integrated microchip. This course covers both fundamental and advanced concepts that are needed for understanding, designing and simulating simple passive building blocks for such photonic integrated circuits (PICs). The course merges optical physics and mathematical tools, including differential equations, differential operators (Laplacian, curl, divergence, gradient), Fourier transforms, coupled-mode theory, and finite-difference time-domain (FDTD) simulations. A quick review of ray and wave optics is presented, along with electromagnetic wave propagation in isotropic media. Planar and two-dimensional dielectric waveguides are then explored, as well as an introduction to photonic crystals. The theory of ring resonators and optical add/drop multiplexers (OADM) is also covered, and simple optical architectures for interconnects, routers and switches are presented. Advanced numerical simulations in MATLAB and MEEP/Lumerical (FDTD software) are also covered. This course is essential for students focusing their research in Photonics.

ECCE 674 Semiconductor Optoelectronic Devices (3-0-3)
Prerequisite: ECCE 672 Principles and Models of Semiconductor Devices (or equivalent).

This course covers optical properties of semiconductors; physics of absorption, spontaneous and stimulated emission. Theory and design of semiconductor optoelectronic devices, applications and current state-of-the-art are covered in depth. Devices covered include photo-detectors (p-i-n, avalanche, MSM), modulators (carrier injection, electro-absorption), light-emitting diodes (LEDs), semiconductor optical amplifiers and semiconductor lasers.

ECCE 675 Nanoscale Integrated Circuit Devices and Technology (3-0-3)
Prerequisite: ECCE 672 Principles and Models of Semiconductor Devices (or equivalent).

Practical and fundamental limits to the evolution of the technology of modern MOS devices and interconnects. Modern device architectures and their impact on circuit's performance. Advanced device materials and associated fabrication challenges and techniques. What are sub-10nm future materials and novel devices to maintain progress in integrated electronics? Impact of nano-scale on device operations, reliability and circuits.

ECCE 694 Selected Topics in Electrical and Computer Engineering (3-0-3)
Prerequisite: Will be specified according to the particular topics offered under this course number.

This course covers selected contemporary topics in electrical and computer engineering. The topics will vary from semester to semester depending on faculty availability and student interests. Proposed course descriptions are considered by the Department of Electrical and Computer Science on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the Graduate Studies Committee. The Course may be repeated once with change of contents to earn a maximum of 6 credit hours.

ECCE 699 Master's Thesis (minimum 12)
Co-requisite: ENGR 695 Seminar in Research Methods, approval of the Department Chair and the Associate Dean for Graduate Studies.

In the Master's Thesis, the student is required to independently conduct original research-oriented work related to important electrical and computer engineering problems under the direct supervision of a main advisor, who must be a full-time faculty in the Electrical Engineering and Computer Science Department, and at least one other full-time faculty who acts as co-advisor. The outcome of the research should demonstrate the synthesis of information into knowledge in a form that may be used by others and lead to publications in suitable reputable journals/conferences. The student's research findings must be documented in a formal thesis and defended through a viva voce examination. The student must register for a minimum of 12 credit hours of Master's Thesis.

ECCE 701 Power System Modelling and Control (3-0-3)
Prerequisite: Graduate level course in advanced power system analysis.

This course gives depth learning for developing the transient model of power system equipment and FACTS devices. The course covers modeling issues for AC transient, fault, generation units, transformers, Transmission system (OHTL and Cables), FACTS devices, renewable energy systems, distributed generation, power system control as well as power system conceptual studies with practical example serving to illustrate the subject. Several cases will be applied in details to highlight the practical situation encountered in power system.

ECCE 703 Embedded Generation Operation and Control (3-0-3)
Prerequisite: Graduate level course in advanced power system analysis.

The course provides an advanced outlook at the technical and economic issues related to distributed generation. A detailed description of the theory of operation of the most dominant renewable energy systems (PV and Wind) will be presented. The impact of DG on the distribution system planning and operation will be presented with emphasis on stochastic planning, Volt/Var control, islanding detection and power quality. A detailed DG connection impact assessment from the regulatory perspective will be presented. The course will focus on advanced techniques and methods used for microgrid operation and control. A detailed economical evaluation for DG integration will be presented.

ECCE 706 Power Quality and FACTS Devices (3-0-3)
Prerequisite: Graduate level course in power electronics.

Power Quality is an issue that is becoming increasingly important to power system engineers and electricity consumers at transmission and distribution levels. The worldwide trend of generation of electricity from renewable energy sources, especially connected to low voltage distribution networks, additionally introduces challenges in ensuring adequate quality of power. The course is designed to provide an in-depth understanding of the major power quality problems, their analysis and different modern mitigation techniques to overcome the power quality issues.

ECCE 710 Analysis of Power Systems Over-voltages and Transients (3-0-3)
Prerequisite: Graduate level course in advanced power system analysis.

This course presents key aspects in analysis of power system transients. It provides students with the theory of numerical simulation tools such as the EMTP and numerical electromagnetic analysis. Procedures and techniques for the determination of transient parameters for the main power components: synchronous machine, overhead line, underground cable, transformer, surge arrester, and circuit breaker. It also presents important aspects in creating an adequate and reliable transient model of each component, including transient and dynamic characteristics of renewable energy systems.

ECCE 711 Advanced Power System Grounding and Safety (3-0-3)
Prerequisite: Graduate level course in advanced power system analysis.

The course provides highly specialized material with analytical and computational techniques for the design and testing of grounding systems in high voltage power installations. DC, AC, high frequency and impulse performance of ground electrodes and systems are treated and the course will contain practical elements including laboratory and field-based testing using research-based test equipment.

ECCE 714 Application of Heuristic Optimization Techniques to Power Systems (3-0-3)
Prerequisite: Graduate level course in advanced power system analysis.

This course gives an overview of modern heuristic techniques and covers specific applications of heuristic approaches to power system problems, such as optimal power flow, power system scheduling and operational planning, power generation expansion planning, reactive power planning, transmission and distribution planning, and power system control.

ECCE 721 Analog Mixed Signal Design Techniques (3-0-3)
Prerequisite: Graduate level course in advanced analog integrated circuits.]

This course covers general architecture and circuit level design issues for A/D and D/A converters

used in sensors and communication circuits. It introduces different architectures and system level design concepts for A/D and D/A converters followed by circuit level design techniques. System level issues and trade-offs needed for block/circuit level specifications are extensively discussed. The course starts from fundamental concepts like quantization noise, sampling, linearity and will evolve to complete architectures used in A/D and D/A conversion Students will gain a significant amount of experience in simulating A/D and D/A circuits at the transistor level using state of the art EDA (Electronic Design Automation) tools such as Cadence and Synopsys

ECCE 722 Numerical Simulation of Circuits and Systems (3-0-3)
Prerequisite: Graduate level course in engineering mathematical analysis or numerical methods in engineering.

This course covers the theory, algorithms, and best programming practices for the numerical simulation of circuits and systems. Methods for the automatic generation of large-scale circuit netlists are presented, including the nodal, modified nodal, and tableau formulations. Linear DC circuits are solved first using the direct and iterative techniques of numerical linear algebra with emphasis on the sparse nature of the circuit graph. Numerical issues such as stability, pivoting, conditioning, and accuracy are discussed in depth. Next Newton's algorithm for the DC analysis of non-linear circuits is presented along with the automatic generation of the companion models of nonlinear circuit elements. For transient analysis, the course covers the numerical algorithms for the solution of non-linear ordinary differential equations using first-order and higher-order methods with emphasis on linear multistep methods along with their stability and error theories. Advanced topics related to specialized circuits such as interconnect-dominated or RF circuits will be introduced, and exemplary algorithms from state-of-the-art commercial circuit simulators will be given. This course will appeal to graduate students in both electronics and power engineering.

ECCE 723 High Speed Communication Circuits (3-0-3)
Prerequisite: Graduate level course in advanced analog integrated circuits.

This course covers general architecture and circuit level design issues for wired/wireless/fiber optics communication circuits. It introduces different architectures and system level design concepts for wired/wireless/fiber optics communication followed by circuit level design techniques. High Speed Communication Circuits like High Speed Logic are introduced in the first part, followed by Transimpedance amplifiers, Limiters, Laser drivers and Data and Clock Recovery Circuits. In the second part of the course many building blocks needed in a modern Wireless Transceiver are discussed (LNA, PA, Mixers, VCO, PLL's) and their design equations derived. The specifications for the building blocks is a result of System Level Considerations and trade-offs. Students will gain a significant amount of experience in simulating RF/ Broadband circuits at the transistor level using state of the art EDA (Electronic Design Automation) tools such as Cadence and Synopsys.

ECCE 730 Advanced Deep Learning (3-0-3)
Prerequisite: Graduate level course in Artificial Intelligence, Deep Learning or Machine Learning.

This course will provide the students with the knowledge and skills required for applying advanced AI models in real-life applications, such as identifying functional modules in biological networks, autonomous driving, and learning from the small number of training samples. Topics include deep social networks, deep reinforcement learning, deep meta-learning, and lifelong learning. It will also cover active research topics in these topics.

ECCE 731 Distributed Computing (3-0-3)
Prerequisite: Graduate level course in operating systems and advanced computer networks.

Motivation, models, architectures and enabling technologies of distributed computing systems and their applications. Models for communication, processes, remote invocation, distributed naming, synchronization, replication, consistency, fault tolerance, distributed file systems, and distributed clocks. Cloud and grid computing, storage systems, and peer-to-peer systems. Design and implementation of distributed applications.

ECCE 732 Machine Learning and Applications (3-0-3)
Prerequisite: Graduate level advanced data structure, advanced statistics, optimization techniques.

Machine learning, a subset of Artificial Intelligence, aims to create systems that automatically improve with experience. It has many applications, including on-line data analysis, data mining and anomaly detection for cyber-security. Prediction and the study of generalization from data are central topics of Data Analysis and Statistics. These two domains aim at the same goal, that is, gaining insight from data and enabling prediction. This course provides a selection of the most important topics from both of these subjects. The course will start with machine learning algorithms, followed by some statistical learning theory, which provides the mathematical foundation for them. We will then bring this theory into context, providing the transition into Bayesian analysis.

ECCE 733 Computer Arithmetic (3-0-3)
Prerequisite: Prior coursework in digital design (or equivalent) and computer organization (or equivalent).

Study the theory and design of high-performance implementations of arithmetic in computers. Various types of numbering systems, computer arithmetic operations: adders, high-speed adders, multi-operand adders, multipliers, and dividers, fixed-point numbers, floating-point numbering system and floating point primitives. Implementation techniques for high-speed VLSI architectures, DSP and cryptographic protocols.

ECCE 734 Advanced Computer Architecture (3-0-3)
Prerequisite: Graduate level course in computer architecture.
This course covers advanced topics in computer architecture with focus on emerging advancement in the field. A project will be used to enhance students' practical capabilities on research, communication, and technical writing.

ECCE 735 Advanced Computer Vision Paradigms (3-0-3)
Prerequisite: Graduate level course in image processing and analysis (or equivalent).

Computer systems that automate the analysis and the interpretation of image are getting increasing demand in areas of basic research and industrial applications. Current applications include remote sensing medical diagnosis from radiographic images, control of manufacturing through parts inspection, image recovery from web servers, database management and image archives, automatic digital photo generation, criminal and forensic investigation, to mention just few. This course covers the essential and recent advanced in computer vision paradigms related deep learning and other advance image analysis techniques for solving real work applications.

ECCE 736 Advanced Topics in IoT and Blockchain (3-0-3)
Prerequisite: Graduate level course in advanced computer networks.

IoT applications and protocols including MQTT and CoAP; IoT hardware and sensors; IoT deployment within the cloud and fog networks; Cloud platforms for IoT; Democratization of IoT devices using blockchain; Programmability of blockchain using smart contracts; Blockchain-based solutions for IoT; Open research problems in IoT including IoT Security.

ECCE 737 Network and Information Security (3-0-3)
Prerequisite: Graduate level course in advanced computer networks.

Secure Network Communication: Cryptographic algorithms, Digital Certificates, PKI. Network Entity Authentication and Access Control, Network Reconnaissance, Firewalls, Intrusion Detection and Prevention Systems, Honeynets. Security Protocols: IPsec, SSL, VPN, HTTPS. Application Security: Popular application attacks and countermeasures. Advanced Topics in cyberecurity: IoT Security, Blockchain, Cloud Security, Cyber Physical Systems (CPS) security.

ECCE 738 High Performance Computing (3-0-3)
Prerequisite: Graduate level knowledge of operating systems, computer communication, computer architecture, dynamical systems and partial differential equations.

This course is a hands-on introduction to high-performance computing (HPC) for PhD students whose research includes highly complex computational problems. The course will cover the HPC hardware infrastructure and programming models with emphasis on the HPC cluster currently available in KU. The first half of the course will focus on familiarizing the students with the available HPC tools such as the multicore processing nodes, graphics processing nodes, operating system, programming languages, job submission, communication protocols, and programming models. The second half of the course will apply these tools to the solutions of computational problems from various engineering disciplines, including video processing, computer animation, large-scale power grid analysis, deep learning, computational electromagnetics, and computational fluid dynamics. One distinguishing feature of this course is a semester-long project that will result in the implementation of a full, working HPC program and its application to a computational problem in the student's area of PhD research.

ECCE 741 Advanced Digital Communications (3-0-3)
Prerequisite: Graduate level course in communication systems design.
This course discusses the fundamental techniques used in the physical layer of digital communication systems. In particular, it covers topics related to the design and performance of digital communication systems over AWGN and multipath fading channels.

ECCE 742 Advanced Concepts in Stochastic Processes, Detection, and Estimation Theory (3-0-3)
Prerequisite: Graduate level course in stochastic processes, detection, and estimation.

The aim of this course is to cover some advanced and important topics in stochastic processes, signal detection, and estimation. The course includes topics such as Detection of Random Signals with Unknown Parameters, Unknown Noise Parameters, Model Change Detection, Complex/Vector Extension, Bayesian Estimation, General Bayesian Estimators, Linear Bayesian Estimators, Estimation for Complex Data and Parameters.

ECCE 743 Broadband Communication Systems (3-0-3)
Prerequisite: Graduate level courses in communication systems design and/or wireless communications systems.

The course covers topics in single-carrier and multi-carrier OFDM transceivers. It also discusses issues related to multiple-Antenna techniques, relaying and cooperative Communications, spectrum management, the next generation wireless networks, and satellite communication standards.

ECCE 744 Optical Wireless Communication Systems (3-0-3)
Prerequisite: Graduate level course in wireless communications systems.

The course covers topics related to optical wireless communications, including, but not limited to, optical light sources and their characteristics, link performance analysis, optical diversity techniques and visible light communications.

ECCE 751 Discontinuous Control Systems (3-0-3)
Prerequisite: Graduate level course in advanced linear systems.

Relay feedback and variable-structure systems as two main types of discontinuous control systems. Describing function analysis of self-excited oscillations in discontinuous control systems. Definition of sliding mode, sliding mode in relay and variable structure systems. Multidimensional sliding modes. Design of sliding surface. The use of second Lyapunov's method for sliding mode control design. Principal and parasitic dynamics. Chattering phenomenon and chattering reduction. LPRS analysis of chattering and closed-loop performance of sliding mode systems. Sliding mode observers. Integral sliding mode. Second-order and higher-order sliding mode control. Applications of discontinuous control.

ECCE 752 Nonlinear Control Systems (3-0-3)
Prerequisite: Graduate level course in advanced linear systems.

Analysis and design of nonlinear control systems. The course will cover advanced topics in nonlinear control including passivity and input-output stability, stability of feedback systems, tracking, regulation, disturbance rejection, observers, and backstepping.

ECCE 753 Computational Prototyping of Dynamical Systems (3-0-3)
Prerequisite: Graduate level courses in engineering mathematical analysis or numerical methods in engineering.

This course covers the theory, algorithms, and best programming practices for the numerical simulation of dynamical systems. The course will draw examples from a variety of engineering disciplines, including electrical, mechanical, chemical, and aerospace engineering. Methods for the automatic generation of large-scale, state-space descriptions are presented. Direct and iterative techniques from numerical linear algebra are used to compute steady state solutions of linear systems. Numerical issues such as stability, pivoting, conditioning, and accuracy are discussed in depth. Special attention is given to sparse matrix techniques. Newton's algorithm for finding the equilibrium points of non-linear systems is presented next along with the automatic generation of the companion models of nonlinear elements. For transient analysis, the course covers the numerical algorithms for the solution of non-linear ordinary differential equations using first-order and higher-order methods with emphasis on linear multistep methods. The stability and error theories of such methods are also covered. State-of-the-art topics related to the macromodeling of dynamical systems using model-order reduction methods will

wrap up the course. One distinguishing feature of this course is a semester-long project that will result in the implementation of a full, working dynamical system simulator and its application to solve a computational problem in the student's area of PhD research.

ECCE 754 Computational Prototyping of Partial Differential Equations (3-0-3)
Prerequisite: Graduate level courses in engineering mathematical analysis or numerical methods in engineering.

This course covers the theory, algorithms, and best programming practices for the numerical solution of partial differential equations. The course will draw examples from a variety of disciplines, including fluid dynamics, heat and mass transfer, electromagnetics, solid mechanics, and mathematical finance. Algorithms covered include: finite-difference schemes, finite-element methods, boundary-element methods, and random-walk methods. One distinguishing feature of this course is a semester-long project that will result in the implementation of a full, working PDE solver and its application to a computational problem in the student's area of PhD research.

ECCE 755 Cognitive Robotics (3-0-3)
Prerequisite: Graduate level courses in autonomous robotic systems and machine vision and image understanding.

To provide students with an advanced treatment of autonomous systems, how cognitive systems acquire information about the external world through learning and association of interrelationships between the observed world and their contextual frames. To learn how robotics cognitive systems can be designed to produce appropriate responses that make them more intelligent and autonomous.

ECCE 756 Robotic Perception (3-0-3)
Prerequisite: Graduate level courses in autonomous robotic systems and machine vision and image understanding.

To provide students with knowledge in the principles and practices of quantitative perception for robotic devices. To study both sensing devices and algorithms that emulates perception and intelligent systems. Learn to critically examine the sensing requirements of typical real world robotic applications. To acquire competences for development of computational models for autonomous robotic systems.

ECCE 757 Control of Robotic Systems / Cross-Listed with MEEN 767 (3-0-3)
Prerequisite: Graduate knowledge of engineering mathematics and computation.

This course is designed to teach students concepts and tools for analysis, design and control of robotic mechanisms. Kinematics, statics and dynamics of robotic systems.

ECCE 771 Advanced Integrated Circuits Technology (3-0-3)
Prerequisite: Graduate level courses in micro/nano processing technologies and advanced microelectronics devices.

What are the practical and fundamental limits to the evolution of the technology of modern MOS devices and interconnects? How are modern devices and circuits fabricated and what future changes are likely? Advanced techniques and models of devices and back-end (interconnect and contact) processing. What are sub-10nm future structures and materials to maintain progress in integrated electronics? MOS front-end and back-end process integration.

ECCE 772 Advanced Microsystem Design (3-0-3)
Prerequisite: Graduate level course in engineering mathematical analysis.

This course covers the design, modeling and characterization of micro-electro-mechanical systems (MEMS) with emphasis on the full microsystem design flow using state-of-the-art computer-aided design (CAD) tools. It addresses the various MEMS sensing and actuation modalities and provides in-depth treatment of the multi-faceted interplay between process, device, and electronic interface with its impact on overall system performance. Throughout the course, repeated use will be made of fundamental multi-domain formulations, CAD tools, and parameterized macromodels. Specific MEMS case studies will be selected from the areas of inertial motion sensing, piezoelectric energy harvesting, ultrasound transduction, RF-MEMS, and optical MEMS.

ECCE 773 Photonic Materials and Metamaterials Design for Engineers (3-0-3)
Prerequisite: Graduate knowledge of fundamentals of photonics.

The design of photonic devices and systems requires a strong background on the materials behavior with light. For an engineer there are significant opportunities in designing new metamaterials that provide functionality not found in natural materials, for application in fields such as energy harvesting, sensing, advanced displays, to name a few. The student will learn the modeling concepts and design flow for designing and fabricating novel engineered optical materials.

ECCE 774 Advanced Photonic Integrated Circuits (3-0-3)
Prerequisite: Graduate knowledge of fundamentals of photonics.

This course covers optical signal processing for photonic integrated circuits (PICs) and discusses state-of-the-art PIC components. The primary focus is being placed on multi-stage filter design and synthesis. Minimum, maximum, and linear-phase filters, optical lattice filters, Fourier filters, and generalized pole-zero architecture. Techniques such as least squares methods for IIR filter designs will be presented. State-of-the-art PIC examples including bandpass/bandstop filters, optical gain equalizer, dispersion compensators, and arrayed waveguide grating (AWG) routers will be discussed in depth. Also included Bragg grating synthesis algorithm using coupled-mode approach. System-level application examples to microwave photonics, sensor networks, and coherent optical detection will be given. In addition to learning filter synthesis methods, students will gain a significant amount of experience in optimizing optical circuits at the subsystem level using MATLAB/Simulink and Lumerical software suite. The above techniques will take into consideration process variations, wavelength, and polarization dependence.

ECCE 778 Physics and Manufacturability of Advanced Micro and Nano Devices (3-0-3)
Prerequisite: Graduate level courses in micro/nano processing technologies and advanced microelectronics devices.

Explores the impact of physics on nanoscale devices and associated manufacturing challenges. Presents advanced physical models and practical aspects of advanced architecture devices' front-end microfabrication processes, such as oxidation, diffusion, ion implantation, chemical vapor deposition, atomic layer deposition, etching, and epitaxy. Covers topics relevant to CMOS, bipolar, and optoelectronic device fabrication, including high k gate dielectrics, gate etching, implant-damage enhanced diffusion, advanced metrology, SiGe and fabrication of process-induced strained Si. BEOL Integration and reliability. Studies CMOS process integration concepts for advanced

planar and 3D devices with Si, Si-Ge, III-V, 2D material systems. Assess the interaction of device characteristics, processing scheme and the design space. Leading to yield modeling and manufacturability vs. process complexity and the required balancing. Students use modern process simulation tools.

ECCE 781 The Physics of Solar Cells (3-0-3)
Prerequisite: Graduate level course in advanced microelectronics devices.

The physics of solar cells: solar history, semiconductor fundamentals, p-n junction physics, mono-crystalline solar cells, thin film solar cells, managing light, new novel solar concepts, TCAD solar cells design and simulation, cleanroom fabrication of solar cells.

ECCE 794 Selected Topics in Electrical and Computer Engineering (3-0-3)
Prerequisite: Will be specified according to the particular topics offered under this course number.

This course covers selected contemporary topics in electrical and computer engineering. The topics will vary from semester to semester depending on faculty availability and student interests. Proposed course descriptions are considered by the Department of Electrical and Computer Engineering on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the Graduate Studies Committee. The Course may be repeated once with change of contents to earn a maximum of 6 credit hours.

ENGINEERING (ENGR)

ENGR 602 Engineering Numerical Methods (3-0-3)
Prerequisite: Fundamental knowledge of undergraduate mathematics.

This is an introductory graduate level course that deals with the numerical treatment of engineering problems encountered in various disciplines. Rudiments of how to develop, analyze, and use numerical methods are covered. Emphasis is put on the algorithms and application of numerical techniques and not on the theory except in passing.

ENGR 603 Multivariate Data Analysis /Cross-Listed with BMED 603 (3-0-3)
Prerequisite: Undergraduate knowledge of linear algebra, differential equations and statistics.

Introductory graduate level course in Multivariate Data Analysis. This course focuses on the some of the most important techniques of data reduction and analysis of qualitative data, especially encountered in Biomedical Engineering.

ENGR 605 Systems Optimization / Cross-Listed with ESMA 603 (3-0-3)
Prerequisite: Undergraduate knowledge of linear algebra (or equivalent).

This course provides an introduction to systems optimization focusing on understanding system tradeoffs. It introduces modeling methodology (linear, integer, and nonlinear programming), with applications in production planning, scheduling and workforce planning, time-phased planning, inventory planning, and supply contracts, logistics network design, facility sizing, and capacity expansion, capital budgeting models, assignment and matching, and transportation models. In this class, students will learn powerful modeling and solution techniques for decision-making problems that are used today by thousands of successful companies to help them make millions of dollars.

ENGR 606 Advanced Engineering Mathematics / Cross-Listed with MEEN 630 (3-0-3)
Prerequisite: Undergraduate calculus and differential equations (or equivalents).

This course focuses on concepts and techniques, analytical as well as numerical, for solving applied problems arising in various engineering disciplines. Analytics cover separation of variables, integral transforms, Green's functions, similarity, and perturbation methods. Numerics include finite differences, finite elements, and discrete and fast Fourier transforms. Emphasis would be on formulating and solving problems as well as on interpreting and analyzing the solutions to gain physical insight. Engineering applications would be stressed in addition to mathematical formalities. MATLAB is required in some of the homework problems.

ENGR 610 Risk, Reliability and Uncertainty in Engineering Systems (3-0-3)
Prerequisite: Undergraduate level calculus.

Engineering risk, reliability, uncertainty. Risk degrees, reliability analysis, data modeling and analysis, Monte-Carlo simulation, design problems.

ENGR 695 Seminar in Research Methods (1-0-0)
Prerequisite: Graduate standing.

This course introduces graduate students to research methodologies and the process of formal inquiry in engineering and applied sciences. It develops the skills necessary to read and critically evaluate the research of others with emphasis on contemporary issues. The course covers the process of developing, documenting and presenting research proposals. It also addresses codes of ethics in the engineering profession. Finally, the course will provide suggestions and best practices for success in graduate studies.

ENGR 699 Master's Thesis (1-24 credit hours)
Co-requisite: ENGR 695 Seminar in Research Methods, two relevant MSc courses and approval of the Department Chair and the Associate Dean for Graduate Studies.

A student must complete a master's thesis that involves significant creative, research-oriented work within the particular engineering field of interest, under the direct supervision of at least one full-time faculty advisor from the particular research discipline. The student must submit a formal report at the end of each semester that details the progress made in the research and the plans for the following semester. The thesis advisors assess the reports and approve the submission of the final thesis. During the final semester, the research findings must be documented in a formal thesis and defended successfully in a viva voce examination. The student must register for a minimum total of 24 credit hours of Master's Thesis.

ENGR 701 Research Methods in Engineering (3-0-3)
Prerequisite: Graduate standing.

This course provides sound knowledge and understanding of research methodology and project management skills and their application to engineering research and project development. Topics covered include Aspects of PhD research, Critical literature review, Citations and references, Technical writing, Presentation skills, Software and Experimental Methods, Modeling and Simulation Methods, Reliability and Validity of Results, Analysis and Interpretation of Results, Project management, and Professional issues in research.

ENGR 703 PhD Research Seminar I (0-0-0)
Prerequisite: ENGR 701 Research Methods in Engineering.

In this course a PhD student is required to attend a minimum of 5 seminars on research

topics given by faculty, visiting scholars and fellow PhD in Engineering students. The student must submit a brief report about each seminar that he/she attends.

ENGR 704 PhD Research Seminar II (0-0-0)
Prerequisite: ENGR 796 PhD Research Proposal Examination.

In this course, PhD candidates must present a public seminar on their thesis topic as part of the PhD program requirements before the semester in which they expect to graduate. The seminar is not an oral examination of the student's thesis. The seminar must be attended by at least the main advisor and one of the co-advisors. In addition to presenting a seminar, a PhD student must attend a minimum of 5 seminars on research topics given by faculty, visiting scholars and fellow PhD in Engineering students. The student must submit a brief report about each seminar that he/she attends.

ENGR 795 PhD Written Qualifying Examination (0-0-0)
Prerequisite: Approval of Advisor and Associate Dean for Graduate Studies.

The primary objective of the PhD Written Qualifying Exam (WQE) is to ensure that students pursuing a doctoral degree in a particular concentration/specialization have a graduate level understanding of the undergraduate fundamentals of that concentration/specialization. The PhD WQE evaluates a student's understanding of the fundamental principles and her/his ability to apply them to solve problems in three topical exam areas. The syllabi for the topical exam areas are taken from undergraduate courses in the College of Engineering at Khalifa University. Full-time PhD students typically take the PhD WQE at the end of their 2nd semester of active registration. Part-time students typically take the PhD WQE at the end of their 4th semester of active registration. A student who registers to take the WQE can count that, if he/she so wish, to be the equivalent of one course in the particular semester he/she will do the exam. This is in order to give the student time to prepare for the WQE during that semester. This does not affect the minimum credit requirements of the PhD in Engineering program.

ENGR 796 PhD Research Proposal Examination (0-0-0)
Prerequisite: ENGR 795 PhD Written Qualifying Examination, approval of the Advisor and Associate Dean for Graduate Studies.

The PhD Research Proposal Examination (RPE) is an oral exam that evaluates the student's ability to synthesize and integrate material as applied to her/his research focus area. It is expected that the student demonstrates a certain breadth of knowledge and is able to apply this knowledge to the research problem he/she is focusing on. The student must pass the RPE before being allowed to progress further in the PhD program. Full-time PhD students typically take the PhD RPE at the end of their 4th semester of active registration. Part-time students typically take the PhD RPE at the end of their 6th semester of active registration. The PhD RPE is assessed on Pass/Fail basis. A student who registers to take the RPE can count that, if he/she so wish, to be the equivalent of one course in the particular semester he/she will do the exam. This is in order to give the student time to prepare and defend the research proposal during that semester. This does not affect the minimum credit requirements of the PhD in Engineering program.

ENGR 799 PhD Research Dissertation (minimum 36 credits)
Co-Requisite: ENGR 701 Research Methods in Engineering and Approval of the Department Chair and Associate Dean for Graduate Studies.

A student must complete a minimum of 36 credit hours of PhD Research Dissertation that involves novel, creative, research-oriented work under the direct supervision of at least one full-time faculty advisor from the College of Engineering. The main research advisor of a student who opts for a PhD with a concentration/specialization must be a full-time faculty member in the department offering the particular concentration/specialization. The outcome of research should demonstrate the synthesis of information into knowledge in a form that may be used by others. The research findings must be documented in a formal dissertation and defended successfully in a viva voce Dissertation Defense examination.

ENGINEERING SYSTEMS AND MANAGEMENT (ESMA)

ESMA 601 System Architecture (3-0-3)
Prerequisite: Knowledge of systems project management, systems engineering or equivalent.

Systems architecting is one of the first stages in the product design and development process in which the system's or the product's concept is generated. These early stage decisions are fundamental to the success of the product or system because they impact all of the detailed design decisions made later on. They are also challenging because the system architect must manage ambiguity, complexity, and project management all prior to giving a formal quantitative basis to the new concept. This course will give students the tools to analyze and conceive system architectures systematically in small group environments. The course will address system form, function, and concept and conclude with special topics in systems architecting.

ESMA 602 Product Design and Development (3-**0-3)**
Prerequisite: Knowledge of system architecture, systems engineering or equivalent.

The course covers modern tools and methods for product design and development. The cornerstone is a project in which teams of management, engineering, and industrial design students conceive, design, and prototype a physical product. Class sessions employ cases and hands-on exercises to reinforce the key ideas. Topics include: product planning, identifying customer needs, concept generation, product architecture, industrial design, concept design, and design-for-manufacturing.

ESMA 603 Systems Optimization / Cross-Listed with ENGR 605 (3-0-3)
Prerequisite: Undergraduate course in linear algebra or equivalent.

This course provides an introduction to systems optimization focusing on understanding system tradeoffs. It introduces modeling methodology (linear, integer, and nonlinear programming), with applications in production planning, scheduling and workforce planning, time-phased planning, inventory planning, and supply contracts, logistics network design, facility sizing, and capacity expansion, capital budgeting models, assignment and matching, and transportation models. In this class, students will learn powerful modeling and solution techniques for decision-making problems that are used today by thousands of successful companies to help them make millions of dollars.

ESMA 604 System Dynamics for Business Policy (3-0-3)
Prerequisite: Undergraduate knowledge of calculus and engineering economic analysis or equivalent.
Advanced concepts in system dynamics modeling for applications in business operations, strategy and policy. Students gain recognition of dynamic modes of behavior in complex systems and develop skills to represent this behavior in formal modeling structures and test policies using simulation experiments. Emphasizes a formalized modeling process covering problem articulation and formulation, dynamic hypotheses, simulation model formulation, model testing, and policy design and evaluation. Extensive use of system dynamics modeling software with applications to case studies.

ESMA 605 System Project Management (3-0-3)
Prerequisite: Undergraduate knowledge of engineering economic analysis or equivalent.

This course guides students through fundamental project management concepts and behavioral skills needed to successfully plan and manage complex systems projects. Assuming that a system/project has already been selected, the course then focuses on the preparation, planning, monitoring and adaptation of projects. The course is organized into five loosely interwoven modules.

ESMA 607 Management and Entrepreneurship for Engineers (3-0-3)
Prerequisite: Undergraduate knowledge of organizational behavior, accounting and finance or equivalent.

This course provides an overview of management issues for graduate engineers and deeper review of the dynamics of start-up firms and entrepreneurship in a variety of organizations. The topics approached aim to provide the engineering practitioner with tools, frameworks and thinking processes to support the translation of engineering technology into commercial products, services and processes. Specific topics include idea generation, opportunity recognition, innovation, intellectual property, financial analysis, customer needs, market assessment, competition, exit strategy, innovation ecosystems, and business planning. Through selected readings from texts and case studies we focus on the development of individual skills and management tools. The course requires student participation in class discussion, final examinations, and a term project that involves preparation and presentation of a start-up business plan.

ESMA 608 Environmental Policy and Economics (3-0-3)
Prerequisite: Undergraduate knowledge of systems project management or equivalent.

This course tackles issues related to the impact of the economy on the environment, climate change challenges, and the appropriate way of regulating economic activity so that balance is achieved among environmental, economic, and other social goals. We discuss and measure the impact on the environment of producers' behavior and consumers' needs. We address the role of markets in determining the "right" amount of pollution and market failures in achieving the socially desirable amount of pollution. We analyze the development of GHG emissions policies and other environment related policies. In addition, we explore issues faced by different countries in the developed and developing world with regard to environmental policy.

ESMA 610 Business Analytics, Statistics for Engineering Systems (3-0-3)
Prerequisite: Undergraduate knowledge of probability and statistics or equivalent.

This course deals primarily with the descriptive and predictive functions of business analytics which uses data and statistical methods to analyze past performance and build predictive models to support business planning decisions. The course focuses on the basic topics of data collection, analysis and statistics, data visualization and summarization, Hypothesis testing, descriptive statistical measures, probability distributions, data modeling, sampling and estimation, statistical inference, linear regression analysis, forecasting and data mining techniques.

ESMA 617 Innovation and Creativity in Technology Organizations / Cross-Listed with BMED 602 (3-0-3)
Prerequisite: Knowledge of innovation and entrepreneurship or equivalent.

This course explores three important concepts in business: creativity, innovation, and entrepreneurship. The course introduces several techniques to develop creativity and innovation in an organization. It explains how to develop a plan for building an innovation strategy and shows the importance of leveraging the potential of the digital transformation for innovation and research. Finally, the course describes the Lean Start-up method, and shows how entrepreneurs validate concepts and ideas, and refine their business strategy to create value and grow their business.

ESMA 618 Strategic Management of Technology and Innovation (3-0-3)
Prerequisite: Undergraduate knowledge of innovation and entrepreneurship or equivalent. This course focuses on developing general management tools and analytical frameworks that are particularly applicable to managing technology and innovation in private industry and government agencies. The course identifies strategic and operating challenges commonly encountered in meeting performance, cost and schedule requirements in new product development and roll-out, and discusses policy, organizational, financial and program management structures that can help to meet such challenges. The appropriate use of various budget and financial management tools such as earned value and total quality management will be explored in the context of the high project risk often associated with innovative technologies. Course requirements include extensive student participation in class discussions and exercises, written class assignments, a group project, a mid-term exam and a final exam.

ESMA 619 Advanced Quality Management System (3-0-3)
Prerequisite: Knowledge of business analytics or equivalent.

This course addresses topics in advanced Quality Management Systems and its implementation into process control, product development, certification, and problem solving strategies. Examples of the specific techniques and concepts will include Failure Modes and Effect Analysis, Quality Loss Function and Orthogonal Arrays. The course is structured in three modules; Introduction to Quality and Data collection, Quality Control, and Quality Management.

ESMA 621 Production, Operations and Inventory Management (3-0-3)
Prerequisite: Knowledge of systems optimization or equivalent.

This course covers concepts and problems underlying the design and operation of contemporary production systems. The course content includes: models for inventory control;

dynamics of production processes; production, operations and inventory planning activities from queuing theoretic perspective. While the emphasis is placed on manufacturing facilities, many of the presented results apply also to the design, planning and control of operations taking place in the service sector.

ESMA 623 Advanced Lean Manufacturing (3-0-3)
Prerequisite: Knowledge of systems optimization or equivalent.

This course provides a deep understanding into the fundamental principles of lean manufacturing. Specific topics covered include: lean philosophy, push vs pull; value stream mapping, current and future state mapping, implementing the future state; establishing continuous flow, designing level pull and material distribution strategies; mixed model value streams; strategies to respond to dynamic demand; seeing the whole.

ESMA 633 System Simulation: Modelling and Analysis (3-0-3)
Prerequisite: Knowledge of systems optimization or equivalent.

This course provides an advanced and in-depth treatment of discrete-event simulation modeling and analysis techniques. Topics include: modeling large-scale and complex systems; queuing theory; pseudo-random number and random variate generation, input modeling (data collection, analysis, and fitting distribution), output analysis (initial bias and termination bias, variance reduction techniques), sensitivity analysis, design of experiments, comparison of alternative systems.

ESMA 641 Supply Chain, Logistics and Transportation Networks (3-0-3)
Prerequisite: Knowledge of systems optimization techniques or equivalent.

This course focuses on mathematical modeling and optimal solution techniques for designing and evaluating large scale supply chain, logistics and transportation networks. The covered topics include network design fundamentals and solution methodologies. Factors considered include: shipping routes, warehouse locations, modes of transportation (air, road, rail, and sea), pricing, transportation and distribution costs (volatile fuel costs), infrastructure constraints, security and regulatory requirements, risks, etc.

ESMA 642 Global Supply Chain Management (3-0-3)
Prerequisite: Knowledge of business analytics or equivalent.

The course focuses on development and management of complex global supply chains for companies sourcing components form as well as selling products in the global market. The topics covered in this course include strategic sourcing, structuring the global supply chain, international logistics, material management and replenishment strategies, coordination and collaboration, quality management, efficiency, responsiveness, resilience and risk management for global supply chain. The course is particularly structured to design and manage lean supply chains.

ESMA 643 Warehousing and Distribution (3-0-3)
Prerequisite: Knowledge of systems optimization or equivalent.

A systems approach to managing the movement of goods through the supply chain with an emphasis on warehouses for storage and demand-driven distribution centers. The course provides the fundamental concepts, issues, and algorithms to design and operate these facilities. Topics covered include warehouse configuration, storage and handling equipment, space management and storage policies; cross-docking, order picking; inbound/outbound logistics; and vendor managed inventory.

ESMA 650 Cost Engineering (3-0-3)
Prerequisite: Knowledge of managerial accounting especially cost accounting, probability and statistics especially basic distributions (e.g. PDF/CDF) and regression or equivalent.

Cost engineering provides an analytical framework for cost determination in various contexts such as in merchandising, manufacturing, service and projects. Topics include cost estimation, cost control, business planning and management, profitability analysis, project cost management, and life cycle costing.

ESMA 671 Healthcare Operations Management (3-0-3)
Prerequisite: Knowledge of business analytics, statistics for engineering systems or equivalent.

Healthcare spending and the demand for health services continue to increase. Thus, improving the quality and efficiency of healthcare delivery are urgently needed. This course introduces the students to healthcare management as well as the methods used in the design and structure of healthcare systems. In addition, the course explores opportunities for improvement in the design and management of healthcare operations using data analytics.

ESMA 672 Lean Service Systems (3-0-3)
Prerequisite: Knowledge of systems optimization or equivalent.

This course provides an overview of the fundamental principles of lean service systems, especially in healthcare, that balances inefficiency with service availability. Specific topics covered include lean philosophy, value in healthcare; healing pathway analysis (value stream mapping), current and future state mapping, implementing the future state; implementing value-based initiatives; finding solutions for the whole.

ESMA 673 Healthcare Information Systems / Cross-Listed with BMED 635 (3-0-3)
Prerequisite: Knowledge of business analytics or equivalent.

This course provides a detailed overview of healthcare information systems for professionals who will work at the interface of clinical care, information technology, and the healthcare system. Topics include evidence-based care, clinical workflow analysis, unintended consequences of systems, and life-cycle management of complex clinical computing systems.

ESMA 694 Selected Topics in Systems and Engineering Management (3-0-3)
Prerequisite: Will be specified according to the particular topics offered.

This course covers selected contemporary topics in Engineering Systems and management. The topics will vary from semester to semester depending on faculty availability, and faculty and student interests. Proposed course descriptions are considered by the Department of Industrial and Systems Engineering on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the Graduate Studies Committee. The Course may be repeated once with change of contents to earn a maximum of 6 credit hours.

ESMA 699 Master's Thesis (minimum 12)
Co-requisite: ENGR 695 Seminar in Research Methods, approval of the Department Chair and the Associate Dean for Graduate Studies.

In the Master's Thesis, the student is required to independently conduct original research-oriented work related to important chemical engineering problems under the direct supervision of a main advisor, who must be

a full-time faculty in the Industrial & Systems Engineering Department, and at least one other full-time faculty who acts as co-advisor. The outcome of the research should demonstrate the synthesis of information into knowledge in a form that may be used by others and lead to publications in suitable journals/conferences. The student's research findings must be documented in a formal thesis and defended through a viva voce examination. The student must register for a minimum of 12 credit hours of Master's Thesis.

ESMA 701 Advanced Systems Optimization (3-0-3)
Prerequisite: Graduate level course in systems optimization (or equivalent).

The course covers state-of-the-art techniques to solve integer programming problems, with respect to both theory and the practice. The course we will cover modeling, polyhedral theory and valid inequalities, and solution techniques such as cutting plane methods, branch-and-bound, branch-and-cut, branch-and-price, column generation and Danzig-Wolfe decomposition, as well as available commercial software.

ESMA 710 Time Series Analysis Modeling and Prediction (3-0-3)
Prerequisite: Graduate level courses in business analytics, statistics for engineering systems or statistics and prior computer programming experience.

This course will cover modeling and prediction of time series. The emphasis will be on the time domain, although the frequency domain will also be explored. The structure of the model will depend on the physical knowledge of the process, as well as the form of the observed data. Models that relate the present value of a series to past values and past prediction errors are called ARIMA models (Autoregressive Integrated Moving Average). Central problems are the properties of different models and their prediction ability, estimation of the model parameters, and the model's ability to accurately describe the data. Particular attention will be given to linear modeling of time series: meaning of linearity, autoregressive and moving average models and their statistical properties, likelihood estimation and residual analysis, forecasting and simulation. An integral part of the course is the use of a statistical or numerical software such as MATLAB or R for simulation, calculation, and implementation of time series analysis techniques.

ESMA 711 Advanced Business Analytics (3-0-3)
Prerequisite: Graduate level course in business analytics or system optimization (or equivalent).

This course is intended for graduate students who have taken the introductory ESMA 610 Business Analytics course. The basic course presented descriptive and predictive analytics tools in the context of business cases, with an emphasis on the challenges that can arise in implementing analytical approaches within an organization. This course goes beyond the basic analytic course in several ways. First, the course will cover the tools and theory at a deeper level. Second, the course will be based on both MATLAB and R. R is a programming language and software environment for statistical computing and graphics. The R language is widely used among statisticians and data miners. The course presents real world examples where a significant competitive advantage has been obtained through large scale data analysis. Examples include advertising, eCommerce, finance, health care, marketing, and revenue management.

ESMA 720 Advanced Production and Operations Management (3-0-3)
Prerequisite: Graduate level course on system optimization or production operations and inventory management or knowledge of advanced calculus, probability and statistics, and optimization.

This is a PhD level course on the analysis of production, inventory, and distribution systems. The emphasis of this course is on principles of inventory management, demand estimation, production planning, and scheduling. Topics covered include: deterministic inventory models, variability assessment, lot sizing, aggregate planning, production planning with time-varying demand, stochastic inventory models, and multi-echelon inventory problems with deterministic and stochastic demand, facility location problems.

ESMA 721 Stochastic Processes and Applications (3-0-3)
Prerequisite: Real analysis, linear algebra, probability. Graduate level course on business analytics, statistics for engineering systems or equivalent.

Techniques and methods for solving engineering design problems for stochastic systems: Renewal Theory, Markov Chains, Queueing Theory, Markov Decision Processes. Methods to analyze and capture short- and long-term effects of randomness in the real-life systems. Applications including inventory, reliability, and service systems will be discussed.

ESMA 722 Technology Strategy (3-0-3)
Prerequisite: Graduate level course on strategic management of technology and innovation (or equivalent).

This course provides a series of strategic frameworks for managing high-technology businesses. The emphasis throughout the course is on the development and application of conceptual models which clarify the interactions between competition, patterns of technological and market change, and the structure and development of organizational capabilities. This is not a course in how to manage product or process development. The main focus is on the acquisition of a set of powerful analytical tools which are critical for the development of a technology strategy as an integral part of business strategy. These tools can provide the framework for deciding which technologies to invest in, how to structure those investments and how to anticipate and respond to the behavior of competitors, suppliers, and customers. The course should be of particular interest to those interested in managing a business for which technology is likely to play a major role, and to those interested in consulting or venture capital.

ESMA 730 Complex Network Analysis (3-0-3)
Prerequisite: Graduate level course on systems optimization (or equivalent).

This course is intended to analyze complex systems or networks from a graph theory point of view. A large portion of the course is dedicated to mathematical modelling, algorithms design, and complexity analysis through the use of graph theory. This course covers fundamental network flow problems and also reviews the latest research publications in graph theory applications on complex system: energy, transportation, water, health, and social-communication.

ESMA 740 Sustainable Development: Theory and Policy (3-0-3)
Prerequisite: Graduate level course on sustainable energy or environmental policy and economics or equivalent.

This course examines alternative conceptions and theoretical underpinnings of the notion of "sustainable development." It focuses on the sustainability problems of industrial countries (i.e., aging of populations, sustainable consumption, institutional adjustments, etc.); and of developing states and economies in transition (i.e., managing growth, sustainability of production patterns, pressures of population change, etc.). It also explores the sociology of knowledge around sustainability, the economic and technological dimensions and institutional imperatives along with implications for political constitution of economic performance.

ESMA 741 Advanced Modeling for Energy Planning (3-0-3)
Prerequisite: Graduate level course on system dynamics or system optimization (or equivalent).

Advanced Modeling for Energy Planning is a PhD seminar course that deepens the understanding and applications of modeling and simulation tools as used in medium and long-range energy planning. The seminar consists of three modules: Fundamental dynamics of the global energy systems with a view of the energy transition, Energy modeling approaches, and Constraints and practical implications of using models for energy planning. The seminar provides a deep understanding of the dynamic behaviors of global and regional energy systems including trade, presents a comprehensive review of energy modeling methodologies used for planning purposes, provides the context for applying these through practical guidelines and pitfalls that should be avoided for effective policy analysis.

ESMA 742 Energy Economics, Finance and Policy (3-0-3)
Prerequisite: Graduate level course on applied statistics (or equivalent) and undergraduate microeconomics (or equivalent).

This course teaches advanced theories of energy economics, finance and policy and reviews the latest development of theoretical/empirical research in these fields.

ESMA 743 Engineering for Energy and Poverty Solutions (3-0-3)
Prerequisite: Graduate level course on environmental policy and economics or product design and development or sustainable energy (or equivalent).

Engineering Energy and Poverty Solutions examines the challenges of reducing poverty within developing communities by promoting improved access to modern energy services. Normative assumptions underlying various definitions and approaches for development are examined, with an emphasis on the human development and capabilities approach as a useful theoretical foundation on which to base effective engineering solutions. Statistical data and indicators on energy poverty and energy access are critically examined to better understand current global energy needs. Students learn and apply advanced tools and methodologies for localized energy needs assessment, energy planning, and design of integrated energy systems. Throughout the semester, students work in small teams on a structured, in-depth design project that addresses an energy related need for a specific community, and participate in a week-long visit to work with the community on the project. The course is highly interactive and multidisciplinary, and relies heavily on readings, class participation and the successful management of team projects.

ESMA 780 Advanced Urbanism: Urban Design Ideals and Action
Prerequisite: Knowledge of theory and practice in urban design and sustainability or equivalent.

Urban design is an increasingly popular and powerful means of shaping settlement, influencing social forces, and accentuating economic activity via the purposeful manipulation of the built environment. Yet the form and realization of good urban design are often uncertain. Contrasting ideologies, shifting power structures, and competing imperatives make designers' jobs challenging. The result is that many human environments seem little impacted by the ideals of urban design. There is only a single city; how can there be multiple urban designs? The course material and research are structured to investigate: How is one to evaluate which urban design ideals to subscribe to, and thus design better sustainable environments?

ESMA 781 Modeling Urban Systems Energy Flow (3-0-3)
Prerequisite: Graduate level course on thermal energy in buildings (or equivalent).

Using numerical modeling, this course analyzes the challenges that cities will face and strategies they can use to mitigate the negative environmental impacts of energy use in the built environment. A primary focus of the course is the study of energy flows in the urban environment. The scale of the investigation ranges from individual buildings to blocks/districts to cities. Students will learn to use model-based techniques (detailed and simplified) to predict and modify energy use and urban microclimate. Emphasis will be on understanding and modeling the strong interaction, in dense urban settings, between buildings, vegetation, paved roads and the urban microclimate. The mode and intensity of this interaction can significantly impact energy use and thermal comfort. These microclimatic effects include shading of neighboring buildings, long-wave radiation, wind flow patterns and urban heat island (UHI). Students are expected to be able to (or be willing to learn to) use various software tools such as Rhinoceros/ Grasshopper and MATLAB. Limited tutorial sessions will be offered.

ESMA 794 Selected Topics in Engineering Systems and Management (3-0-3)
Prerequisite: Will be specified according to the particular topics offered under this course number.

This course covers selected contemporary topics in Engineering Systems and Management. The topics will vary from semester to semester depending on faculty availability and student interests. Proposed course descriptions are considered by the Department of Engineering Systems and Management on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the Graduate Studies Committee. The Course may be repeated once with change of contents to earn a maximum of 6 credit hours.

HEALTH, SAFETY AND ENVIRONMENTAL ENGINEERING (HSEG)

HSEG 601 Introduction to HSE Engineering (3-0-3)
Prerequisite: None.
Concepts of workplace health, safety and environment (HSE) will be discussed as they relate to the oil, gas, petrochemical and associated industries. Students will develop an understanding of how businesses manage HSE and the regulatory responsibilities, and be able to prepare for further study in the field. Included is a historical perspective of the legislative process of regulations, explanation

of HSE terms, ethics and professionalism, recordkeeping and HSE statistics, accident investigation and analysis, emergency preparedness, security, workers' compensation, concepts of pollution control, waste management, and HSE management systems.

HSEG 602 Industrial Hygiene Engineering (3-0-3)
Prerequisite: None.

This course studies the anticipation, recognition, evaluation, and control issues associated with industrial health and hygiene in the workplace. Topics include toxicology, epidemiology, noise, ionizing and non-ionizing radiation, chemicals, airborne contaminants, biological substances and sampling techniques. These subjects will be discussed in relation to all regulatory requirements using engineering and non-engineering controls for reducing or eliminating health hazards in the workplace.

HSEG 604 Hazard Control in Production Systems **(3-0-3)**
Prerequisite: None.

This course addresses the application of scientific and engineering principles and methods to achieve optimum safety and health through the analysis and design of processes, equipment, products, facilities, operations, and environments. Topics will include mechanics of failure applications, plant layout and design, systems safety, powered industrial vehicles, machine guarding, robotics, industrial processes, welding and cutting, walking and working surfaces, materials handling and storage, electrical practices and release of hazardous energy. These subjects will be discussed in relation to regulatory requirements.

HSEG 605 System Safety Engineering and Risk Management (3-0-3)
Prerequisite: None.

This course focuses on the evaluation of system design and process safety from the standpoint of risk, using system safety analysis techniques. Topics covered include concept of risk, system definition, hazard identification, risk assessment, risk management, sensitivity analysis and economics of system safety methodology, mathematics of systems analysis including statistical methods, Boolean algebra and reliability. Skills gained include the ability to calibrate a risk assessment matrix, perform preliminary hazard analysis (PHA), failure mode and effect analysis (FMECA), fault tree analysis (FTA), job safety analysis, event tree analysis, task analysis, process flow analysis, HAZOP (hazard and operability) analysis, and other system safety analysis techniques.

HSEG 606 Fire Protection Engineering (3-0-3)
Prerequisite: None.

This course covers fire and fire protection systems and fire program management. Topics covered include the physics, chemistry, characteristics and behavior of fire, fire hazards of materials, fire suppression systems, extinguishing agents, and detection and alarm systems. Relevant design and regulatory requirements will also be covered.

HSEG 607 Industrial Security and Disaster Preparedness (3-0-3)
Prerequisite: None.

This course will introduce the student to the fundamentals of security and emergency planning, including the nature, scope, history, and essential elements of security in the workplace, with emphasis on facilities. Specific areas include the operational aspects of security strategies for identifying and controlling security exposures, applicable legal issues, personal protection, property protection, role of intelligence, and concepts of disaster planning and management.

HSEG 608 QHSE Program Management (3-0-3)
Prerequisite: None.

This course examines the concepts and principles used in the development and management of an effective Quality, Health, Safety and Environment (QHSE) Program with emphasis on minimizing undesired operational events (accidents, downtime, errors and product/process defects). In addition, analytical concepts and quantitative techniques that support these concepts will also be covered. The philosophy and historical development of major concepts are presented with particular emphasis on areas of special concern in operational incident prevention. Special attention is given to the influence of morale, education and training, the role of the supervisor, inspections, auditing, total quality management, policies and procedures, and other program elements of value to the QHSE manager. The course is designed to familiarize students with the basic information applicable to organizational operational incident prevention and development of operational incident prevention programs.

HSEG 610 Hazardous Waste Management (3-0-3)
Prerequisite: None.

This course covers standards and regulations on management of hazardous waste that include identification, storage, transportation, monitoring, avoidance, reuse, reduction, recycling, recovery, treatment and disposal practices. Current environmental cleanup practices and technologies as well as principles for restoration of contaminated land based on formation type and local regulations will be thoroughly emphasized.

HSEG 611 Ergonomics and Human Factors Engineering (3-0-3)
Prerequisite: None.

This course studies human performance and its effect on the safety and reliability of systems. Information about human abilities, limitations and other characteristics will be used to design jobs, equipment, work methods and environmental conditions that will optimize human productivity in occupational settings. Engineering anthropometry, human information processing, biomechanics of motion and work posture, work physiology and human performance, thermal conditions (heat stress), the human visual system, vibration, illumination and indoor air quality, are covered in context of their application and workplace design.

HSEG 613 Analysis and Design of Air Pollution Control Systems (3-0-3)
Prerequisite: None.

This course covers analysis and engineering design of air pollution mitigation systems. Pollutant sampling techniques across occupational, community, and personal exposures will be addressed. Students will be exposed to data analysis methods and use these skills to interpret the health effect of air pollutants. Engineering controls and best management practices required of the practicing HSE engineer will be discussed. Also included will be industrial emission control technologies for compliance in the workplace. Environmental impact assessment will also be addressed.

HSEG 694 Selected Topics in HSEG (3-0-3)
Prerequisite: Will be specified according to the particular topics offered under this course number.

This course covers selected contemporary topics in health, safety and environmental engineering. The topics will vary from semester to semester depending on faculty availability and student interests. Proposed course descriptions are considered by the Department of Industrial and Systems Engineering on an ad hoc basis and the

course will be offered according to demand. The proposed course content will need to be approved by the Graduate Studies Committee. The Course may be repeated once with change of contents to earn a maximum of 6 credit hours.

HSEG 697 HSEG Graduate Project (3-0-3)
Prerequisite: ENGR 595 Seminar in Research Methods. Completion of a minimum of 18 credits of HSE courses and approval of the advisor.

In this course the student undertakes a major project under the supervision of a faculty member that brings to bear the competencies acquired through the program. This course allows students to build on and use earlier course information and to draw upon their engineering background, experience, and other pertinent resources to support the capstone report. Students also learn to apply suitable research techniques and methodologies as well as data collecting and analysis methods. An interim and a final presentation will be required.

INTERNATIONAL AND CIVIL SECURITY (IICS)

IICS 601: Introduction to International Relations and Security Issues (3-0-3)
Prerequisites: None.

This course provides a broad overview of how international security is studied and pursued. In doing so, students will learn about contending views on the nature of security and how it is best attained. They will be introduced to such concepts as the national interest, geopolitics, dimensions and measures of power, grand strategy, the changing nature of war, the security dilemma, deterrence, offense and defense, alliances, security regimes, the role of small states, the role of civil security, economics and security, belief systems and security, and security and human welfare. Finally, the course will survey major threats to international and regional security, including emerging threats and possible responses.

IICS 602: Introduction to Civil Security (3-0-3)
Prerequisites: None.

Civil security involves the combined and coordinated effort by governments, non-government organizations and individuals to prevent, prepare, respond and recover from natural and man-made hazards/threats which have their impact primarily within the State's borders. The role of civil security is to protect the state, its people, assets and interests which conceptually, involves the integration of multiple security paradigms (e.g. state, human and transnational security). Civil security is more than homeland security. Homeland security is predominantly a US concept focusing on countering terrorism, homeland defence and disaster management. This course introduces security to many civil security dimensions including physical security and risk management as well as natural disasters, technological disasters, and disaster and emergency response. The focus of the course is practical rather than theoretical, which reflects both the limited theoretical base of civil security and that the management of hazards and threats are derived from practitioner methodologies rather than theory. The course is focused at the governmental level rather than an organization level which reflects the fact that governments are the main driver of formal civil security responses.

IICS 603: Social Science Research Methods (3-0-3)
Prerequisites: None.

The purpose of this class is to provide students with the foundations to successfully conduct research and analysis in the social sciences, including international studies and civil security. The course will also provide students with practical skills in research and writing that they can apply to professional activities after graduation. Both qualitative and quantitative methods of social science inquiry are introduced.

IICS 604: Regional Security and the Terrorist Threat (3-0-3)
Prerequisites: None.

This course introduces student to concepts and events associated with state and non-state violence. It looks first at possible definitions of terrorism its various typologies. Additionally, an exploration of the theories and possible explanations for political violence and whether this is a new phenomenon lays the groundwork for discussions about terrorist groups, actions, motivations and, in some cases, their demise. This includes a historical and worldwide survey of violent extremist movements from the late 19th century. After examining movements and groups from both the left and right of the political spectrum, the course moves to an exploration of so-called Islamist terrorism. The course looks at the emergence of radical Islamism in the Middle East and the wider region. The first focus is on al-Qaeda, with an examination of its origins, its justifications for its actions, and the international effort to bring an end to its activities. We then explore other violent "franchise" groups such as Islamic State, Boko Haram and al-Shabaab, taking an in-depth look at their actions and rhetoric but also questioning what local and regional variables inhibited or encouraged their rise. The final portion of the course looks at counterterrorism efforts that may involve a spectrum of responses: intelligence, military action, law enforcement, economic operations, interrogation, and information warfare. Finally, the course explores the future of terrorist groups and actions, focusing on potential weapons, funding sources, and targets, with a look at strategy that seeks to end terror primarily by eliminating its root causes. Students, having evaluated the spectrum of possible causes and response to Islamist extremism, will develop counterterrorism strategies relevant to the UAE and/or other states based on an analysis of previous counterterrorism efforts (military, legal, extra-legal etc.).

IICS 621: Technology and International Security (3-0-3)
Prerequisites: IICS 601.

Technology influences security and globalization in comprehensive political and economic terms. The problem, however, is that the nature of the relationship between technology and security is unclear, especially during times of rapid and pervasive technological change. The purpose of this seminar is to explore the ways in which technology influences international security by examining its political, economic, and strategic implications. This seminar begins by examining technologies that shaped security in the 20th century, and then shifts the discussion to how contemporary technologies are influencing political, economic, and military security in the 21st century.

IICS 622: Technology and Civil Security (3-0-3)
Prerequisites: IICS 602.

This course will examine common security technology using the methodology of design and evaluation of physical protection systems. This methodology is an industry standard, and security objectives to be the basis of design. This provides a structured approach to examining technologies to detect, delay and respond. These include exterior and interior intrusion sensors, entry control technology, radiological detection, access delay technology, and critical infrastructure and border security technologies.

IICS 623: Regional Security Challenges and Policy Options (3-0-3)
Prerequisites: IICS 601.

This course will introduce the student to the international relations (IR) of the Middle East/ Arabian Gulf. Understanding the current situation requires historical context, and the course will begin with an overview of the region's history since the end of World War I and the collapse

of the Ottoman Empire. The course will then turn to look at four specific aspects of regional security and IR: The Iraq/Iran war and the politics of identity; Energy Security, Oil and Political Economy in the IR of the Middle East; the Gulf Wars and the IR of the Gulf; and the Middle East and its evolving relationship with the US, China, India, Russia and other state actors. IR in the Middle East is shaped by a variety of material factors, including military power and technology; great power intervention; globalization and economic development; geography and natural resources; and demography and migration. The course will look at proposed solutions to conflict and regional conundrums, both in terms of diplomatic approaches to specific conflicts, and broader efforts to address the roots of regional (and global) conflict. For all of these issues, the role and perspective of the UAE will be considered first and foremost.

IICS 624: Creating Integrated Civil Security (3-0-3)
Prerequisites: IICS 602.

The primary purpose of civil security is to protect society from major threats and facilitate the restoration of society when disasters occur. This is an inherently interdisciplinary problem requiring a working partnership of all levels of government, the private and service sectors, numerous operational disciplines and the general public. This course will examine the stakeholders in this endeavor, the models for integration, the goals and challenges of their collaboration, and current approaches for building and strengthening comprehensive integrated civil security.

IICS 625: Globalization and Middle East Security (3-0-3)
Prerequisite: IICS 601.

Developments in the UAE, the Arabian Gulf, and the broader Middle East occur in the context of deepening global integration, a phenomenon, generally referred to as "globalization." This course builds on its prerequisite, IICS 601, and looks in depth at how globalization is reshaping the security environment for the UAE and the region, including: deepening economic interdependence, the revolutionary integration of global media and information systems, the global diffusion of weapons technologies, the global reach of terrorist groups, and the creation of a global labor force. These factors and trends are examined in terms of their impact on the regional balance of interstate power, the reshaping of power within states, political extremism, social stability, terrorism and counterterrorism, and, overall, the challenges confronting domestic and regional security. At the beginning of the course, the class will read the Abu Dhabi 2030 Plan and other future visions of prosperity in a context of peace. The term paper will represent an exploration—in light of the factors listed above—on how best to secure the future security and prosperity of the UAE and the region.

IICS 626: Comparative Civil Security Systems (3-0-3)
Prerequisite: IICS 602.

The goals of civil security are similar across countries. It seeks to protect the state, its people and its interests from threats and hazards that primarily have their impact within the State's borders. However, each country approaches building civil security is a particular way which reflects the country's unique history and circumstances. This course compares and contrasts how different countries approach civil security. Insights from this examination allow students to gain a greater understanding of why the UAE approaches civil security in the way it does, and alternative approaches to achieving UAE civil security goals.

IICS 645: Policy Analysis (3-0-3)
Prerequisite: IICS 601, IICS 602.

The purpose of this class is to provide students with the foundations to successfully conduct research and analysis in policy-related topics, including international studies and civil security. Methods of analysis are explored in the context of the policy-making process. The set of "policy options" arises from the complicated interactions among actors in the policy process. The course will ask how policy problems and solutions can be framed differently, looking at a variety of case studies.

IICS 646: Intelligence and National Security (3-0-3)
Prerequisites: IICS 601, IICS 602.

Intelligence is a critical element of national and civil security. The primary purpose of national intelligence is to support situational awareness and decision making by leaders across all levels of government. This course introduces students to the role of intelligence in support to the decision making process, the intelligence process, and practical issues of national intelligence in the emerging national, regional, and global security environment.

IICS 647: Exercise Design and Technology (3-0-3)
Prerequisites: IICS 601, IICS 602.

This course provides students with the knowledge, skills and technology to develop and deliver security related exercises. Exercises are a primary methodology for research, analysis and process improvement in many aspects of security. Students who complete this course will have a strong understanding of the uses of exercises, how they are developed, and related technologies that can be used to enhance them. This course will provide hands on experience in the use of these powerful practices and tools and their uses in analysis, evaluation and improvement of security practices.

IICS 648: The Changing Nature of War and Conflict (3-0-3)
Prerequisites: IICS 601, IICS 602.

This course provides a multidisciplinary understanding of the characteristics, practice and consequences of the use of force by states and non-state actors throughout the international system. It situates strategic studies in broader international relations and security studies debates whilst exploring core concepts such as the causes of war; the legality and morality of the use of force; revolutions in military affairs; the role, concepts and practices of land power, sea power and airpower; the so-called "new wars", and counterinsurgency.

IICS 649: Cybersecurity and its Implications for Statecraft
Prerequisites: IICS 601, IICS 602.

This policy oriented course designed to meet the UAE's unique security needs provides a multidisciplinary understanding of the components of cybersecurity as it pertains to national security and statecraft. It builds on traditional warfighting domains such as land, air and sea and explores the ramifications of cyber in a holistic fashion. The course delves into the role of cyber in the military defense, civil security protection, stability of civilian life, environmental security and economic prosperity.

IICS 690: Civil Infrastructure Protection Design (3-0-3)
Prerequisite: IICS 602, IICS 603.

Asses the key elements of civil infrastructure protection design, including: threat and hazard assessment; conventional and nuclear environments; conventional and nuclear loads on structures; behavior of structural elements; dynamic response and analysis; connections,

openings, interfaces, and internal shock; and structural systems-behavior and design philosophy.

IICS 691: Nuclear Non-proliferation and Security (3-0-3)
Prerequisite: IICS 601, IICS 602.

Assesses the key elements of nuclear security, including: safeguards and nonproliferation, safeguards principles and logistics, nuclear materials accountancy methods, accountancy and verification measurements, and international nuclear law and the Middle East context.

IICS 692: Computer and Network Security (3-0-3)
Prerequisite: IICS601, IICS 602.

Assesses the foundations of computer and network security, including: identification and authentication, access control, vulnerability assessment and management, malicious codes, foundations of network security, network based threats and attacks, security services and security mechanism, and network security devices and firewalls.

IICS 693: Wireless Network and Mobile Security (3-0-3)
Prerequisite: IICS 692.

This course presents information on wireless network sand mobile security, including: Wireless security threats, wireless LAN technology, wireless PAN security, mobile security fundamentals, third generation security, E- and M-commerce security.

IICS 694: Information Security Management (3-0-3)
Prerequisite: IICS 601, IICS 602.

This course presents the fundamental principles and practices used in the management of information security, including: the need for information security management, management techniques, management tools and applications, security strategy, policy and standards, building IT security architecture.

IICS 695: Independent Study (3-0-3)
Prerequisite: IICS 601, IICS 602, IICS 603, IICS 604, program approval.

Students who wish to design and complete individual study projects geared to their particular interests, aptitudes and needs may register for this course (usually completed within one semester). The study must be managed by at least one academic advisor and approved by the Director of IICS. The topic of the project should be clearly related to international or civil security and should be a topic that is not covered through the regular IICS course offerings. The Independent Study may include: self-directed reading, research, fieldwork experience, public performance, occupational experience and/or other methods as appropriate.

As Independent Study is largely driven by the student, the student must:

- Propose a topic for study;
- Identify an IICS or KU faculty member and request their supervision. Please remember that faculty members are not required to supervise an Independent Study; you are asking for a favor.

The student must meet with his/her faculty supervisor in person on regular intervals. The faculty supervisor will keep records of these meetings. In the first week of the Independent Study, the student must produce a Study Plan, approved by the faculty supervisor. At the conclusion of the Independent Study, the student will prepare a written report and an oral presentation of their findings or the equivalent thereof.

IICS 698: Thesis Workshop (3-0-3)
Prerequisite: Completion of a minimum of 18 course credit hours (four core courses and either two track courses or any two other courses).

This workshop is designed to help MA students develop a well-crafted Master's Thesis, sustain their research and writing agenda throughout the dissertation process, and learn about the academic profession as a whole. This class requires a high level of student interaction and engagement.

IICS 699: Master's Thesis (1-0-9)
Prerequisite: IICS 698. Completion of a minimum of 18 course credit hours.

Registration subject to departmental approval.

MATERIAL SCIENCES ENGINEERING (MSEN)

MSEN 605 Structure and Properties of Polymers (3-0-3)
Prerequisite: General chemistry, undergraduate level organic chemistry, mechanical properties of materials or equivalent.

Review of polymer molecular structure and bulk morphology; survey of molecular and morphological influence on bulk physical properties, biopolymers and carbohydrates, solid-state deformation, and toughness. Case studies for functionalized polymers and polymer applications.

MSEN 606 Materials Processing and Manufacturing Technologies (3-0-3)
Prerequisite: Undergraduate course in mechanics of materials or equivalent.

Discusses a wide variety of basic and recent technologies related to materials processing and manufacturing including materials removal, deformation, joining and solidification. Emphasis will be on the underlying science of a given process rather than a detailed description of the technique or equipment.

MSEN 607 Thermodynamics of Materials (3-0-3)
Prerequisite: Undergraduate course in thermodynamics and fundamentals of material science.

This course provides students with an advanced treatment of the laws of thermodynamics and their applications to equilibrium and the properties of materials. The course is useful to the students who are interested in doing research in materials field. They will learn the concepts of thermodynamics of materials and their applications to understand materials processing.

MSEN 608 Kinetics of Materials (3-0-3)
Prerequisite: Undergraduate physics, chemistry, materials science, thermodynamics or instructor approval.

This course presents a unified treatment of phenomenological and atomistic kinetic processes in materials. Topics include: irreversible thermodynamics; diffusion; nucleation; phase transformations; fluid and heat transport; morphological instabilities; gas-solid, liquid-solid, and solid-solid reactions.

MSEN 611 Photovoltaic Technologies: Materials, Devices and Systems (3-0-3)
Prerequisite: Undergraduate physics, materials science, or electrical engineering, or instructor approval.

Photovoltaic technologies that enable the direct conversion of solar energy into electricity are presented from the science and engineering viewpoints. The materials and fundamental processes involved are emphasized first. The device level is then treated through design, modeling, simulation as well as implementation and testing perspectives. Thin-film, third-generation, novel and emerging PV technologies are also addressed.

MSEN 612 Physics for Solid-State Application (3-0-3)
Prerequisite: Undergraduate course in quantum mechanics, linear algebra, differential calculus or instructor approval.

Crystal lattices, electronic energy band structures, phonon dispersion relations, effective mass theorem, semiclassical equations of motion, electron scattering and semiconductor optical properties will be developed. Band structure and transport properties of selected semiconductors will be calculated. Connection of quantum theory of solids with quasi-Fermi levels and Boltzmann transport used in device modeling will be made.

MSEN 619 Crystallography and Diffraction (3-0-3)
Prerequisite: Undergraduate vector algebra and structure of materials.

Major topics of the course include: crystallography – symmetry, point group, space group, lattice and crystal systems; Principles of x-ray diffraction – x-ray sources, x-ray detectors, x-ray scattering by matters, Bragg's law, structure factor; Experimental techniques for x-ray diffraction, unit cell determination and refinement, structure determination and refinement.

MSEN 621 Mechanical Properties of Materials (3-0-3)
Prerequisite: Undergraduate course in materials science with instructor approval.

This course deals with the mechanical properties of various materials and their relationship with: (1) the internal structure (atomic, molecular, crystalline, micro-and macro); (2) processing and; (3) service conditions.

MSEN 622 Electrical, Optical and Magnetic Properties of Amorphous Materials (3-0-3)
Prerequisite: Undergraduate physics courses.

Electrical, optical, opto-electronic and magnetic properties of non crystalline (amorphous) materials. Discussion of roles of disorder, defects and doping on the optoelctronic properties of the materials. Discussion of methods of growth and characterization of these materials. A number of applications using these materials will be discussed in detail.

MSEN 623 Electrical, Optical and Magnetic Properties of Crystalline Materials (3-0-3)
Prerequisite: Undergraduate physics courses (II-III-IV).

Electrical, optical, opto-electronic and magnetic properties of mono and poly-crystalline materials (metals, semiconductors). Discussion of roles of bonding, structure (crystalline, defect, energy band and microstructure) and composition in influencing and controlling physical properties.

MSEN 624 Thermal Properties of Materials (3-0-3)
Prerequisite: Undergraduate course in materials science or physics, with instructor approval.

This course explores the thermophysical and radiative properties of various materials such as metals, semiconductors, ceramics. It examines the correlations of these properties with:

1. The materials internal structures (atomic, molecular, crystalline, micro-and macro);
2. Fabrication and processing conditions.

MSEN 694 Selected Topics in Material Science and Engineering (3-0-3)
Prerequisite: Will be specified according to the particular topics offered under this course number.

This course covers selected contemporary topics in material science and engineering. The topics will vary from semester to semester depending on faculty availability and student interests. Proposed course descriptions are considered by the Department of Mechanical Engineering on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the College of Engineering Graduate Studies Committee. The course may be repeated once with change of contents to earn a maximum of 6 credit hours.

MSEN 699 Master's Thesis (minimum 12)
Co-requisite: ENGR 695 Seminar in Research Methods, approval of the Department Chair and the Associate Dean for Graduate Studies.
In the Master's Thesis, the student is required to independently conduct original research-oriented work related to important material science and engineering problems under the direct supervision of a main advisor, who must be a full-time faculty in the Mechanical Engineering Department, and at least one other full-time faculty who acts as co-advisor. The outcome of the research should demonstrate the synthesis of information into knowledge in a form that may be used by others and lead to publications in suitable reputable journals/conferences. The student's research findings must be documented in a formal thesis and defended through a viva voce examination. The student must register for a minimum of 12 credit hours of Master's Thesis.

MSEN 701 Electrochemical Processes and Devices (3-0-3)
Prerequisite: Graduate level courses on thermodynamics of materials and kinetics of materials (or equivalent).

This course covers a variety of topics concerning electrochemical engineering, including thermodynamic and transport properties of aqueous and non-aqueous electrolytes, the electrode/electrolyte interface, and the kinetics of electrode processes. It also covers electrochemical characterization with regards to D.C. techniques (controlled potential, controlled current) and AC. techniques (voltammetry and impedance spectroscopy). Applications of the following will also be discussed: electrowinning, electrorefining, electroplating, and electrosynthesis, as well as electrochemical power sources (batteries and fuel cells).

MSEN 710 Advanced Solid State Physics (3-0-3)
Prerequisite: Graduate level course on electrical, optical and magnetic properties of crystalline materials (or equivalent). Knowledge of quantum mechanics is helpful.

The purpose of this course is to provide a deep and operational understanding of classical and quantum mechanical models of electrons and lattice vibrations in solids aimed at the development of numerical models. The course will emphasize physical models for elastic properties, electronic transport, and heat capacity. Crystal lattices, electronic energy band structures, phonon dispersion relations, effective mass theorem, semiclassical equations of motion, electron scattering and semiconductor optical properties will be developed.

MSEN 712 Imaging of Materials: Scanning Electron Microscopy and X Ray Microanalysis (3-0-3)
Prerequisite: Graduate level course on crystallography and diffraction (or equivalent).

This course will study and investigate principles and applications of imaging techniques for materials characterization including scanning electron microscopy and X-ray microanalysis. Topics include: electron optics, electron guns, electron lenses and their aberration, electron specimen interactions, image formation and

interpretation, X Ray Spectral Measurement and Quantitative X Ray Analysis, SEM sample preparation including organic and inorganic samples. Lectures are complemented by real-case studies and computer simulations. The course will enable the students to start their SEM practical experience with the SEM training in Quanta 250.

MSEN 715 Advanced Imaging of Materials: Transmission Electron Microscopy (3-0-3)
Prerequisite: Graduate level course on crystallography and diffraction (or equivalent).

This course focuses on the principles and applications of transmission electron microscope (TEM). Students choosing this course will learn advanced theory and applications of TEM operation and sample preparation during the semester. Topics include: Electron optics, lens aberrations, depth of field, depth of focus, resolution, contrast, bright and dark field microscopy, selected area diffraction, calibration, specimen preparation, electron scattering, electron diffraction, Bragg's law, Laue conditions, structure factor, Ewald construction, double diffraction, twinning, Kikuchi lines, contrast theory, kinematical theory of diffraction by perfect and imperfect crystals, extinction contours, dynamical theory, special techniques, introduction to HRTEM.

MSEN 730 Science and Engineering of Thin Films, Surfaces and Interfaces (3-0-3)
Prerequisite: Graduate level course on electrical, optical and magnetic properties of crystalline materials (or equivalent).

Technologies used in the synthesis and growth of thin films of various materials (metals, semiconductors, and ceramics). Processing and transformations of surfaces and interfaces. The course includes elements of vacuum science and technology, structural, physico-chemical and functional characterization methods for thin-films, surfaces and interfaces. Case studies are drawn from a variety of applications including active and passive thin films and coatings, semiconductor devices, nanostructures, advanced and functional materials.

MSEN 740 Advances in Investigation of Intermolecular and Surface Forces (3-0-3)
Prerequisite: Knowledge of electromagnetism and quantum mechanics, or permission of instructor.

Intermolecular forces embrace all forms of matter, and yet one finds very few university courses devoted to the fundamental aspects of this subject. This course aims at presenting a comprehensive view of intermolecular and surface forces and the common way to investigate these forces by means of different scanning probe microscopy techniques. The first part of the course will describe the role of such force in determining the properties of simple and complex system. This subject touches on a very broad area of phenomena in physics, chemical engineering and biology and due to the wide range topic covered and different disciplines to which the course is addressed, I have presumed only the basic knowledge of molecular science. The second part of the course present the fundamentals underlying Atomic Force Microscopy (AFM) for the investigation of intermolecular and surface forces. AFM is one of the foremost tools for imaging, measuring, and manipulating matter at the nanoscale by gathering information of the surface throughout a mechanical probe.

MSEN 750 High Efficiency Silicon Solar Cells: Designs and Technologies (3-0-3)
Prerequisite: Graduate level course on photovoltaic technologies materials, devices and systems (or equivalent).

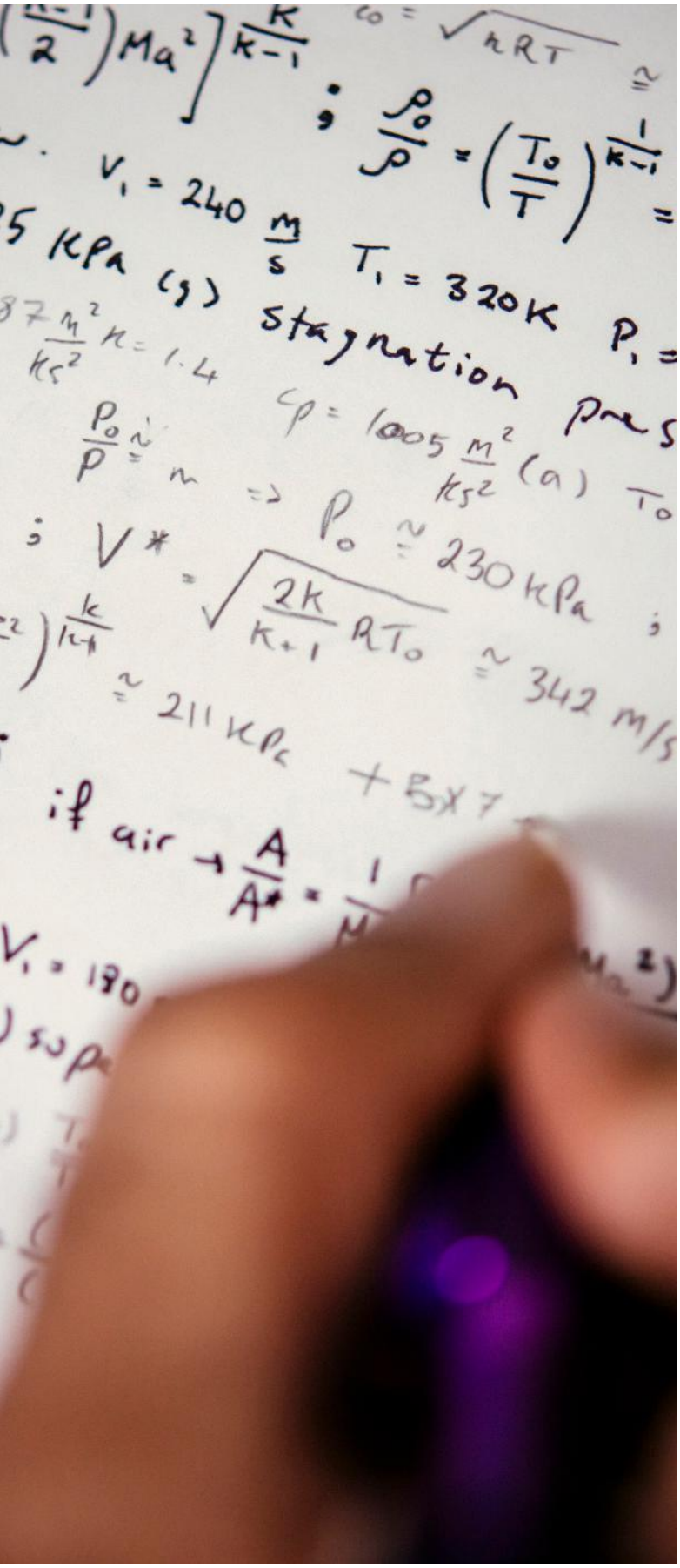
The course addresses the surface physics and chemistry of crystalline silicon including the critical phenomenon of surface passivation. It covers in depth the recombination mechanisms of charge carriers in crystalline silicon. A study of the different passivation approaches to the surface and their impact on the performance of solar cell technologies such as PERC, PERL and HIT, newer architectures will be explored.

MSEN 760 Thin-Film Solar Cells: From Design to Applications (3-0-3)
Prerequisite: Graduate level course on photovoltaic technologies materials, devices and systems (or equivalent).

Photovoltaic technologies that enable the direct conversion of solar energy into electricity are presented from the science and engineering viewpoints. The materials and fundamental processes involved are described. The device level is then treated through design, modeling, simulation as well as implementation and testing perspectives. Thin-film, third-generation, novel and emerging PV technologies are addressed. Case studies are presented including manufacturing, applications and deployment of diverse PV technologies.

MSEN 794 Selected Topics in Materials Science and Engineering (3-0-3)
Prerequisite: Will be specified according to the particular topics offered under this course number.

This course covers selected contemporary topics in Material Science and Engineering. The topics will vary from semester to semester depending on faculty availability and student interests. Proposed course descriptions are considered by the Department of Mechanical Engineering on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the Graduate Studies Committee. The Course may be repeated once with change of contents to earn a maximum of 6 credit hours.



MATHEMATICS (MATH)

MATH 601: Engineering Mathematical Analysis (3-0-3)

Prerequisite: MATH 211 Linear Algebra and Differential Equations, (or equivalent). Introductory graduate level course in engineering mathematical analysis. Review of vector calculus and linear algebra; solution of ordinary differential equations; special functions; partial differential equations of engineering physics: linear elliptic, parabolic, and hyperbolic PDE's governing heat transfer, electromagnetic, and vibratory phenomena; Eigen function expansions.

MATH 602: Numerical Methods in Engineering (3-0-3)

Prerequisite: MATH 211 Linear Algebra and Differential Equations, (or equivalent).

Introductory graduate level course in numerical methods in engineering. Numerical integration for initial value problems; finite difference methods; linear algebra; optimization; and the finite element method.

MATH 603: Random Variables and Stochastic Processes (3-0-3)

Prerequisite: MATH 311 Probability and Statistics with Discrete Mathematics, (or equivalent).

Random variables, vectors, and processes, statistical detection and classification, principles of parameter estimation, biased and unbiased estimators, Cramer-Rao inequality, minimum variance and unbiased estimates, expectation as estimation, Correlation and linear estimation, linear filtering of random processes, discrete time linear models, moving-average and autoregressive processes, discrete time Gauss–Markov process, Maximum likelihood (ML) estimation, Fourier analysis, correlation and coherence, spectral analysis of random signals.

MATH 604 Multivariate Data Analysis (3-0-3)
Prerequisite: MATH 213 Engineering Statistics or MATH 311 Probability and Statistics with Discrete Mathematics (or equivalent), and MATH 211 Linear Algebra and Differential Equations (or equivalent).

Graduate level course providing an introduction to Multivariate Data Analysis. This course focuses on the some of the most important techniques of data reduction and analysis of qualitative data. These techniques have a wide range of engineering applications such as Materials Science, classification of engineering-geological environments and of correspondence analysis in clinical trials.

MECHANICAL ENGINEERING (MEEN)

MEEN 601 Advanced Dynamics (3-0-3)
Prerequisite: Undergraduate knowledge of linear algebra and dynamics (or equivalent).

Dynamics of particles and rigid bodies using Newtonian and variational methods of mechanics. Gyroscopic mechanics, Lagrangian and Hamiltonian mechanics, applications.

MEEN 602 Advanced Vibrations (3-0-3)
Prerequisite: Undergraduate knowledge of vibrations (or equivalent).

This course builds upon the undergraduate vibrations course. It introduces energy based methods for derivation of governing equations (Lagrange's equation, Hamilton's principle), vibration of distributed parameter systems (strings, rods, beams, and membranes). The second half of the course is focused on practical aspects including signal processing (sampling process, FFT, FRF calculation), basics of modal analysis, dynamics and condition monitoring of rotating machinery.

MEEN 603 Advanced Thermodynamics (3-0-3)
Prerequisite: Undergraduate knowledge of thermodynamics.

This course provides a strong basis in the fundamentals of classical and statistical thermodynamics. The covered topics include: Availability and Exergy analysis, Maxwell relations and thermodynamic properties, Psychrometrics, kinetic theory of gases, and an introduction to statistical thermodynamics.

MEEN 604 Advanced Fluid Mechanics (3-0-3)
Prerequisite: Undergraduate knowledge of fluid mechanics.

To introduce advanced concepts of fluids and fluid mechanics, and enable the students to solve more practical engineering problems in fluid motion. This course will cover the formulation of the fluid flow problem, friction, viscous flow, boundary layer theory, transition, and incompressible and compressible flow.

MEEN 605 Advanced Continuum Mechanics (3-0-3)
Prerequisite: Undergraduate knowledge of mechanics of deformable solids (or equivalent).

The course presents an introduction to the mechanics of continuous media, including solids and fluids. It provides the students with the mathematical background required to derive the equations of motion for solid and fluid continua in compliance with the conservation principles.

MEEN 606 Advanced Mechanics of Solids and Materials (3-0-3)
Prerequisite: Undergraduate knowledge of multivariable calculus, linear algebra and vector analysis and strength of materials (or equivalents).

This course presents the physical laws, mathematical methods, and computer

algorithms that are used to predict the response of materials and structures to mechanical and/or thermal loading. Topics include: Fundamentals of solid mechanics, Review of Cartesian Tensors, Two and Three Dimensional Theories of Stress and Strain (Method of Continuum Mechanics, Theory of Elasticity), Isotropic linear elasticity and isotropic linear thermo-elasticity. Boundary value problems for linear elastic solids. Variational and energy methods. Linear viscoelasticity. Small-strain elastic-plastic deformation; nonlinear elasto-plastic material behavior. Failure modes, failure theories and fracture in solid materials.

MEEN 607 Sustainable Energy (3-0-3)
Prerequisite: Undergraduate knowledge of thermodynamics.

Assessment of current and potential energy systems, covering extraction, conversion, and end-use, with emphasis on meeting regional and global energy needs in a sustainable manner. Examination of energy technologies and energy types: renewable (solar, biomass, wind, hydro, geothermal), fossil (oil, gas, synthetic), nuclear (fission and fusion), along with storage, transmission, and conservation issues. Focus on evaluation and analysis of energy technology systems in the context of social, economic, and environmental goals.

MEEN 610 Applied Finite Element Analysis (3-0-3)
Prerequisite: Undergraduate knowledge of mechanics of materials and dynamics (or equivalents).

This course provides a review of solid mechanics with a brief introduction to the theory of elasticity. An in-depth derivation of the finite element procedure is presented. Applications of static and dynamic finite element analysis of real world mechanical systems are performed. A commercial Finite Element Method code is used to perform analysis.

MEEN 611 Combustion Theory and Applications (3-0-3)
Prerequisite: Undergraduate knowledge of thermodynamics, fluid mechanics and heat transfer (or equivalents).

Combustion thermo-chemistry of different fuels, adiabatic flame temperature and combustion products composition, chemical kinetics and important combustion chemical mechanisms, ideal flow reactors, laminar premixed flames, diffusion flames including liquid droplet and solid particle combustion, turbulent premixed and non-premixed flames, pollutant emissions and control. All of the above are treated with emphasis on a wide variety of practical applications that motivate or relate to the various theoretical concepts and current research interests.

MEEN 612 Advanced Viscous Flow Analysis (3-0-3)
Prerequisite: Undergraduate knowledge of fluid mechanics or equivalent.

This course focuses on viscous flow concepts and theory. It introduces the fundamentals necessary for the analysis of incompressible Newtonian viscous flows, incompressible boundary-layers and free shear flows in the laminar and turbulent regime. It aims to develop skills required by engineers working in Thermofluids and prepares for advanced courses in Turbulence and its modeling, Computational Fluid Dynamics, Multiphase Flows and Convective Heat Transfer.

MEEN 613 Advanced Heat Transfer (3-0-3)
Prerequisite: Undergraduate knowledge of heat transfer.

Rigorous review of conductive, convective and radiative heat transfer with a short extension to mass transport. Thermal conductivity and mechanisms of energy transport. Differential and integral form of the energy conservation equation. Impulsive and unsteady non-isothermal flows. Energy transport in turbulent flows. Radiation transport with emphasis on participating media. Brief reference to the similarities between heat and mass transfer.

MEEN 614 Advanced Energy Conversion (3-0-3)
Prerequisite: Undergraduate knowledge of thermodynamics, fluid mechanics and heat transfer (or equivalents).

This is a graduate level course designed to give students an overview of conventional and non-conventional energy conversion techniques. Basic background, terminology, and fundamentals of energy conversion are introduced. Current and emerging technologies for production of thermal, mechanical, and electrical energy are discussed; topics include fossil and nuclear fuels, solar energy, wind energy, fuel cells, and energy storage.

MEEN 615 Multiphase Flow Engineering (3-0-3)
Prerequisite: Undergraduate knowledge of fluid mechanics or equivalent.

This course is designed to introduce the fundamental concepts and principles that underlie multiphase flow processes. It introduces the fundamentals necessary for the analysis of two phase flows such as liquid-gas and liquid-solid flows. Measurements techniques, CFD Analysis and applications of multiphase flow processes are covered together with examples of applications involving the oil and gas industries.

MEEN 616 Solar Thermal Analysis, Design and Testing (3-0-3)
Prerequisite: Undergraduate knowledge of heat transfer (or equivalent).

Course develops advanced heat transfer topics applied to collection, storage, conversion, and utilization solar thermal energy. Solar position, shading, atmospheric attenuation and sky models are covered. Optical properties of materials and reflector and receiver geometries are developed. Dynamic models and simulation are introduced. Low-temperature applications of desalination, water heating, and space-heating and cooling (SHAC) and high temperature applications of concentrating solar power (CSP) and advanced solar cooling are described.

The course will include the following topic areas: fundamental engineering principles of solar energy collection, thermal energy storage, and thermodynamic cycles for power, cooling, and dehumidification. Students will be introduced to system modeling in TRNSYS, EES and/or MATLAB and will perform laboratory measurements and standard tests on typical flat-plate, line- and heliostat-concentrating collectors.

MEEN 617 Fuel Cell Systems (3-0-3)
Prerequisite: Undergraduate knowledge of fluid mechanics, thermodynamics and heat transfer (or equivalents).

This course covers fundamentals of fuel cell systems for both mobile and distributed power applications. It includes detailed analyses of the principles and component designs of various types of fuel cells including proton exchange membrane fuel cell (PEMFC), phosphoric acid fuel cell (PAFC), solid oxide fuel cell (SOFC), and molten carbonate fuel cell (MCFC); discussions on water and thermal management, and balance of power plant; review of hydrogen storage and safety consideration; and challenges and future opportunities.

MEEN 618 Computational Fluid Dynamics and Fire Modeling
Prerequisite: Undergraduate fluid mechanics, numerical analysis, and differential equations, or equivalents. Some programming (MATLAB, C, Fortran) experience is also helpful.

This course introduces the methods of CFD with an emphasis on the numerical methods that are used for elliptic and parabolic equations. Topics will include flows near solid boundaries as well as reactive flow modeling with emphasis on modeling of fires. Applications will be illustrated utilizing ANSYS-FLUENT and the Fire Dynamic Simulator.

MEEN 619 Fire Dynamics Laboratory (0-3-3)
Prerequisite: Undergraduate fluid mechanics and heat transfer. Familiarity with standard laboratory practices will be helpful.

The course exposes the students to the experimental techniques that are used for the study of fire dynamics. The students are asked to combine visualization with quantitative measurements, analyze critically the results, and explore the effect of physical parameters on fire characteristics, such as temperature, heat release, and combustion products.

MEEN 620 Measurements and Instrumentation (3-0-3)
Prerequisite: Undergraduate knowledge of core measurements laboratory (or equivalent).

This is an advanced course on the theory and design of engineering measurements. Integrated throughout the course are the necessary elements for the design of measurements systems and measurement test plans, with an emphasis on the role of statistics and uncertainty analysis in design. Topics also include sensors, signal conditioning circuits and noise reduction techniques. Typical sensor topics include temperature, force, torque, pressure, flow and acceleration. Practice will be given to students, through course projects, on the measurement of mechanical engineering quantities. Software use such as LabVIEW and MATLAB will be integrated into course projects.

MEEN 621 Feedback Control (3-0-3)
Prerequisite: Undergraduate knowledge of system dynamics and controls (or equivalent).

This course provides basic material about feedback control of systems. Topics include a review of Laplace transform techniques and time response analysis; stability and feedback interconnections; basic transfer function analysis and design methods; robustness; state-space analysis and state feedback design.

MEEN 622 Control System Theory and Design (3-0-3)
Prerequisite: Undergraduate knowledge of dynamics and control, linear algebra and differential equations (or equivalents).
This is a fundamental graduate course on the modern theory of dynamical systems and control. It builds on an introductory undergraduate course in control and emphasizes state-space techniques for the analysis of dynamical systems and the synthesis of control laws meeting given design specifications.

MEEN 630 Advanced Engineering Mathematics / Cross-Listed with ENGR 606 (3-0-3)
Prerequisite: Undergraduate knowledge of calculus and differential equations (or equivalents).

This course focuses on concepts and techniques, analytical as well as numerical, for solving applied problems arising in various engineering disciplines. Analytics cover separation of variables, integral transforms, Green's functions, similarity, and perturbation methods. Numerics include finite differences, finite elements, and discrete and fast Fourier transforms. Emphasis would be on formulating and solving problems as well as on interpreting and analyzing the solutions to gain physical insight. Engineering applications would be stressed in addition to mathematical formalities. MATLAB is required in some of the homework problems.

MEEN 631 Fatigue and Fracture of Engineering Materials (3-0-3)
Prerequisite: Undergraduate knowledge of mechanics of solids, and strength and fracture (or equivalent).

This is an advanced course in fatigue and fracture of engineering material with in-depth presentations on fatigue, linear elastic fracture mechanics, damage modeling, life prediction methods. It also covers fatigue fracture of composites, as well as emerging new engineering materials such as nanocomposites.

MEEN 632 Micro/Nanotechnology and Applications (3-0-3)
Prerequisite: Undergraduate knowledge of engineering materials, mechanics of solids, fluid mechanics (or equivalents).

This course will give an advanced survey to different aspects of active research in micro and nanotechnology, covering the broad area of science in micro- and nano-scale materials. Introduction to micromachining, fundamental properties of micro and nanotechnology such as, mechanical, electronic, magnetic, optical, and biochemical properties will be covered.

MEEN 633 Advanced Manufacturing Processes (3-0-3)
Prerequisite: Undergraduate knowledge of materials, and manufacturing processes (or equivalents).

This is an advanced course in manufacturing processes where a survey of important manufacturing processes is presented. The course will also cover fundamentals of machining, advanced machining processes and microelectronics fabrication, rapid prototyping, tribology, and some competitive aspects in manufacturing.

MEEN 659 Modeling and Control of Robotic Systems /Cross-Listed with ECCE 659 (3-0-3)
Prerequisite: Undergraduate knowledge of complex variables and transforms and feedback control systems (or equivalents).

The course covers the theory and practice of the modeling and control of robotic devices. This includes kinematics, statics and dynamics of robots. Impedance control and robot programming will also be covered. Different case-studies will be presented to support hands-on experiments.

MEEN 694 Selected Topics in Mechanical Engineering (3-0-3)
Prerequisite: Specified according to the particular topics offered under this course number.

This course covers selected contemporary topics in mechanical engineering. The topics will vary from semester to semester depending on faculty availability and student interests. Proposed course descriptions are considered by the Department of Mechanical Engineering on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the Graduate Studies Committee. The Course may be repeated once with change of contents to earn a maximum of 6 credit hours.

MEEN 699 Master's Thesis (minimum 12)
Co-requisite: ENGR 695 Seminar in Research Methods, approval of the Department Chair and the Associate Dean for Graduate Studies.

In the Master's Thesis, the student is required to independently conduct original research-oriented work related to important mechanical engineering problems under the direct supervision of a main advisor, who must be a full-time faculty in the Mechanical Engineering Department, and at least one other full-time faculty who acts as co-advisor. The outcome of the research should demonstrate the synthesis of information into knowledge in a form that may be used by others and lead to

publications in suitable reputable journals/ conferences. The student's research findings must be documented in a formal thesis and defended through a viva voce examination. The student must register for a minimum of 12 credit hours of Master's Thesis.

MEEN 701 Fracture Mechanics and Fatigue / Cross-Listed with AERO 711 (3-0-3)
Prerequisite: Graduate level course on advanced mechanics of solids and materials (or equivalent).

Concept of linear elastic fracture mechanics, stress intensity factor, Griffith energy balance, determination of the elastic field at a sharp crack tip, J integrals analysis, experimental determination of fracture toughness, elastic plastic fracture mechanics, fatigue crack growth, elastic-plastic crack tip fields, critical crack sizes and fatigue crack propagation rate prediction. Fracture mechanisms and fracture modes associated with failure of engineering materials.

MEEN 702 Damage Mechanics of Solids and Structures / Cross-Listed with AERO 712 (3-0-3)
Prerequisite: Graduate level course on continuum mechanics (or equivalent).

This course aims to teach students the basic mechanisms of damage (degradation) and fracture (cracking) and how to develop theoretical models and computational algorithms that can be used in simulating and understanding damage evolution, fracture, and ultimate failure of various engineering materials, composites, and structural systems and devices. Damage and fracture in various brittle and ductile materials and their engineering implications will be studied. Formulation of time-independent and time-dependent damage and fracture models taking into consideration linear and nonlinear material behavior will be discussed in this course. Modeling of damage and fracture due to various loading conditions (e.g., mechanical, thermal, chemical, electrical, fluid) will be presented. Also, the capabilities and limitations of well-known damage and fracture models for various applications will be assessed.

MEEN 703 Linear and Nonlinear Finite Element Methods (3-0-3)
Prerequisite: Graduate level course on advanced engineering mathematics and advanced continuum mechanics or advanced mechanics of solids and material (or equivalent). An introductory knowledge of finite element analysis and programming skills will be beneficial.

This course is designed to provide a unified framework to model, formulate and numerically solve advanced linear and nonlinear problems in solids, structures and fluids using finite element methods. Two- and three-dimensional linear and nonlinear initial/boundary value problems are covered with particular emphasis on interdisciplinary applications. Various nonlinearities are studied in detail to gain insights into mathematical and numerical aspects. This course particularly emphasizes on formulation of geometrically nonlinear and materially nonlinear finite elements. Incremental and iterative methods for solution of nonlinear systems of equations and their computer implementation issues are rigorously addressed.

MEEN 704 Computational Inelasticity (3-0-3)
Prerequisite: Graduate level course on advanced mechanics of solids and materials (or equivalent).

This course introduces students to advanced topics in solid mechanics using tensor algebra. In addition to the theoretical approach for elastostatics, the course focuses on computational inelasticity and nanomechanics.

MEEN 705 Micromechanics of Materials (3-0-3)
Prerequisite: Graduate level knowledge of strength and fracture, mechanics of deformable solids.

Introduction Overview; materials classification; typical microstructural constituents--grains, phases, particles, etc.; stress, strain and simple tension experiments Review of necessary elements of solid mechanics Tensor algebra, Stress, Strain and deformation, Conservation principles Elastic and thermal properties of heterogeneous materials: Maxwell and Voigt simple bounds; self-consistent field models; bounding approaches, Unit cells of crystalline materials; Hooke's law, physical basis of linear elasticity; anisotropic linear elasticity; elastic properties of heterogeneous media Micromechanics of failure/damage: Constitutive behavior of materials with voids and cracks; localization of plastic flow; local failure mechanisms. Dislocation theory Ideal shear strength of perfect crystals; topology and properties of dislocations; generation of dislocations and resultant permanent deformation; dislocation interaction with other dislocations and with other defects. Toughening mechanisms Critical resolved shear stress in single crystals; plastic deformation in polycrystals; strengthening mechanisms; plastic yielding under complex stress states; limit analysis. Phase transformations. Current research topics in mechanics of materials.

MEEN 706 Theory of Plasticity (3-0-3)
Prerequisite: Graduate level course on advanced continuum mechanics (or equivalent).
This course introduces phenomenological and mathematical formulation of the constitutive laws of plasticity; yield criteria and their experimental verification; plastic stress-strain relations and their associated flow rules; correspondence between rate-independent and rate-dependent plasticity; solutions to basic boundary-value problems, including plane problems and those involving cylindrical and spherical symmetries; variational and minimum principles; limit analysis; plane-strain problems and crystal plasticity; finite-strain theory.

MEEN 721 Computation Fluid Mechanics (3-0-3)
Prerequisite: Graduate level course on fluid mechanics, undergraduate numerical analysis, and partial differential equations, or equivalents. Some programming (MATLAB, C, Fortran) experience is also helpful.

This course provides engineering applications of computational fluid dynamics with background information on the most common numerical methods; two dimensional inviscid and viscous flows; boundary layer flows; and an introduction to three dimensional flows. Applications will be illustrated utilizing FLUENT code.

MEEN 722 Non Newtonian Fluid Mechanics (3-0-3)
Prerequisite: Graduate level courses on advanced engineering mathematics and advanced fluid mechanics (or equivalent).

Course material includes rheology of complex fluids, in particular polymeric liquids and their characteristics used to understand the modelling of their flow behaviour. It includes inelastic and visco-elastic fluids. Applications to polymer melt flows will be highlighted.

MEEN 723 Advanced Combustion (3-0-3)
Prerequisite: Graduate level course on combustion theory and applications (or equivalent).

Extend the combustion theory and applications course and draws the connection between reactive flow, combustion fundamentals, combustion engineering, flames, and aerodynamics interactions. The main topics will focus on the following areas: Reactive flow transport phenomena, chemical kinetics,

preferential-diffusion and flame stretch interaction, reaction mechanism reduction, combustion engineering, Biofuel combustion characterization, hydrodynamic and aerodynamic flame stability, oxygen enhanced combustion, combustion driven acoustics and vibration, fire dynamic simulation, combustion mechanisms in spark ignition and compression ignition engines, flamelet models for CFD combustion. A wide variety of practical models and applications related to the various concepts as well as experimental methods and diagnostics will be covered in lab and through literature survey.

MEEN 724 Advanced Modeling of Cooling Systems (3-0-3)
Prerequisite: Graduate level course on advanced heat transfer and advanced thermodynamics (or equivalent).

Establishes comprehensive heat and mass transfer, psychrometric, and refrigerant state relations needed to rigorously model a wide variety of cooling and dehumidification processes. Effectiveness-NTU methods using concentration and enthalpy difference analogous to temperature difference formulation are covered. Two-phase moving boundary models are formulated for evaporator and condenser models. Physical and semi-empirical compressor models are comprehensively explained working with measured and published performance data. Numerical methods of successive approximation, grid search and Newton-Raphson are applied to solve systems of non-linear equations and systems of empirical and first-principles component models. Linear regression methods to identify models from measured cooling load time series and resulting model used to estimate seasonal performance of a given chiller or heat pump design.

MEEN 725 Multiphase Flow in Porous Media (3-0-3)
Prerequisite: Graduate level courses on fluid mechanics, heat transfer, thermodynamics, or equivalents.

The course is focused on the achievement of a clear and rigorous understanding of the fundamental properties, concepts and theories which are of importance in treating storage and multiphase fluid flow in porous media, with or without heat transfer, mass transfer, and/or chemical reactions.

MEEN 741 Advanced Conduction and Radiation Heat Transfer (3-0-3)
Prerequisite: Graduate level courses on advanced engineering mathematics, advanced heat transfer (or equivalent).

This course covers in depth the physical processes involved in the transfer of thermal energy by conduction and radiation heat transfer. Topics include steady and transient multi-dimensional conduction, blackbody radiation, radiation surface characteristics, radiation exchange in enclosures, radiation through continua, and combined mode heat transfer. Emphasis is placed on the use of analytical methods, numerical techniques and approximate solutions. Problems and examples highlighting theory and applications drawn from a spectrum of engineering design problems are presented.

MEEN 742 Advanced Convection Heat Transfer (3-0-3)
Prerequisite: Graduate level course on advanced heat transfer (or equivalent).

This course covers the conservation equations of momentum and energy. Topics covered include: convection boundary layers, laminar and turbulent flows, mixed convective heat transfer, convective heat transfer at high speed flow, forced convection phase change heat transfer, and impingement heat transfer.

MEEN 743 Micro/Nano Energy Transport (3-0-3)
Prerequisite: Graduate level courses on thermodynamics and heat transfer.

This course covers energy transport at micro/nanoscale where it focuses on energy states, energy transport and thermal energy storage at the micro and nanoscale by means of statistical mechanics and solid state physics. Energy transport will be introduced by means of kinetic theory and Boltzmann Transport Equation. The course will focus on energy transport and energy storage in gases and solids by diffusion and radiation in addition to some applications to heat transfer in micro/nanofluidics.

MEEN 744 Interfacial Transport and Phase Change Heat Transfer (3-0-3)
Prerequisite: Graduate level courses on advanced fluid mechanics and advanced heat transfer (or equivalent).

This course aims to present an insightful understanding of phase-change and multiphase flow phenomena in nature, power, and energy industries. It covers different levels of principles, from fundamental gas kinetics, liquid-vapor interfacial behavior, to interfacial liquid-vapor transport dynamics, to evaporation and condensation characteristics, and to transient analysis of thermal-fluid processes. Theoretical analysis, numerical simulation and experiments are used together to probe complicated multiphase thermal-fluid physics. Advanced lab characterization tools are introduced to engage state-of-the-art thermal-fluid research with knowledge discovery and innovation in power and energy sectors.

MEEN 745 Concentrated Solar Power and Thermal Energy Storage (3-0-3)
Prerequisite: Graduate level courses on advanced thermodynamics, advanced heat transfer (or equivalents).

This course covers principles of concentrated solar power (CSP) technologies (solar field optics theory, heat transfers, and production of electricity in the power block) and associated thermal energy storage (TES) systems at commercial and research level.

MEEN 761 Advanced Process Dynamics and Control / Cross-Listed with AERO 761 (3-0-3)
Prerequisite: Graduate level courses on dynamics and control, advanced engineering mathematics (or equivalent).

This course aims to provide multidisciplinary fundamentals and solid mathematical foundation of modern energy process systems engineering. It presents a systematic framework for physics-based and empirical dynamic process modeling, transient analysis, feedback control and optimization. This course is particularly dedicated to the most popular advanced control strategy in energy process industries - model predictive control (MPC). Other optimal control approaches are also introduced to deal with plant disturbances, uncertainties, nonlinearities, instabilities and constraints. This course emphasizes the use of advanced math tools to develop dynamic models and design advanced controllers for energy process systems.

MEEN 762 Analysis and Simulation of Mechatronics Systems (3-0-3)
Prerequisite: Graduate level course on dynamic systems and vibration (or equivalent).

This course focuses on the modeling of dynamic engineering systems in various energy domains using Bond Graph Modeling Technique, analysis and design of dynamic systems, response of linear systems, and computer simulation using MATLAB.

MEEN 763 Theory and Design of Digital Control Systems (3-0-3)
Prerequisite: Graduate level course on feedback control (or equivalent).

Feedback control systems emphasizing state space techniques and discrete time systems. The course covers the z-transform, z-domain analysis, design of control systems via the z-transform, state space analysis, controllability and observability, observer design, control design in state space.

MEEN 764 Optimal Control / Cross-Listed with AERO 764 (3-0-3)
Prerequisite: Graduate level course in advanced engineering mathematics.

This course is designed to teach students methods of optimal control and parameter estimation using Linear Quadratic Gaussian design approach, optimal control theory of non-deterministic systems, optimal control of nonlinear and time-varying systems with known inputs, as well as parameters and state estimation.

MEEN 765 Acoustics and Noise Control (3-0-3)
Prerequisite: Graduate level course on advanced engineering mathematics (or equivalent).

This course covers principles of acoustics; propagation, transmission, reflection and absorption of acoustic waves; passive and active noise control methods.

MEEN 766 MEMS Theory and Applications (3-0-3)
Prerequisite: Graduate level course on advanced engineering mathematics (or equivalent).

This course is designed to teach students Micro-Electro-Mechanical Systems (MEMS) design, analysis and applications. The course focuses on advanced MEMS theory, design considerations, squeeze film damping, types of sensors and actuators, micro-resonators, gyroscopes and their applications, and economics of microfabrication.

MEEN 767 Control of Robotic Systems / Cross-Listed with ECCE 757 (3-0-3)
Prerequisite: Graduate level knowledge of engineering mathematics and computation.

This course is designed to teach students concepts and tools for analysis, design and control of robotic mechanisms. Kinematics, statics and dynamics of robotic systems.

MEEN 781 Materials Selection in Mechanical Design (3-0-3)
Prerequisite: Graduate knowledge of materials science.

This course introduces procedures for selection the optimum materials(s) under multiple constraints resulting from functional, reliability, safety, cost and environmental issues. A variety of problems that illustrate materials-limited design and relationship between design and materials selection will be covered.

MEEN 782 Materials Characterization Techniques (3-0-3)
Prerequisite: Graduate knowledge of materials science.

This course introduces the different materials characterization techniques to determine atomic structure, morphology and physical properties of the engineering materials.
The selection process of the most suitable characterization method for a certain application of materials is also discussed.
The common advanced techniques covered in this course are electron microscopy (SEM and TEM with principles of bright-field, dark-field and weak-beam imaging), Scanning Tunneling Microscopy (STM) and Atomic Force Microscopy (AFM), thermal analysis (DSC, TGA), X-ray diffractometer (XRD), spectroscopic methods (IR, Raman, and UV), and chromatographic methods.

MEEN 791 Inference and Estimation from Models and Data (3-0-3)
Prerequisite: Graduate level course on advanced engineering mathematics, undergraduate level of statistics, basic MATLAB skills.

This course presents a variety of inversion (or parameter estimation) and forecasting techniques. The advanced mathematical and statistical underpinnings of each technique are developed. The course combines theory with programming exercises that include use of existing MATLAB routines and coding advanced algorithms thus providing the numerical and statistical tools to test models and make inferences from observations of natural processes or experiments. The student will gain practice and judgment in selection of appropriate models.

MEEN 792 Advanced Nanomaterials and Their Mechanical Applications (3-0-3)
Prerequisite: Graduate standing.

This course is designed for PhD students, aiming to provide a broad background on nanotechnologies, and offer substantial depth on nanomaterials and their mechanical applications. The course will cover the background of nanotechnology, physics at nanoscale, nanomaterials and nanosystem, nano-characterization, and their applications in mechanical engineering. A project will be used to enhance students' practical capabilities on research, communication, and technical writing.

MEEN 794 Selected Topics in Mechanical Engineering (3-0-3)
Prerequisite: Will be specified according to the particular topics offered under this course number.

This course covers selected contemporary topics in Mechanical Engineering. The topics will vary from semester to semester depending on faculty availability and student interests. Proposed course descriptions are considered by the Department of Mechanical Engineering on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the Graduate Studies Committee. The Course may be repeated once with change of contents to earn a maximum of 6 credit hours.

MEDICINE (MDBS, MDCM, MDMS, MDPS, MDRT)

MDBS 601 Molecules, Genes and the Cells (6 credits, 90 hours, 6 weeks)
Prerequisites: None.

Molecules, Genes and Cells introduces first year medical students to foundational concepts of cell biology, biochemistry, nutrition, medical genetics, therapy and disease prevention. Students will learn about the biological molecules associated with cells, cellular processes, metabolic pathways, their interrelatedness and regulation and the consequences of bimolecular defects on these processes at the molecular and cellular level. Students will increase their knowledge of human patterns of genetic inheritance beyond Mendelian concepts with the objective of seeing patients through a genetic lens. Biochemical, genetic and genomic tests for diagnosis and characterization will be taught so that students will have a broad understanding of the advantages and limitations of these technologies. Students will have opportunities throughout the course to apply the knowledge gained though course work with review of clinical cases in class based discussions and further extend their knowledge through group work activities. This course is foundational to the Period II courses.

MDBS 602 Structural Organization of the Human Body (4 credits, 60 hours, 4 weeks)
Prerequisites: None.

During the course first year medical students are introduced to fundamental concepts of human anatomy, consisting of early human development, composition of different tissues, and organ morphology. Basic concepts of embryology, histology, gross anatomy and neuroanatomy from the microscopic to the organ system level are taught as the basis for a thorough understanding of the physiology and pathology of the human body and of clinical medicine. Course objectives are delivered using lectures, laboratory sessions, application exercises and case presentations. This course is foundational to the Period II courses.

MDBS 603 Integrated Functions of the Human Body (5 credits, 75 hours, 5 weeks)
Prerequisites: None.

This course introduces first year medical students to essential concepts of physiology and immunology. The course provides students with a strong foundation relevant to their understanding of normal and pathological conditions and to their future diagnostic and therapeutic decision making. Physiology is taught using an organ system approach, emphasizing the interplay of molecules, cells, tissues, organs and systems to maintain normal function of the human body. Normal and abnormal functions of the immune system are introduced and integration of immunology with organ system physiology is emphasized. This course is foundational to the Period II courses.

MDBS 604 Pathology (3 credits, 45 hours, 3 weeks)
Prerequisites: None.

This course explores the science of the causes and effects of disease. The underlying mechanisms of disease processes are defined for the purposes of diagnosis and forensic examination. Laboratory examination of body tissues is an important part of this course with an emphasis on identifying the morphological features of the major organ systems. Being able to distinguish classical features between lesions in tissue is an important outcome of the course. Students study the concepts of necrosis, apoptosis, inflammation, repair, hemodynamic disorders and neoplasia, and how these concepts relate to environmental factors such as nutrition and genetic factors. The legal procedures at the end of life in order to certify death is discussed. This course is foundational to the Period II courses.

MDBS 605 Microbiology and Infectious Disease (3 credits, 45 hours, 3 weeks)
Prerequisites: None.

This course is an introduction to microorganisms (bacteria, viruses, fungi and parasites) significant to human disease and disease processes. Students study infectious diseases, their etiopathogenesis and clinical manifestations, routes of transmission, treatment and techniques in detection and identification of pathogenic microorganisms. Differential diagnoses and use of broad spectrum and targeted antimicrobial treatments are presented. Students make diagnoses of diseases based on clinical findings, discuss the epidemiology and pathogenesis based on clinical presentations, make differential diagnoses, and suggest management of disease. Pedagogical linkages exist between this course and MDBS 603 Integrated Functions and MDBS 606 Pharmacology and Therapeutics. This course is foundational to the Period II courses.

MDBS 606 Pharmacology and Therapeutics (4 credits, 60 hours, 4 weeks)
Prerequisites: None.

This course provides students with the underlying principles of pharmacology and therapeutics. It explores the major drug

classes, including their routes of administration, absorption, distribution, onset and duration of action, dose response, metabolism, and excretion. Target and common drug mechanisms, drug toxicity, and drug interactions are also explored. Factors influencing drug efficacy and toxicity; including comorbidities, demographic, environmental and genetic factors are also covered. This course is foundational to the Period II courses.

MDBS 701 Cardiovascular and Respiratory Systems (6 credits, 90 hours, 6 weeks)
Prerequisites: None.

This course introduces students to the Cardiovascular and Respiratory Systems and their interrelationships with other organ-systems. The course reviews and builds upon the foundational sciences relevant to the Cardiovascular and Respiratory systems, including their molecular and cellular biology, genetics, embryology, anatomy, histology, microbiology, pathology, and physiology. The course also delves into the pathophysiologic mechanisms that lead to common Cardiovascular and Respiratory disorders, as well as diagnostic and therapeutic strategies to manage and/or prevent these disorders. Clinical correlations, application exercises, and other teaching and learning strategies are used to illustrate the relevance of the biomedical sciences of the Cardiovascular and Respiratory systems to the practice of medicine.

MDBS 702 Hematopoietic and Lymphoreticular Systems (3 credits, 45 hours, 3 weeks)
Prerequisites: None.

The knowledge that is delivered in this course is designed to equip students with the foundational concepts for understanding diseases of the blood. The pathogenesis and mechanism of hematological disease, whether genetic or acquired, are covered and morphological features of these diseases will be discussed in an up-to date manner using recent finding and research.

MDBS 703 Integumentary System (2 credits, 30 hours, 2 weeks)
Prerequisites: None.

In the integumentary course, the structure and function of this system is studied. Students learn about normal development and other acquired pathological conditions and common congenital diseases. Reviewing and interpreting diagnostic tests, in order to determine the appropriate treatment options. Applying the pathophysiologic reasoning presents the student with opportunities to determine differential diagnoses, using clinical laboratory results and radiology reports.

MDBS 704 Musculoskeletal Systems (3 credits, 45 hours, 3 weeks)
Prerequisites: None.

This second-year course provides the medical student the opportunity to learn the normal development, structure, and function of the musculoskeletal system, to expand on the foundations from the first-year anatomy course. Common congenital and acquired pathologic conditions and the interpretation of diagnostic tests and basic treatment options are reviewed. The following areas are emphasized: effects of environment, nutrition, exercise, and aging on bone and joint homeostasis; radiological assessment and correlation with patho-anatomy; basis of autoimmunity, rheumatologic diseases and inflammatory disorders. The course provides opportunities to learn and assess application of pathophysiologic reasoning as well as clinical, laboratory and radiologic findings to assist in differential diagnosis with review of treatment strategies.

MDBS 705 Gastrointestinal System (4 credits, 60 hours, 4 weeks)
Prerequisites: None.

This course introduces students to the Gastrointestinal (GI) System and its interrelationships with other organ-systems. The course reviews and builds upon the foundational sciences relevant to the GI system, including its molecular and cellular biology, genetics, embryology, anatomy, histology, microbiology, pathology, and physiology. The course also delves into the pathophysiologic mechanisms that lead to common GI disorders, as well as diagnostic and therapeutic strategies to manage and/or prevent these disorders. Special attention is given to the role the GI System plays in nutrition and nutritional disorders. Clinical correlations, application exercises, and other teaching and learning strategies are used to illustrate the relevance of the biomedical sciences of the GI system to the practice of medicine.

MDBS 706 Endocrine System (3 credits, 45 hours, 3 weeks)
Prerequisites: None.

The Endocrine System course will: 1. Build upon the specific topics discussed in the course Structural Organization of the Human Body, introduce medical students to the abnormal processes and principal therapies of endocrine disorders; 2. Advance their knowledge and comprehension of the aforementioned disorders and therapeutic modalities including the influence and effects of gender, ethnicity, and behavior of patients on specific endocrine diseases. To provide an interactive teaching and learning environment, the course will include question & answer sessions interspersed during the lectures as well as case discussions. A solid understanding of normal endocrine processes including the anatomy and function of endocrine organs, hormone synthesis, secretion, action and metabolism are required to successfully master this course.

MDBS 707 Reproductive System (3 credits, 45 hours, 3 weeks)
Prerequisites: None.

Reproductive System provides an overview of the development of the male and female reproductive systems with a focus on abnormalities of sexual differentiation and function, the physiology of control of the menstrual cycle, conception, infertility, menopause and pregnancy. In addition, the pathophysiology of the male reproductive system will be covered.

MDBS 708 Renal System (3 credits, 45 hours, 3 weeks)
Prerequisites: None.

This course introduces students to the Renal System and its interrelationships with other organ-systems. The course reviews and builds upon the foundational sciences relevant to the Renal system, including its molecular and cellular biology, genetics, embryology, anatomy, histology, microbiology, pathology, and physiology. The course also delves into the pathophysiologic mechanisms that lead to common Renal disorders, as well as diagnostic and therapeutic strategies to manage and/or prevent these disorders. Clinical correlations, application exercises, and other teaching and learning strategies are used to illustrate the relevance of the biomedical sciences of the GI system to the practice of medicine.

MDBS 709 Nervous Systems (6 credits, 90 hours, 6 weeks)
Prerequisites: None.

This course provides an integrated, multidisciplinary overview of the structural and functional relationships of the central and peripheral nervous systems under both healthy and diseased conditions. The course covers essential concepts in normal and

pathologically altered neurological functions (using neuroanatomy, neurophysiology, neuropharmacology, neuropathology, and clinical neurology). Students learn to diagnose and locate the causes of abnormal neurological function, by identifying a patient's symptoms and then locating the source of the problem within the nervous system. The format of the course includes lectures, laboratory work, small-group case-based discussions, and a select number of clinical correlates presented through a variety of application exercises.

MDBS 710 Behavioral System (3 credits, 45 hours, 3 weeks)
Prerequisites: None.

The course will present the fundamentals of psychiatry and psychological principles that are the foundation for clinical work in Period 3. These principles include psychiatric diagnoses and treatment, cognitive neuroscience, cognitive and emotional development, and principles of psychopharmacology and psychotherapy. Learning will take place in an interactive process using team-based learning, problem-based learning, and some traditional lectures. Independent study and preparation prior to group activities will be an integral part of the learning process.

MDBS 800 Core Concepts in Medicine (5 credits, 75 hours, 48 weeks)
Prerequisites: None.

The major themes of these Thursday sessions are student-driven inquiry, learning and teaching with integration of the 6 core competencies of medical education. Problem-based learning in small groups followed by large group consultation with specialists will serve as the primary learning format. Individual and pair assignments in critical appraisal, clinical application of statistics, and a group assignment in case development will also support the course learning objectives.

MDCM 600 Clinical Skills I (5 credits, 75 hours, 26 weeks)
Prerequisites: BLS Certification
Clinical Skills I focuses on teaching the knowledge, skills and attitudes needed in areas such as communication, physical and mental examinations, basic procedures, and medical documentation. These skills are developed and refined using various teaching modalities and later integrated with more advanced clinical skills during the Clinical Medicine II course.

MDCM 700 Clinical Skills II (5 credits, 75 hours, 38 weeks)
Prerequisites: BLS Certification

Clinical Skills II (CSII) builds on concepts and skills that were taught in CSI. Interviewing, communication and physical examination skills are expanded and deepened as each organ system is examined. CSII focuses on combining the skills of taking a history and physical/mental examination with underlying pathophysiology in order to develop working differential diagnoses. Students learn the professional role of a physician within the scope of the healthcare system by gaining more experience in the healthcare setting.

MDCM 801 Internal Medicine (8 credits, 8 weeks)
Prerequisites: None.

The eight (8) week clerkship in Internal Medicine (IM) has two components: ambulatory (40%) and hospital-based (60%) and is designed to provide medical students with the foundation of knowledge, skills and attitudes necessary to approach and care for adult patients in both settings. The student's primary work will be under direct supervision of internal medicine preceptors from the community, the public health system and the academic setting and will emphasize basic assessment and management of core

common problems in IM, including identifying patient problems, establishing a differential diagnosis and planning an appropriate evaluation and treatment in preparation for an increased independence in management and therapeutics during period four. Clinical judgment and diagnostic reasoning skills will be a focus of this clerkship. There will be elective opportunities to experience IM specialties with 1-week or 2-week rotations such as cardiology, pulmonary, renal, infectious diseases and gastroenterology. Emergency medicine experiences will give opportunities to learn the acute presentation of IM and surgical disorders. This rotation will also build experience in mastering a number of procedural skills.

MDCM 802 Surgery (8 credits, 8 weeks)
Prerequisites: None.

This clerkship will provide students with experience in the recognition and management of surgical disease and in basic surgical techniques. During this clerkship, students will develop understanding of the scientific basis of surgical diseases and disorders. Students will then learn to perform assessments and develop differential diagnoses for these surgical presentations participating in preoperative care, operative procedures, outpatient surgery clinics and didactic experiences on management of surgical diseases. Students will also learn how to evaluate normal and complicated postoperative recovery with surgical inpatients and outpatients. Upon completion of the surgery clerkship, students will also fully understand norms of professional behavior by working effectively with patients and families as a member of the health care team.

MDCM 803 Medical Imaging (4 credits, 4 weeks)
Prerequisites: None.

The four (4) week Radiology clerkship will be conducted on KU-CMHS campus and will provide medical students with a basic understanding of the common techniques used in medical imaging, the evidence-based choice of appropriate studies for given clinical symptoms, the potential complications and side effects of such studies and the interpretation of medical imaging studies of common clinical conditions.

MDCM 804 Neurology (4 credits, 4 weeks)
Prerequisites: None.

The Neurology clerkship will provide medical students with experience in general and specialty neurology. Students will learn to diagnose and treat non-emergent neurological disorders in the outpatient setting, as well as neurological emergencies in the inpatient setting. The Neurology clerkship course has three components with each constituting approximately 33%: ambulatory, didactic and hospital-based.

MDCM 805 Obstetrics and Gynecology (6 credits, 6 weeks)
Prerequisites: None.

The Obstetrics-and-Gynecology clerkship gives third-year medical students a six (6) week rotation in the core discipline of women's health. Medical students are exposed to all aspects of the specialty, including ambulatory clinics, hospital inpatient wards, the operating room, emergency room visits and consults, radiology, and the labor and delivery suite. Throughout the rotation, faculty and nurse midwives will serve as instructors to the various fundamentals in women's health

MDCM 806 Pediatrics Clerkship (6 credits, 6 weeks)
Prerequisites: None.

The Pediatrics clerkship will provide students with experiences in the evaluation, diagnosis, and management of pediatric patients.

Training will be in both inpatient and outpatient settings and will expose students to a wide variety of pediatric patients presenting with acute illnesses, chronic illnesses, and health maintenance needs. Students will actively participate in clinical care, simulated cases, simulation laboratory scenarios, and didactic lectures. The clerkship emphasizes the basic skills of assessment and management of common pediatric problems.

MDCM 807 Psychiatry (6 credits, 6 weeks)
Prerequisites: None.

This clerkship introduces Period 3 medical students to general and specialty psychiatry and allows them to develop competencies in diagnosing and treating psychiatric disorders. The structure of the clerkship ensures that students receive exposure to different clinical practice settings, including emergency department (ED), inpatient, outpatient, and consultation-liaison services.

MDCM 808 Family Medicine (6 credits, 6 weeks)
Prerequisites: None.

Family Medicine (FM) is the specialty which provides continuing and comprehensive care for the individual and family, and encompasses all ages, both sexes, each organ system and every disease entity. It is a specialty which integrates biological, clinical and behavioral sciences. The Period 3 FM clerkship provides a practical opportunity for students to demonstrate progressive skill development integrating their knowledge of basic and social sciences, clinical skills, professional development, and social accountability. Under the supervision of KU Family Medicine faculty, students will be involved in provision of clinical care, conducting and documenting history and physical exam, developing an assessment, differential diagnosis, and management plan and provide patient education. The course will give students an exposure to a wide range of clinical conditions, providing an excellent preparation for Period 4 rotations and potential future careers as family physicians.

MDCM 900 Emergency Medicine (4 credits, 4 weeks)
Prerequisites: None.

This four (4) week rotation is intended to give the student an in-depth experience in the management of patients with an acute, undifferentiated medical condition. This allows the student to further build on the clinical knowledge and skills obtained in their Period 3 clerkships. During the first week a series of small group discussions and simulations will prepare the students to deal with common acute clinical conditions. The remainder of the rotation will be in the emergency rooms of clinical partners.

MDCM 901 Advanced Medicine, Advanced Surgery, Advanced Pediatric Medicine or Advanced Pediatric Surgery (4 credits, 4 weeks)
Prerequisites: None.

Period 4 students will choose a four (4) week experience in a medical, surgical, pediatric medical or pediatric surgical setting, predominantly inpatient. This will build on the experience gained in the Period 3 clerkships and will give the student more responsibility for direct patient care (supervised).

MDCM 902 Geriatrics (2 credits, 2 weeks)
Prerequisites: None.

This rotation will provide students with an experience in the evaluation, diagnosis, and management of geriatric patients in both the inpatient and outpatient setting. Throughout patient clinical experiences, students will be exposed to a wide variety of geriatric patients presenting with acute illnesses, chronic illnesses, evaluation of disabilities and preventive health maintenance visits. Students will participate in clinical evaluations,

simulated cases, simulated laboratory scenarios, and didactic lectures. The rotation emphasizes comprehensive assessment and management of core common geriatric conditions.

MDCM 903 Sub-Internship (4 credits, 4 weeks)
Prerequisites: None.

In a sub-internship experience the student is expected to perform at the level of a (supervised) intern and will take increasing responsibility for the care of patients in a predominantly inpatient setting. Students will be expected to do history and physical examinations on patients admitted to the hospital, formulate a differential diagnosis, evaluation and management plan and write appropriate orders. They will follow the patients daily with the team, participate in surgery where appropriate, and be involved in the discharge planning and follow-up.

MDCM 904 Electives I, II, III, IV (4 credits, 4 weeks)
Prerequisites: None.

At this stage of the curriculum students will have decided on which specialty path they wish to train post-graduation. These electives will be in a medicine, surgery or hospital-based (e.g. radiology, pathology) specialty.

MDCM 905 Selectives I, II (4 credits, 4 weeks)
Prerequisites: None.

Selectives are elective experiences with two major differences: they need to be completed at the medical school and they are chosen from a limited number of selections which are intended to broaden the student experience e.g. medical ethics, medical teaching.

MDCM 999 Transitions V (2 credits, 30 hours, 4 weeks)
Prerequisites: None.

Transitions V is a four (4) week experience in which the student is exposed to situations that they will encounter during their first year of graduate medical education. Student will have the opportunity to assess and fine tune basic clinical competencies and the entrustable professional activities they are expected to demonstrate at the time they report for residency training. They will perform task training in more complex procedures such as central line insertion, thoracentesis, paracentesis, etc. and participate in simulated scenarios that reflect sophisticated clinical situations typically faced in hospital-based settings.

MDMS 600 Medicine and Society I (3 credits, 26 weeks)
Prerequisites: None.

Medicine and Society I aims to provide a foundation of empirical knowledge for understanding and promoting health in households, communities and populations with special emphasis on disparities, cultural sensitivity, social determinants, environmental stress, and concomitant physiological and pathological consequences on patients. Students will explore concepts related to systems-based practice, and practice-based learning and improvement. Critical analyses of the evidence will be juxtaposed with practical, clinical applications described by practitioners through clinical cases. Students will identify legal concerns and consider broader policies in preparation for a socially responsible approach to medicine. Students will begin to develop collaborative skills to work effectively with other healthcare professions, including nursing, social work, and the health sciences, to address barriers to effective care, to identify complimentary practice strategies, and to maximize outcomes through case-based problem solving.

During Medicine and Society I, students will explore their future role as members of an interprofessional healthcare team providing personalized and preventative medicine through the Balsam Program.

The fundamental aspects of personalized assessment and preventive medicine will be presented while developing skills related to health education, health promotion, appropriate use of screening and diagnostic testing, and disease management. The course aims to give students the skills to work effectively in interprofessional teams and to assess the behavioral, psychosocial, cultural, occupational, and environmental considerations necessary to provide effective healthcare.

MDMS 700 Medicine and Society II (3 credits, 38 weeks)
Prerequisites: None.

This course aims to provide a foundation of empirical knowledge for understanding and promoting health in households, communities and populations with special emphasis on disparities, cultural sensitivity, social determinants, environmental stress, and concomitant physiological and pathological consequences on patients. Students will explore concepts related to systems-based practice, and practice-based learning and improvement. Critical analyses of the evidence will be juxtaposed with practical, clinical applications described by practitioners through clinical cases. Students will identify legal concerns and consider broader policies in preparation for a socially responsible approach to medicine. Students will begin to develop collaborative skills to work effectively with other healthcare professions, including nursing, social work, and the health sciences, to address barriers to effective care, to identify complimentary practice strategies, and to maximize outcomes through case-based problem solving.

During Medicine and Society II, students will explore their future role as members of an interprofessional healthcare team providing personalized and preventative medicine through the Balsam Program. The fundamental aspects of personalized assessment and preventive medicine will be presented while developing skills related to health education, health promotion, appropriate use of screening and diagnostic testing, and disease management. The course aims to give students the skills to work effectively in interprofessional teams and to assess the behavioral, psychosocial, cultural, occupational, and environmental considerations necessary to provide effective healthcare.

MDMS 800 Medicine and Society III (3 credit, 38 weeks)
Prerequisites: None.

During this course, which occurs throughout Period 3, students continue to participate in home health visits as part of an inter-professional team within the Balsam program. They continue to explore the fundamental aspects of personalized assessment and preventive medicine while developing skills related to health education, health promotion, appropriate use of screening and diagnostic testing, and disease management.

MDMS 900 Medicine and Society IV with Capstone: (3 credits, 38 weeks)
Prerequisites: None.

During this course, which occurs throughout Period 4, students will continue to participate in home health visits as part of an inter-professional team within the Balsam program. They continue to explore the fundamental aspects of personalized assessment and preventive medicine while developing skills related to health education, health promotion, appropriate use of screening and diagnostic testing, and disease management. They complete a capstone project, a reflective essay on their medical school education and an analysis of the impact the Balsam program has had on their household and its members.

MDPS 600 Transitions I (2 credits, 30 hours, 4 weeks)
Prerequisites: None.

Transitions I is designed to help entering medical students understand the many personal, educational and professional challenges they will experience over the next four years of undergraduate medical training. Students are exposed to the various educational pedagogies used in the MD program, including team-based learning (problem-based learning, case-based learning), a flipped classroom, and simulation training. Students are also introduced to concepts of assessment and evaluation, including formative and summative evaluation, self- and peer- assessment, and objective structured clinical evaluation (OSCE). Students are introduced to clinical skills learning involving standardized patients and will undergo training to acquire Basic Life Support (BLS) certification. Students will work individually with a learning specialist to identify their preferred learning styles, any potential weaknesses, and strategies to address such weakness. Time management, resource management, test-taking strategies, and personal health and wellness are also explored to maximize student success in the MD program.

MDPS 601 Physicianship I (3 credits, 26 weeks)
Prerequisites: None.

Physicianship I is a course within the longitudinal strand of Physicianship designed to introduce and guide student discernment of awareness of certain values, emotions and attitudes, behaviors and self-reflection. This course applies the philosophy and general understanding of preparing the future physician for the many diverse psychological experiences associated with the clinical setting and professional life. Specifically, to have an understanding and awareness of one's behavioral and personal issues, the emotional stress found in practicing medicine, and how these can impact patient care and health outcomes. Students will also acquire a foundation in bioethics and the ethics of medical practice. It begins preparing them to make daily ethical decisions and respond to the ethical issues, challenges, and dilemmas they will encounter as students and physicians. The course provides historical background on the social and moral foundations of modern medicine. Students will review the history of medicine, including the major medical oaths and codes; analyze the ethical basis of decision-making; and work through case studies that exemplify ethics in practice. They discuss the social and cultural factors in patient-doctor interaction. Lastly, students will explore the steps of the informed-decision making process, necessary for career exploration and the selection and pursuit of their chosen specialty.

MDPS 700 Physicianship II (3 credits, 38 weeks)
Prerequisites: None.

This course is a continuation of the Period 1 Physicianship experience. Topics in Physicianship II focus on the acquisition of knowledge and skills in a number of areas common to the practice of medicine, including counseling patients and families, cultural competence, interprofessional collaboration, diversity and unconscious bias, reproductive health and sexually transmitted diseases, physical injury and violence, and careers in medicine.

MDPS 800 Physicianship III (3 credits, 48 weeks)
Prerequisites: None.
Course under development.

MDPS 900 Physicianship IV (3 credits, 38 weeks)
Prerequisites: None.
Course under development.

MDRT 600 Research, Technology, and Innovation I (3 credits, 45 hours, 26 weeks)
Prerequisites: None.

This course develops competencies required to conduct research. Part I focuses on the foundations of research, including the scientific method, quantitative and qualitative research,

evidence-based medicine, and human subjects research. Part II couples initial clinical experiences with research literature to formulate research questions focused on healthcare quality improvement. Students appraise evidence as a basis for addressing a healthcare/clinical query and develop strategies for implementing evidence-based changes. Students evaluate the effects of evidence-based changes in practice within the healthcare system. Students complete CITI training and review an IRB application. The student identifies a research mentor to develop a research or design project.

MDRT 700, MDRT 800, MDRT 900 Research, Technology, and Innovation II, II, and IV (3 credits each, 38-48 weeks per year)
Prerequisites: None.

The student will be a full participant and a crucial element in the generation of a research idea, the development of the project proposal, data collection tools, data collection activities, analysis, and interpretation. Students will work under the supervision of a research mentor. Creation of a publishable paper or presentation by the end of Period 4 is required for graduation.

NUCLEAR ENGINEERING (NUCE)

NUCE 301 Radiation Science and Health Physics (3-0-3)
Prerequisites: PHYS 102 General Physics II or equivalent; MATH 206 Differential Equations and Applications or equivalent. Co-Requisites:

NUCE302 Applied Mathematics for Nuclear Engineering (only required if it is to replace the prerequisite of MATH 206).
This course provides students with a thorough understanding of nuclear and radiation science, including radiation shielding, as a foundation to understanding the theoretical and practical aspects of radiological protection and a working knowledge of radiation protection legislation. Topics include Introduction to Atomic and nuclear; Nuclear physics; Radioactivity; Nuclear reactions; Interaction of radiation with matter; Radiation detection; Introduction to radiological protection; radiation dose, legislation; External dosimetry; Radiation monitoring; Personal dosimetry; Accident response.

NUCE 302 Applied Mathematics for Nuclear Engineering (3-0-3)
Prerequisites: MATH 106 Calculus II or equivalent; MATH 204 Linear Algebra or equivalent.

This course recaps some of the undergraduate mathematics materials relevant to the advanced graduate courses. Furthermore, basic introductory material for the numerical analysis will be also provided to the students. Topics include Differentiation and Integration; Ordinary Differential Equation; Vector Calculus; Partial Differential Equation; Introduction to Numerical Analysis; Probability; Statistics.

NUCE 303 Engineering Principles for Nuclear Engineering (3-0-3)
Prerequisites: PHYS 101 General Physics or equivalent; MATH 201 Calculus III or equivalent. Co-Requisites: NUCE 302 Applied Mathematics for Nuclear Engineering (only required if it is to replace the prerequisite of MATH 201).

The course provides students with a thorough understanding of principles of various engineering concepts. Topics include Review of Classical Mechanics; Review of Solid Mechanics; Materials Fundamental; Deformation and mechanical properties; Review on Thermodynamics; Fluid Properties and Thermodynamic Devices; Three Modes of heat transfer; Introduction to turbulent flow.

NUCE 401 Introduction to Nuclear Reactor Physics (3-0-3)
Prerequisites: MECH 341 Heat Transfer or equivalent Co-Requisites: NUCE 301 Radiation Science and Health Physics or equivalent;

NUCE 303 Engineering Principles for Nuclear Engineering (only required if it is to replace the prerequisite of MECH 341).

The course provides the students with the basic understanding of nuclear reactor physics and the fundamental principles and practical applications related to the utilization of nuclear energy from fission. Topics include Introduction to Nuclear Reactors, Power Plant System and Components; Neutron Interactions; Fission Reaction; Nuclear Reactors; Neutron Diffusion; Reactor Theory; Kinetics; Multimedia Exercises.

NUCE 601 Thermal Hydraulics in Nuclear Systems (3-0-3)
Prerequisites: NUCE 401, NUCE 303 (or equivalent).

This course provides the basic principles of nuclear system thermal hydraulics, and cover from advanced single-phase fluid mechanics and heat transfer relevant to nuclear system to basic two-phase flow principles and modeling. Topics include thermal hydraulic characteristics of power reactors, thermal design principles and reactor heat generation, thermodynamics of nuclear energy conversion, thermal analysis of fuel elements, review of single-phase flow, transport equations for two-phase flow, two-phase flow dynamics, two-phase heat transfer, and single channel analysis.

NUCE 602 Nuclear Materials, Structural Integrity and Chemistry (3-0-3)
Prerequisites: NUCE 303 (or equivalent).

This course provides an understanding of the materials behaviors in nuclear power plant environments including identification of the key aging mechanisms of alloys and components in relation to the operating environments; How to assess the integrity of key components using fracture mechanics; An understanding of the role of water chemistry in managing the materials aging on light water reactors. Topics include failure of materials and structures, micro-structural aspects of failure, corrosion, environmentally assisted cracking, low allow steels, stainless steels, nickel alloys, non-destructive evaluation, fracture mechanics, flaw analysis, PWR primary water chemistry and secondary system chemistry.

NUCE 603 Nuclear Reactor Theory (3-0-3)
Prerequisite: NUCE 301, NUCE 401 or equivalent.

To provide students with a principled understanding of the reactor physics theory and practice involved in the design of nuclear reactors and applications in related areas. Topics include neutron transport, numerical solutions of the diffusion equation, multi-group diffusion theory, the treatment of resonance, reactor kinetics including numerical exercises, elements of the Monte Carlo method in reactor analysis, and modeling exercise using various reactor codes.

NUCE 606 Radiation Measurement and Applications (3-0-3)
Prerequisite: NUCE 301, NUCE 401 or equivalent.

This course provides a theoretical and hands-on understanding of radiation detection and measurements and its applications in measurements and analysis. Topics include a review of radiation interactions and the physical principles of detection and measurements, radiation detection electronics, uncertainty and error analysis in measurements, gas filled detectors, scintillation detectors, semiconductor detectors, spectroscopy analysis, background sources of radiation, neutron detectors, applications in radiation detection, security and safeguards.

NUCE 607 Principles of Radiological Protection (3-0-3)

Prerequisite: NUCE 301 or equivalent.
This course aims to provide students with an overview of radiation quantities and units, an understanding of biological effects due to the exposure to ionizing radiation, an overview of the organization and components of the International Commission on Radiological Protection System for Radiological Protection, an introduction to dose assessments, both for external and internal exposures, and an introduction to the methodologies to control radiation exposure.

NUCE 608 Radiological Protection in Planned Exposure Situations (3-0-3)
Prerequisite: NUCE 301 or equivalent.

This course aims to provide students with an overview of international Radiation Protection Institutions and their roles, an overview of the current ICRP System for Radiological Protection and a detailed understanding of modern Radiation Protection issues in various fields.

NUCE 609 Radiological Protection in Existing and Emergency Exposure Situations (3-0-3)
Prerequisite: NUCE 301 or equivalent.

This course aims to provide students with an overview of the current ICRP System for Radiological Protection, a detailed understanding of modern Radiation Protection issues in existing exposure situations, a detailed understanding of modern Radiation Protection issues in emergency exposure situations, and an overview of the current approach towards radiological protection of the environment.

NUCE 611 Nuclear Systems Design and Analysis (3-0-3)
Prerequisite: NUCE 601 (or equivalent).

This course provides the fundamentals of nuclear systems design, including design aspects of critical individual components as well as the balance of plant and to provide the basis for analysis on thermodynamic principles. Topics include a review of engineering design principles, the thermal hydraulic design and analysis of reactor cores, the steam generators, the pressurizer, the coolant pumps, the turbine and finally, the design and analysis of the balance of plant.

NUCE 612 Nuclear Safety and Probabilistic Safety Assessment (3-0-3)
Prerequisite: NUCE 601, NUCE 602 (or equivalent).
This course deals with safety principles, various accident phenomena including design basis and severe accidents, preventive and mitigative safety system design, deterministic and probabilistic analyses of those accidents, and safety management for LWRs (Light Water Reactors).

NUCE 613 Nuclear Fuel Cycle and Safeguards (3-0-3)
Prerequisite: NUCE 603, NUCE 606 (or equivalent).

The aim of this course is to provide students with fundamental knowledge of nuclear fuel cycles and nuclear material safeguards, to cover the entire range of processes from ore in the ground to recycled products and wastes. The full range of nuclear material accounting and monitoring measures for all stages of nuclear fuel cycle will be covered. Topics include an overview of the nuclear fuel cycle, nuclear fuel resources, stages of nuclear fuel cycle from mining to waste disposal, economics of the nuclear fuel cycle, the principles and logistics of safeguards, nuclear materials accountancy, accountancy and verification measurements, integrated safeguards (protocols, cyber security etc.), and statistical accountancy.

NUCE 614 Nuclear Nonproliferation and Security (3-0-3)
Prerequisite: NUCE 603, NUCE 606 (or equivalent). Co-Requisite: NUCE 613.

This course provides the key elements of nuclear nonproliferation and security, including describing the historical aspects, treaties and agreements, main principles of nuclear security and physical protection. Topics include an overview of the subject area, the historical perspectives, international treaties and agreements, means of detection of undeclared activities, and approaches and systems for physical protection of nuclear materials.

NUCE 615 Radiation Dosimetry (3-0-3)
Prerequisite: NUCE 301 or equivalent, NUCE 606.
This course aims to provide students with an overview of the problems in dosimetry of ionizing radiation, a detailed understanding of the physics and technology underlying external exposure determinations, a detailed understanding of the physics and technology underlying internal exposure determinations, and a detailed understanding of dose assessments.

NUCE 616 Occupational Radiological Protections (3-0-3)
Prerequisite: NUCE 301 or equivalent, NUCE 606, NUCE 607.

This course aims to provide students with an overview of the general issues in occupational Radiation Protection, a detailed understanding of operational external exposure determinations and controls, a detailed understanding of contamination assessments on surfaces, in the air, and in liquid and solid volumes, including food, and an overview of personal protective equipment against radiation exposure risks.

NUCE 621 Nuclear Instrumentation and Control (3-0-3)
Prerequisite: NUCE 603, NUCE 606 (or equivalent).

This course provides students with introduction to nuclear instrumentation and control (I&C) system, basic and advanced knowledge on static and dynamic characteristic of I&C, fundamentals of signal processing and sensors, control theories including lead lag compensators and PID controller, human-machine interface (HMI) design and evaluation, fundamentals and underlying concepts of nuclear I&C system, and finally nuclear power plant (NPP) instrumentation, control, and protection systems.

NUCE 622 Thermal Hydraulics Computations and Modelling (3-0-3)
Prerequisites: NUCE 601 (or equivalent).
This course provides sufficient background on flow regimes and heat transfer for single and multi-phase flows, the modeling approaches used, empirical treatments for two-phase flows and sources of errors in numerical predictions. The computer laboratories allow for the student to apply the theory part and to gain hands on how to produce meaningful results with existing commercial codes by following the correct steps in Pre-processing, computation, Post-processing and results analysis.

NUCE623 Radiological Environmental Impact Assessment (3-0-3)
Prerequisite: NUCE 606 (or equivalent).

To provide students with an overview of the regulatory requirements applicable to radioactive discharges and associated Radiological Environmental Impact Assessment (REIA), an understanding of the physical and chemical processes which determine the behavior of radionuclides released into the environment and experience in the application of state-of-the art methodologies for REIA.

NUCE 624 Radiation Damage and Nuclear Fuels (3-0-3)
Prerequisites: NUCE 602 (or equivalent).

This course provides the knowledge on the characteristics of various type of fuels and their required properties, an understand the fundamentals of radiation damage and their effects on the changes of the materials properties through the interaction of various defects generated by irradiation, identification of the key damage mechanisms of oxide nuclear fuels and zircalloy cladding in water reactor environments and knowhow to assess the integrity of nuclear fuel affected by the various damage mechanisms. Topics include overview on types of nuclear fuel, basics of radiation damage, ion interactions with solids, displacement cascades, point defect characteristics, multi-dimensional defects in solids, interaction of defects, dimensional changes, property changes due to irradiation, radiation damage in fuels and fuel cladding integrity.

NUCE 625 Advanced Core Physics for Light Water Reactors (3-0-3)
Prerequisites: NUCE 603 (or equivalent).
This course is focused on learning advanced computational methods for analyzing light water reactors. The course presents detailed description of the computations performed on both the fuel assembly- and full core-level of a nuclear reactor. Nuclear cross section libraries, resonance treatment of cross sections, assembly homogenization techniques, cross section functionalization approaches, and pin-power reconstruction techniques are discussed. On the core level, this course presents advanced nodal methods for the numerical solution of the neutron diffusion equation. Modern nodal methods, based on transverse integration procedure including Nodal Expansion Method (NEM) and Analytical Nodal Methods (ANM), are discussed. This course combines theory and practice by studying the application of state-of-the-art, engineering-grade codes to the neutronic design, analysis, and modeling of nuclear fuel assembly and core. The computational paradigm is based on the traditional divide-and-conquer approach where fuel assembly characteristics are obtained using 2-D transport codes; then, a 2-group diffusion code is used to model the 3-D nuclear reactor core. The students will be instructed in the use of a 2-D lattice physics transport code for assembly design and analysis and a 3-D full-core diffusion code for power distribution.

NUCE 630 Biological Effects of the Exposure to Ionizing Radiation (3-0-3)
Prerequisite: NUCE 606, NUCE 607.
This course aims to provide students with an overview of the interaction of radiation with biological matter, a detailed understanding of the mechanisms generating biological harm at high and low doses, a detailed understanding of the consequences of radiation exposure, and an overview of ongoing research in the field of low doses and non-targeted radiation effects.

NUCE 694 Selected Topics in Nuclear Engineering (3-0-3)
Prerequisite: Will be specified according to the particular topics offered under this course number.

This course covers selected contemporary topics in nuclear engineering. The topics will vary from semester to semester depending on faculty availability and student interests. Proposed course descriptions are considered by the Department of Nuclear Engineering on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the College of Engineering Graduate Studies Committee. The course may be repeated once with change of contents to earn a maximum of 6 credit hours.

NUCE 699 Master's Thesis (minimum 12)
Co-requisite: ENGR 695 Seminar in Research Methods, approval of the Department Chair and the Associate Dean for Graduate Studies.

In the Master's Thesis, the student is required to independently conduct original research-oriented work related to important chemical engineering problems under the direct supervision of a main advisor, who must be a full-time faculty in the Nuclear Engineering Department, and at least one other full-time faculty who acts as co-advisor. The outcome of the research should demonstrate the synthesis of information into knowledge in a form that may be used by others and lead to publications in suitable journals/conferences. The student's research findings must be documented in a formal thesis and defended through a viva voce examination. The student must register for a minimum of 12 credit hours of Master's Thesis.

NUCE 701 Advanced Computational Methods of Particle Transport (3-0-3)
Prerequisite: Students should have a sound understanding of nuclear reactors physics theory including diffusion and transport theory, Monte Carlo methods, kinetics, resonance treatment, including the main analytical and numerical methods of solution. Students should also have some ability in developing computational models for reactor core analysis. (e.g., NUCE603 Nuclear Reactor Theory, or equivalent).

This course provides the students with thorough understanding of the principal numerical methods used to solve the Boltzmann transport equation for neutral particles. It will also describe and use mathematical tools to evaluate the performance of different discretization schemes.

NUCE 702 Nuclear Systems and Materials/ Accident Analysis (3-0-3)
Prerequisite: Graduate level courses on thermal hydraulics in nuclear systems and nuclear materials, structural integrity and chemistry (or equivalent).

This course consists of Part I (Reactor Coolant System and its Materials) and Part II (Engineered Safety Features and Accident Analysis). Part I provides an understanding of design bases and degradation of nuclear fuel and reactor coolant system (RCS) components. These components are exposed to the primary coolant and neutron irradiation environments, which cause various material degradation. Considering the material degradation and performance the integrity of the RCS system is discussed. Part II provides an understanding of design basis accident and beyond design basis accident in terms of safety features in nuclear power plant. The students will learn safety system implemented in nuclear power plant and how these systems mitigate the accident by various accident scenario in safety report.

NUCE 703 Aging Management of Nuclear Materials (3-0-3)
Prerequisite: Graduate level course on nuclear materials, structural integrity and chemistry (or equivalent).

This course provides an understanding of material aging and degradation in nuclear power plant environments: General and localized corrosion of metallic and concrete structures; Stress corrosion cracking (SCC) of the primary and secondary components; Irradiation assisted stress corrosion cracking (IASCC) of reactor vessel internals; Radiation embrittlement of reactor vessel. The proposed degradation mechanisms and mechanical, material, and environmental factors controlling the aging and degradation will be presented. Considering the previous operation experience in other nuclear power plants, the aging management of APR 1400 nuclear plants over the design life is discussed.

NUCE 704 The Reactor Core Design Analysis for Light Water Reactors (3-0-3)
Prerequisite: Graduate level courses on thermal hydraulics in nuclear systems and nuclear reactor theory (or equivalent).

This course is aimed to provide the students with an in-depth description of the fuel system design, nuclear design and the thermal-hydraulic design concepts for the pressurized water reactors. In particular, the design features of the APR1400 are discussed in this course. Furthermore, the computational tools used for such a design analysis with the associated capabilities and limitations are described.

NUCE 705 Nuclear Criticality Safety Assessment (3-0-3)
Prerequisite: Graduate level course on nuclear reactor theory and radiation measurement and applications (or equivalent).

To provide students with an in depth understanding of nuclear criticality safety outside of the confines of the nuclear reactor, to provide them with a full range of analytical techniques for assessment of safe critical limits and to give them a thorough understanding of the guides, principles and standards governing nuclear criticality safety.

NUCE 794 Selected Topics in Nuclear Engineering (3-0-3)
Prerequisite: Will be specified according to the particular topics offered under this course number.

This course covers selected contemporary topics in Nuclear Engineering. The topics will vary from semester to semester depending on faculty availability and student interests. Proposed course descriptions are considered by the Department of Nuclear Engineering on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the Graduate Studies Committee. The Course may be repeated once with change of contents to earn a maximum of 6 credit hours.

PETROLEUM ENGINEERING (PEEG)

PEEG 610 Advanced Well Test Analysis (3-0-3)
Prerequisite: Fundamental knowledge of mathematics and undergraduate well testing.

This course will review the fundamentals of fluid flow through porous media, followed by flow and build up test analysis for slightly/fully compressible fluids. The course will cover well test design, methods and test data interpretation in hydraulically fractured wells, naturally fractured reservoirs, injection wells and horizontal wells. The effect of reservoir heterogeneities and wellbore conditions on pressure behaviour is studied and considered in well test interpretations.

PEEG 620 Advanced Drilling Engineering (3-0-3)
Prerequisite: Undergraduate level courses in drilling engineering.

This course will cover the advanced principles of drilling oil and gas wells. Theories, operational procedures, associated drilling problems, and new developments in drilling will be covered. The course outline is listed below. It is tailored to help the students effectively take part in day-to-day drilling activities on the rig and to do better drilling engineering work in the office after graduation.

PEEG 621 Underbalanced Drilling (3-0-3)
Prerequisite: PEEG 620 Advanced Drilling Engineering.

This course will cover the fundamentals and latest principles of underbalanced drilling technology. The course outline is listed below. It is tailored to help the graduate students

effectively perform detailed engineering work in the office as well as in the field operations after graduation.

PEEG 623 Well Stimulation (3-0-3)
Prerequisite: Fundamental knowledge of undergraduate stimulation methods.

The course covers in-situ stresses, effects of stress gradient, theory of hydraulic fracturing, mathematical models of fracture geometry, design and execution of hydraulic fracture treatment with proppant in vertical and horizontal wells, post-fracture productivity analysis, causes of formation damage, theory of matrix acidizing, treatment design of matrix acidizing (sandstone and carbonates), and models of acid fracturing in carbonates and its treatment design.

PEEG 630 Advanced Reservoir Engineering (3-0-3)
Prerequisite: Fundamental knowledge of undergraduate reservoir engineering (PEEG 331 Reservoir Engineering I and PEEG 334 Reservoir Engineering II or equivalents).

The course touches the basics of reservoir engineering; however, the main objective remains discussing the latest advances in reservoir dynamics, suitable flow modeling techniques, complex issues of reservoir/aquifer interactions and description of different types of oil & gas reservoirs. Students will be exposed to review current practices and understand their applications, shortcomings and limitations. Characterization and modelling of unconventional reservoirs will be deliberated in brief.

PEEG 631 Petroleum Reservoir Simulation (3-0-3)
Prerequisite: Fundamental knowledge of undergraduate reservoir engineering.

This is a first formal course in reservoir simulation. Rudiments of the numerical treatment of fluid flow in porous media are covered. Specific topics covered include conservation of mass, Darcy's Law, permeability tensor, gridding and grid orientation effects, mathematical formulation of flow and transport equations, Finite Difference solution schemes, numerical dispersion, multiphase flow, relative permeability, and capillary pressure.

PEEG 632 Enhanced Oil Recovery (3-0-3)
Prerequisite: PEEG 630 Advanced Reservoir Engineering.

This course will cover theory and applications of various EOR processes and a few IOR techniques. A tentative list of topics to be covered follows. Field application aspects will be highlighted through classroom exercises and assignments. Therefore, the course will incorporate a significant student-centered learning component.

PEEG 640 Well Performance Evaluation (3-0-3)
Prerequisite: Fundamental knowledge of production engineering.

The course provides detailed coverage of inflow performance relationships, multiphase flow in pipes and well performance evaluation. The emphasis is on the analysis, design and optimization of the production system using nodal analysis. Commercial software packages will be used to apply learned methods to flowing and artificially lifted wells, injection wells and field-scale production optimization.

PEEG 641 Well Completion and Workover (3-0-3)
Prerequisite: Fundamental knowledge of drilling, in addition to basic knowledge of reservoir engineering and production and surface facilities.

The course provides a comprehensive coverage of the various types of well completions and

their applications and selection criteria: Design and selection of tubing and subsurface production control equipment - Review of the types and applications of completion and workover fluids - Detailed study of perforating and sand control operations - Remedial cementing and stimulation operations - Design and planning of basic workover operations. Remaining challenges in both conventional and non-conventional environments are deliberated as well. Several case studies are reviewed and learned lessons are discussed in the class.

PEEG 650 Advanced Petroleum Economics (3-0-3)
Prerequisite: Fundamental knowledge of principles of economics.

The first segment of the course is dedicated to review principles of petroleum related economics tools. Later, an overview on how the petroleum industry functions as an economic entity within the business community will be deliberated. Special emphasis will be placed on maintaining a positive cash flow while keeping risks under control. Decision analysis in an environment of uncertainty and risk will be comprehensively discussed. Practical case studies and learned lessons from the petroleum industry will be used as a guideline to understand critical concepts. Students will be exposed to current economic challenges facing modern petroleum industry, and expected to contribute in analysing problems and solution options – some of their own!

PEEG 694 Selected Topics in Petroleum Engineering (3-0-3)
Prerequisite: Will be specified according to the particular topics offered under this course number.

This course covers selected contemporary topics in chemical engineering. The topics will vary from semester to semester depending on faculty availability and student interests. Proposed course descriptions are considered by the Department of Petroleum Engineering on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the College of Engineering Graduate Studies Committee. The course may be repeated once with change of contents to earn a maximum of 6 credit hours.

PEEG 699 Master's Thesis (minimum 12)
Co-requisite: ENGR 695 Seminar in Research Methods, and approval of the Department Chair and the Associate Dean for Graduate Studies. In the Master's Thesis, the student is required to independently conduct original research-oriented work related to important petroleum engineering problems under the direct supervision of a main advisor, who must be a full-time faculty in the Petroleum Engineering Department, and at least one other full-time faculty who acts as co-advisor. The outcome of the research should demonstrate the synthesis of information into knowledge in a form that may be used by others and lead to publications in suitable reputable journals/conferences. The student's research findings must be documented in a formal thesis and defended through a viva voce examination. The student must register for a minimum of 12 credit hours of Master's Thesis.

PEEG 723 Stimulation of Conventional and Unconventional Reservoirs (3-0-3)
Prerequisite: Graduate level course on advanced reservoir engineering (or equivalent).

The course covers in-situ stress analysis, theory of hydraulic fracturing and its treatment design, multi-stage horizontal fracturing and execution and evaluation of hydraulic fracture treatment. Hydraulic fracturing content includes unconventional and mature assets. The course also covers formation damage due to mechanical skin, inorganic scales, and its diagnosis and treatment design and removal by

optimized acidizing technique. This also includes design of advanced stimulation techniques using hybrid EOR/IOR methods from Lab scale to Piloting.

PEEG 730 Fluid Flow and Transport Through Porous Media (3-0-3)
Prerequisite: Graduate level course on advanced reservoir engineering (or equivalent).

This is a graduate engineering course Ph.D. level in fluid flow and transport processes in porous media. The course covers both theory and practice of Fundamentals Fluid Flow and Transport Processes in Porous Media and students should be able to see the linkage and relevance of their understanding of reservoir engineering and evaluation in field applications. We study mass, momentum and energy transport in single- and multiphase flow in porous media. Emphasis is placed on use of classical methods for describing these processes on a fluid-fluid and fluid-rock basis. Surface and interfacial phenomena are also presented. Application of theory to various problems in petroleum engineering and groundwater hydrology are emphasized.

PEEG 732 Hybrid Enhanced Oil Recovery (3-0-3)
Prerequisite: Graduate level courses on enhanced oil recovery and advanced reservoir engineering (or equivalent).

This is a graduate engineering course Ph.D. level in theory and applications of various emerging and hybrid Enhanced Oil Recovery (EOR) processes and a few IOR techniques that have been suggested in coupled or modified format. A tentative list of topics to be covered follows. Field application aspects will be highlighted through classroom exercises and assignments. This course will therefore, incorporate a significant student-centered learning component. Further details on topical review report and classroom exercises will be provided.

PEEG 733 Miscible Gas Flooding (3-0-3)
Prerequisite: Graduate level courses on enhanced oil recovery and advanced reservoir engineering (or equivalent).

This is a graduate engineering course Ph.D. level in theory and applications of Miscible Gas Flooding processes. A tentative list of topics to be covered follows. Field application aspects will be highlighted through classroom exercises and assignments. This course will therefore, incorporate a significant student-centered learning component. Further details on topical review report and classroom exercises will be provided.

PEEG 746 Emerging Well Construction Technology (3-0-3)
Prerequisite: Graduate level course on advanced drilling engineering (or equivalent).

This course is a very extensive course designed to provide knowledge in the application of drilling to effective, efficient and economical drilling practices as well as solutions to drilling problems encountered during drilling operations of deviated, horizontal and multilateral wells.

PEEG 747 Horizontal and Multilateral Drilling and Completion (3-0-3)
Prerequisite: Graduate level course on advanced drilling engineering (or equivalent).

This course is a very extensive course designed to equip the students with theoretical and practical knowledge about horizontal and multilateral wells completion and stimulation at its current level of understanding. Commonly asked questions about horizontal and multilaterals technology, other applications, and limitations are covered.

PEEG 749 Characterization and Modeling of Unconventional Reservoirs (3-0-3)
Prerequisite: Graduate level course on advanced reservoir engineering (or equivalent).

Characterization and Modeling of Unconventional Reservoirs: Geological background and factors contributing to the formation of UCRs (Unconventional Reservoirs). Petrophysical properties comparison between CRs (Conventional Reservoirs) and UCRs. Phase behavior envelop of UCR. In-place, reserves and RF evaluation of UCR. Fluid flow in UCR media. Static & dynamic modeling of UCR. Production challenges & hydraulic fracturing. FD (Field Development) of UCR. Economical evaluation, uncertainties and risk involved with play assessment and FD of UCR.

PEEG 752 Simulation of Naturally Fractured Reservoirs (3-0-3)
Prerequisite: Graduate level course on advanced reservoir engineering (or equivalent).

This is a graduate engineering course Ph.D. level in Petroleum Engineering. The course covers advanced simulation aspects of naturally fractured reservoirs from single continuum to dual- and multi-continuum approaches. Specific topics include: discerption of fractures and fissured medium, classification of fractures and scales, fracture connectivity and networks, mathematical modelling of NFRs, dual porosity models, dual porosity/dual permeability models, FD numerical schemes, Mixed Finite Elements, DFN, multiscale approaches, pressure transient analysis of NFRs, and multiphase flow in NFRs.

PEEG 794 Selected Topics in Petroleum Engineering (3-0-3)
Prerequisite: Will be specified according to the particular topics offered under this course number.

This course covers selected contemporary topics in Petroleum Engineering. The topics will vary from semester to semester depending on faculty availability and student interests. Proposed course descriptions are considered by the Department of Petroleum Engineering on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the Graduate Studies Committee. The Course may be repeated once with change of contents to earn a maximum of 6 credit hours.

PETROLEUM GEOSCIENCES (PGEG)

PGEG 611 CARBONATE RESERVOIR PETROLOGY (3-3-4)
Prerequisite: Graduate standing or consent of instructor.

Carbonate Reservoir Petrology covers carbonate depositional textures, microfacies, diagenesis, permeability, and porosity. Students will learn how to unravel the complex geologic history of carbonate reservoirs from deposition through diagenesis to emplacement of hydrocarbons to develop 3D predictive reservoir models.

PGEG 612 SEQUENCE STRATIGRAPHY OF CARBONATE SYSTEMS (3-3-4)
Prerequisite: Graduate standing; concurrent enrolment in PGEG 511, or consent of instructor.

This course instructs in the sedimentological, petrographic, and stratigraphic methods used to analyze and interpret carbonate sediment and sedimentary sequences. Students will learn to interpret physical processes and depositional environments from sedimentary structures, facies, and textures and to apply sequence stratigraphic methods to interpret and model facies and sedimentary basin evolution. The course incorporates modern and ancient examples from the Middle East, particularly from the UAE.

PGEG 613 ADVANCED RESERVOIR CHARACTERIZATION (3-3-4)
Prerequisite: Graduate standing; PGEG 512 or consent of instructor.

Students integrate well log, core, thin section, seismic reflection, and other datasets to characterize and develop geologically realistic, predictive computer model of a carbonate reservoir. Focus is given to depositional geometries, diagenetic processes, and reservoir compartmentalization.

PGEG 623 REMOTE SENSING FOR EARTH SCIENCES APPLICATIONS AND GIS (2-1-3)
Prerequisite: Graduate standing and consent of course coordinators.

After completing the course, students should understand the physical principles of remote sensing, grasp the basic skills of image visualization, processing, interpretation and data manipulation for mapping and be familiar with the major earth observation remote sensing satellites and datasets. The students will learn the basic skills of image visualization, processing, interpretation and data manipulation for mapping. The course emphasizes the use of satellite images as an essential information source for fieldwork.

PGEG 689 SPECIAL TOPICS IN PETROLEUM GEOSCIENCES (1:4-0-1:4)
Prerequisite: Graduate standing and program permission.

The content of this course will include special areas of importance and of interest to Petroleum Geosciences as selected by the faculty and which are not covered in regular courses listed in the curriculum.

PGEG 695 GRADUATE SEMINAR I (1-0-1)
Prerequisite: Graduate standing.

In this course students attend seminars given by faculty, visiting scholars and fellow graduate students.

PGEG 696 GRADUATE SEMINAR II (1-0-1)
Prerequisite: Graduate standing.

In this course students attend seminars given by faculty, visiting scholars and fellow graduate students, and present at least one seminar on an appropriate research topic.

PGEG 699 MASTER OF SCIENCE THESIS (1 to 12 credit hours)
Prerequisite: Graduate standing.
Thesis research leading to an MSc thesis.

PGEG 700 RESEARCH METHODS (3-0-3)
Prerequisite: Enrollment in the PhD PGEG program.

This course is designed for graduate students pursuing a PhD. The purpose of the course is to introduce students to the techniques used by successful researchers in the conception, evaluation, organization, design, execution and communication of technical research projects.

PGEG 701 PETROLEUM SYSTEMS (3-0-3)
Prerequisite: Enrollment in the PhD PGEG program, or consent of instructor.

The course provides a comprehensive overview of the entire petroleum system from hydrocarbon play concepts, preservation of organic matter, source rocks, maturation of source rocks, migration of petroleum, accumulation, and alteration to reservoirs, traps and seals and their temporal occurrences in sedimentary basins. Techniques for seismic facies analysis, sequence stratigraphy, correlation techniques, basin modeling, source rock evaluation and assessing organic maturation are reviewed. Special attention will be given to source rock evaluation related to unconventional play assessment. Students will work in teams to complete a technical assessment of the prospectivity within a basin by defining the petroleum system and identifying the plays, prospects and leads.

PGEG 702 LABORATORY TECHNIQUES IN SEDIMENTOLOGY AND GEOCHEMISTRY (3-0-3)
Prerequisite: Enrollment in the PhD PGEG program, or consent of instructor.

This course provides students with an overview of the available analytical facilities within the Petroleum Institute Research Center. The course will instill appropriate methodologies for best practices in accurate data collection, analysis and interpretation whilst employing appropriate health, safety and environment practices related to working in analytical laboratories. This is a required course for all PhD students working in areas related to, but not limited to, geochemistry, sedimentology, petrography and structural geology.

PGEG 703 LABORATORY AND FIELD TECHNIQUES IN GEOPHYSICS (2-3-3)
Prerequisite: Enrollment in the PhD PGEG program, or consent of instructor.

This course will familiarize students with the logistics and equipment used in geophysical surveys. It will also provide an overview of the instrumentation and software available at the Petroleum Institute for research in geophysics and rock physics. The course will introduce and discuss methodologies for best practices in geophysical data collection and analysis. This is a required course for all PhD students working in areas related to, but not limited to, geophysics.

PGEG 711 CARBONATE PETROLOGY AND STRATIGRAPHY (3-0-3)
Prerequisite: Enrollment in the PhD PGEG program, or consent of instructor.

This course provides graduate students with an advanced knowledge of carbonate petrology and stratigraphy. The course will investigate carbonate sediments at all scales from microscopic studies at the pore-scale to reservoir-scale sequence stratigraphic frameworks. The course will utilise a wide range of examples from throughout the stratigraphic record with a particular emphasis on carbonate systems of the Middle East. This is an elective course recommended for all PhD students working in areas related to, but not limited to, sedimentology, petrography, geochemistry and structural geology. The course will include 3 days of fieldwork.

PGEG 712 FIELD GEOLOGY OF PETROLEUM SYSTEMS (24 days of fieldwork, 4 credit hours)
Prerequisite: Enrollment in the PhD PGEG program, or consent of instructor.

Field Geology of Petroleum Systems focuses on the application and integration of sedimentary, stratigraphic and structural principles to undertake field-based descriptions and interpretations of lithologies and structures, and integrate the results with regional studies. Students record stratigraphic and lateral variations in sedimentary facies geometries in order to facilitate temporally-constrained palaeogeographic reconstructions of depositional facies architecture. Large- and small-scale structural features are considered, in order to understand petroleum systems in three dimensions. The course includes 24 days of field-based datacollection followed by a period of literature reviewing, data integration and report writing based at the Petroleum Institute.

PGEG 713 ROCK PHYSICS (3-0-3)
Prerequisite: Enrollment in the PhD PGEG program, or consent of instructor.

This course covers the major rock physics methods used in geological and geophysical data interpretation. Students gain advanced knowledge on rock properties, and learn about physical processes in rocks related to geophysical exploration and hydrocarbon production. This includes the study of relations between rock properties, fluid type and distribution, and interaction with seismic and electromagnetic waves. Emphasis is on applications of rock physics in carbonate rocks.

PGEG 714 SEISMIC INTERPRETATION IN PETROLEUM EXPLORATION AND PRODUCTION (2-3-3)
Prerequisite: Enrollment in the PhD PGEG program, or consent of instructor.

The course provides hands-on experience of interpreting two-dimensional and three-dimensional seismic datasets from a variety of basin types using industry-standard computer workstation systems. The course aims to expose students to a wide range of structural and stratigraphic styles, encompassing those found in the UAE. Special emphasis is given to applications in hydrocarbon exploration.

PGEG 715 SEISMIC MODELING AND IMAGING (4-0-4)
Prerequisite: Enrollment in the PhD PGEG program, or consent of instructor.

The course will introduce numerical methods to simulate seismic wave propagation in the Earth, and imaging algorithms to reconstruct geological structures of carbonate reservoirs. The simulation methods include seismic ray tracing, finite-difference, finite-element and spectral methods, which are applicable for complex geometries and anisotropic, viscoelastic and poro-elastic rocks. The imaging algorithms will cover reverse-time migration, common geophysical inversion algorithms, seismic ray tomography, nonlinear diffraction tomography and full-waveform inversion.

PGEG 718 BIOGEOCHEMICAL CYCLES (3-0-3)
Prerequisite: Enrollment in the PhD PGEG program, or consent of instructor.

Biogeochemical cycles of carbon, sulfur, nitrogen, phosphorus, calcium, and strontium will be discussed, and changes of reservoirs and reactions over geologic time as well as interactions between cycles will be examined. The elements discussed are important for the evaluation of global change and its effects on the biosphere and lithosphere. Recent anthropogenic perturbations of individual biogeochemical cycles will be evaluated and compared with perturbations known from the geologic past. The evolution of biogeochemical cycles will be evaluated in the context of petroleum systems, focusing on the temporal and spatial distribution of source rocks and reservoirs.

PGEG 719 DEFORMATION AND STRUCTURES OF SEDIMENTARY ROCKS (3-0-3)
Prerequisite: Enrollment in the PhD PGEG program, or consent of instructor.

The course deals with the range of structures produced in sedimentary rock by deformation, and especially the role of fractures and faults in fluid flow. The rheological behavior of rocks associated with stress and strain, the effects of temperature, pressure, and strain rate on deformation will be discussed. Brittle deformation and failure in the upper crust, as well as the mechanisms of fracture and fault generation will be analyzed. The mechanics of sedimentary basins associated with extension, compression and strike-slip deformation will be illustrated with case-studies of basins worldwide.

PGEG 720 ORGANIC GEOCHEMISTRY (3-0-3)
Prerequisite: Enrollment in the PhD PGEG program, or consent of instructor.

The course will provide students with an understanding of analytical techniques and applications of organic geochemistry in modern and ancient environments, and the oil and gas industry. It covers theoretical concepts and analytical methods related to organic matter production, cycling in the biosphere and geosphere, preservation, migration and degradation.

PGEG 721 SEDIMENTARY BASIN ANALYSIS (3-3-4)
Prerequisite: Enrollment in the PhD PGEG program, or consent of instructor
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The course covers the essential processes of the formation and evolution of sedimentary basins, and their implications for the development of petroleum systems. Students will learn the dynamics of basin evolution in tectonically active settings, including convergent, divergent, and strike-slip plate margins and interiors. In addition, students will develop a solid understanding of the major structural, tectonic, and geophysical processes that produce sedimentary basins, and develop skills in basin analysis that allow them to interpret those processes from the stratigraphic record. Key basins to be investigated include the United Arab Emirates (UAE) rifted margin and overlying foreland basins.

PGEG 722 SHARED EARTH MODELS (3-0-3)
Prerequisite: Enrollment in the PhD PGEG program, or consent of instructor.

In this course the quantitative integration of different measurements from geophysics, geology and petrophysics will be introduced, and practical applications will be evaluated and tested with real field data. The results of the reservoir simulation obtained by the integrated Shared Earth Models will be discussed and compared with models obtained from less integrated workflows.

PGEG 723 ISOTOPE GEOCHEMISTRY OF SEDIMENTARY SYSTEMS (3-0-3)
Prerequisite: Enrollment in the PhD PGEG program, or consent of instructor.

Isotope geochemistry is applied to studies of Earth processes such as paleoclimatic, paleooceanographic, and diagenetic reconstructions of sedimentary systems. In this course, students will explore the fundamental techniques and applications of isotope geochemistry in understanding the modern and ancient Earth systems. The course will explore the application of isotope geochemistry in ocean and atmospheric circulation, petroleum and sedimentary geochemistry, paleoecology, and in understanding biogeochemical cycles and processes.

PGEG 793 SPECIAL TOPICS IN PETROLEUM GEOSCIENCES (1-3 credit hours)
Prerequisite: PhD Standing or Instructor's consent.

To introduce special areas of importance and of interest to petroleum geosciences as selected by the faculty and which are not covered in regular courses listed in the curriculum.

PGEG 795 GRADUATE SEMINAR I (1-0-1)
Prerequisite: Enrollment in the PhD PGEG program.

The PhD seminar course is a required, non-credit course for all PhD students. Seminars cover research topics in all disciplines to provide interdisciplinary knowledge to students. Typically, there are a total of approximately 12 seminars per year during fall and spring semesters. Every year, a faculty member is appointed as the coordinator of the seminar, who will schedule speakers from the faculty in Engineering and other disciplines for the entire semester/year.

PGEG 796 GRADUATE SEMINAR II (1-0-1)
Prerequisite: Enrollment in the PhD PGEG program.

The PhD seminar course is a required, non-credit course for all PhD students. Seminars cover research topics in all disciplines to provide interdisciplinary knowledge to students.

Typically, there are a total of approximately 12 seminars per year during fall and spring semesters. Every year, a faculty member is appointed as the coordinator of the seminar, who will schedule speakers from the faculty in Engineering and other disciplines for the entire semester/year.

PGEG 797 WRITTEN QUALIFYING EXAMINATION (0-0-0)
Prerequisite: Enrollment in the PhD PGEG program.

The PhD WQE, coordinated by the Departmental Graduate Committee (DGC) and the Department Chair, is intended to test the student's understanding of the chosen field of study as evidenced by his/her proficiency in a set of graduate courses (in three topical exam areas).

PGEG 798 ORAL QUALIFYING EXAMINATION (0-0-0)
Prerequisite: Enrollment in the PhD PGEG program.

The PhD Research Oral Qualifying Examination (OQE) is an oral exam that evaluates the student's ability to synthesize and integrate material as applied to her/his research focus area. It is expected that the student demonstrates a certain breadth of knowledge and is able to apply this knowledge to the research problem he/she is focusing on. The OQE consists of a presentation of the proposal followed by questions from the PhD Advisory Committee. The questions presented to the student at the OQE will address the research proposal and topics related to the general subject area of the proposal.

PGEG 799 PhD DISSERTATION RESEARCH (1 to 36 credit hours)
Prerequisite: PhD standing.

Research under the mentorship of a member of the Graduate Faculty leading to a PhD dissertation.

PRE-MEDICINE BRIDGE PROGRAM (PMED)

PMED 500 Pre-Medicine Bridge Research (4 credits)
Prerequisite: None

The course Pre-Medicine Bridge Research MCAT is will provide an opportunity for participants to establish or advance their understanding of research through a critical exploration of basic or applied research questions that are pertinent to the medical field. The course introduces the language of research, ethical principles and challenges, and the research process elements within a quantitative, qualitative, or mixed-methods approach. Participants will use these theoretical underpinnings to begin to critically review the literature relevant to their field of interests and determine how research findings are useful in enhancing the United Arab Emirates.

PMED 501 General and Organic Chemistry (3 credits)
Prerequisite: None

The MCAT is a 7.5-hour exam that consists of four sections: Biological and Biochemical Foundations of Living Systems; Chemical and Physical Foundations of Biological Systems; Psychological, Social, and Biological Foundations of Behavior; and Critical Analysis and Reasoning Skills. This course will cover topics in Organic Chemistry that are part of the Chemical and Physical Foundations of Biological Systems section of the MCAT. The Chemical and Physical Foundations of Biological Systems section has 59 questions. The AAMC requires students to complete this section in 95 minutes. This course caters to these requirements and use various in-class and out-of-class activities to prepare students for mastering this section. Please refer to the section titled Course Topics for a full listing of the teaching plan.

PMED 502 Biochemistry (3 credits)
Prerequisite: None

This course presents a comprehensive study of the facts and fundamental concepts of biochemistry. This approach supports a student's understandings of how biomolecules, cells, tissues, organs, and chemical reactions support living systems. Specifically, this course will analyze these elements through the study of enzymes, bioenergetics, metabolic regulation, pentose phosphate pathway, lipid metabolism, glycolysis, gluconeogenesis, citric acid cycle, oxidative phosphorylation, nucleotides, and nucleic acids, amino acids, peptides, proteins, protein structure and function, carbohydrates and lipids.

PMED 511 Physics (3 credits)
Prerequisite: None

The MCAT is a 7.5-hour exam that consists of four sections: Biological and Biochemical Foundations of Living Systems; Chemical and Physical Foundations of Biological Systems; Psychological, Social, and Biological Foundations of Behavior; and Critical Analysis and Reasoning Skills. This course will cover topics in Kinematics and Dynamics, Work and Energy, Thermodynamics, Fluids, Electrostatics and Magnetism, Circuits, Waves and Sound, Light and Optics, Atomic and Nuclear Physics that are part of the Chemical and Physical Foundations of Biological Systems section of the MCAT. The Chemical and Physical Foundations of Biological Systems section has 59 questions. The AAMC requires students to complete this section in 95 minutes. This course caters to these requirements and uses various in-class and out-of-class activities to prepare students for mastering this section. Please refer to the section titled Course Topics for a full listing of the teaching plan.

PMED 515 Math (2 credits)
Prerequisite: None

The MCAT is a 7.5-hour exam that consists of four sections: Biological and Biochemical Foundations of Living Systems; Chemical and Physical Foundations of Biological Systems; Psychological, Social, and Biological Foundations of Behavior; and Critical Analysis and Reasoning Skills. This course will cover topics in Arithmetic and Significant Figures, Scientific Notation, Systems of Measurement, Unit Conversions, Dimensional Analysis, Linear and Quadratic Equations, Systems of Equations, Formulas, Ratios, Percentiles, Exponents and Logarithms, Trigonometric Functions and the Pythagorean Theorem, Problem-Solving, Reasoning about the Design and Execution of Research, The Scientific and Basic Research Methods, Human Subjects Research and Ethics, Collecting and Organizing Data, Sources of Errors, Measures of Tendency, Standard Deviation, Distributions, Probability, Statistical Testing, Charts, Graphs, Tables, Reading and Interpreting Graphs, Direct and Inverse Variation, Correlation and Causation and Applying Data in the Context of Scientific Knowledge that are required and tested across physics and other science sections of the MCAT. Each of the three science sections has 59 questions. The AAMC requires students to complete each section in 95 minutes. This course caters to these requirements and uses various in-class and out-of-class activities to prepare students for mastering this section. Please refer to the section titled Course Topics for a full listing of the teaching plan.

PMED 521 Biology (3 credits)
Prerequisite: None

This course will cover the Biology section of the MCAT exam. This is the 2nd biggest section in the exam (45 questions: 19.6%) after the Verbal Reasoning/CARS section (53 questions). MCAT-based Biology covers 70% of the topics in Biological and biochemical Foundations of living systems. It is worth 30% of all questions on the MCAT. The MCAT is a 7.5-hour exam that consists

of four sections: Biological and Biochemical Foundations of Living Systems; Chemical and Physical Foundations of Biological Systems; Psychological, Social, and Biological Foundations of Behavior; and Critical Analysis and Reasoning Skills. This course will cover topics in Biology that are part of the Biological and Biochemical Foundations of Living Systems section of the MCAT. The section has 59 questions, 10 passages questions, and 65% of them are from Biology. The other 5% comes under the Chemical and Physical Foundations of Biological Systems. The AAMC requires students to complete this section in 95 minutes. This course caters to these requirements and uses various in-class and out-of-class activities to prepare students for mastering this section. Please refer to the section titled Course Topics for a full listing of the teaching plan.

PMED 531 Critical Analysis and Reasoning Skills (2 credits)
Prerequisite: None

The MCAT is a 7.5-hour exam that consists of four sections: Biological and Biochemical Foundations of Living Systems; Chemical and Physical Foundations of Biological Systems; Psychological, Social, and Biological Foundations of Behavior; and Critical Analysis and Reasoning Skills. This course will cover topics in PMED 531 that are part of the CARS section of the MCAT. The CARS section has 53 questions derived from 9 passages on various humanities and social science subjects. The AAMC requires students to complete this section in 95 minutes. This course caters to these requirements and uses various in-class and out-of-class activities to prepare students for mastering this section. Please refer to the section titled Course Topics for a full listing of the teaching plan.

PMED 532 Behavioral Health and Sciences (2 credits)
Prerequisite: None

The MCAT is a 7.5-hour exam that consists of four sections: Biological and Biochemical Foundations of Living Systems; Chemical and Physical Foundations of Biological Systems; Psychological, Social, and Biological Foundations of Behavior; and Critical Analysis and Reasoning Skills. This course will cover topics in Behavioral Health and Sciences that are part of the Psychological, Social, and Biological Foundations of Behavior section of the MCAT. The Psychological, Social, and Biological Foundations of Behavior section has 59 questions. The AAMC requires students to complete this section in 95 minutes. This course caters to these requirements and uses various in-class and out-of-class activities to prepare students for mastering this section. Please refer to the section titled Course Topics for a full listing of the teaching plan.

PMED 591 Kaplan MCAT Coaching (1 credits)
Prerequisite: None

The MCAT is a 7.5-hour exam that consists of four sections: Biological and Biochemical Foundations of Living Systems; Chemical and Physical Foundations of Biological Systems; Psychological, Social, and Biological Foundations of Behavior; and Critical Analysis and Reasoning Skills. This course will cover how to use the Kaplan-suite of resources that will be generally useful for all sections of the MCAT. This course caters to these requirements and uses various in-class and out-of-class activities to prepare students for mastering this section. Please refer to the section titled Course Topics for a full listing of the teaching plan.

SPACE SYSTEMS AND TECHNOLOGY (SSCC)

SSCC 601 Spacecraft Systems and Design (3-0-3)
Prerequisite: Undergraduate calculus and physics or equivalent with permission of the instructor.

The course provides an overview of the design of spacecraft subsystems. Topics related to orbital mechanics, attitude control, communications, power generation, structural design, thermal balance, and subsystem integration will be discussed. At the end of this course the students will be able to evaluate the impact of tradeoffs between subsystem requirements on the efficiency, reliability, weight, and cost at the system level. The course will use examples taken from current satellite systems.

SSCC 602 Spacecraft Systems Lab 1 (0-6-2)
Co-requisite: SSCC 601 or approval of instructor.

The space systems lab is split as three compulsory lab courses (SSCC602, SSCC603, SSCC604) spanning three semesters, where the students will participate in the development of a small satellite (e.g., CubeSat) working as a team. These lab courses are natural extensions to the course SSCC601/SSC501 - Spacecraft Systems and Design, which is the core course of concentration in Space Systems and Technology. The courses will provide the students a hands-on experience in designing and building a small satellite (e.g., CubeSat). The students will be evaluated separately for all the three lab courses. The first lab course provides an overview of the mission and design of spacecraft subsystems. The students will work as a team towards building a small satellite (e.g., CubeSat). Different students will be allocated different tasks which can be related to different small satellite projects.

SSCC 603 Spacecraft Systems Lab 2 (0-6-2)
Co-requisite: SSCC 601, SSCC 602 or approval of instructor.

The space systems lab is split as three compulsory lab courses (SSCC602, SSCC603, SSCC604) spanning three semesters, where the students will participate in the development of a small satellite (e.g., CubeSat) working in a group. These lab courses are natural extensions to the course SSCC601/SSC501 - Spacecraft Systems and Design, which is the core course of concentration in Space Systems and Technology. The courses will provide the students a hands-on experience in designing and building a small satellite (e.g., CubeSat). The students will be evaluated separately for all the three lab courses. The second lab course focuses on the integration and testing aspects of the spacecraft development. At the end of this course the students will be able to work towards building a launch model.

SSCC 604 Spacecraft Systems Lab 3 (0-6-2)
Co-requisite: SSCC 601, SSCC 602, SSCC 603 or approval of instructor.

The space systems lab is split as three compulsory lab courses (SSCC602, SSCC603, SSCC604) spanning three semesters, where the students will participate in the development of a small satellite (e.g., CubeSat) working in a group. These lab courses are natural extensions to the course SSCC601/SSC501 - Spacecraft Systems and Design, which is the core course of concentration in Space Systems and Technology. The courses will provide the students a hands-on experience in designing and building a small satellite (e.g., CubeSat). The students will be evaluated separately for all the three lab courses. The third lab course aims to provide background on launch and operations of the satellites. At the end of the course, the students will be able to understand the requirements for launching a satellite and operate the satellites using a ground station.

SUSTAINABLE CRITICAL INFRASTRUCTURE (SCIN)

SCIN 601 Transportation Systems Analysis: Demand and Economics (3-0-3)

Prerequisite: Undergraduate knowledge of microeconomics.
This course offers an overview of the fundamental principles of transportation systems analysis and modeling, emphasizing the theory and applications of the demand and economics of these systems. It will cover topics such as pricing, regulation, and the evaluation of transportation services. We will draw upon examples from the public transit, road, freight, maritime, and airline industries.

SCIN 602 Urban Design for Sustainability: Theory and Practice (3-0-3)
Prerequisite: Graduate standing.

This is a graduate theory and practice course focused on the body of knowledge and history that informs historical and modern theories in urban design. The course materials will address the major urban design debates, positions, theories, paradigmatic shifts, and unanswered questions. One important agenda will be stressing a series of major debates and models of urban form, its significance and impacts, and proposals to establish healthy and sustainable new communities. The course is ultimately structured to assess and synthesize the classical and contemporary urban design theories related to the intersection of urban form and sustainability. We will accomplish the aforementioned agenda through an extensive set of lectures, readings, assignments, and workshops that synthesize the transformation and debates in urban design theory and practice. Case studies reflecting a wide range of "cities and life style" are introduced to provide a constructed ground for understanding the strategic initiatives and spatial orders being implemented in classical and contemporary urbanism.

The course also explores the broader application of specific urban design strategies and interventions within the UAE's geographic setting and socio-political context. In short, this course explores ways to make better urban places both as a means to serve cities inhabitants, and also as a catalyst to urban regeneration. The seminar should be of benefit to all students interested in the design and morphological aspects of cities. The course also prepares students with no prior design background like engineers and scientists for learning core urban design theories, skills, and applications.

SCIN 603 Management of Infrastructure Systems (3-0-3)
Prerequisite: Undergraduate knowledge of probability and statistics, and in transportation demand and economics.

Infrastructure systems, such as transportation systems, telecommunication systems and electric power systems, have become a crucial component of modern society. This course will apply techniques of risk assessment and decision making under uncertainty in all phases of the infrastructure life cycle to better manage these systems. Emphasis is placed on the planning and design phases since these are most relevant to the region with particular attention to the Abu Dhabi 2030 Economic Vision. The course will also introduce concepts of system reliability, optimization, resilience, and flexibility to uncertainty using real options analysis. Course material will be drawn from textbooks, research papers, and instructor notes.

SCIN 604 Infrastructure Finance (3-0-3)
Prerequisite: Undergraduate knowledge of microeconomics, and transportation demand and economics, or permission of instructor.
The infrastructure finance course focuses on the application of financial theory and risk analysis to the financing of infrastructure

projects. It discusses various sources of financing for infrastructure development and evaluates cost and risk, both from an investor and a project perspective. A number of issues such as public and private financing, limited and full recourse financing, valuation of projects, and refinancing are discussed. This course takes a global perspective, with analysis of international infrastructure projects and discussion of sovereign and exchange rate risk. It also discusses the concept of infrastructure as an asset class, and infrastructure asset based securitization.

SCIN 605 Planning Theory, Practice, and Ethics (3-0-3)
Prerequisite: Graduate standing.

Planning is an ill-defined field. Feinstein and Campbell give four reasons for the difficulty in defining the field, and thus, planning theory: the apparent overlap between the concerns of planning and those of many other social science disciplines; the fuzzy boundaries between planning and other related professions; disagreement as to whether the field should be defined by its object or by its method; and, finally, the fact that planning borrows methodologies from other fields. Given these characteristics of the field, this course is structured to discuss planning theory and its evolution and influence on practice. This course provides you in-depth understanding of the intellectual history, paradigmatic structure, and contemporary debates in the field of planning theory.
The course reading materials, discussion sessions, case studies, assignments, and workshops are organized into two major parts. The first batch of sessions will chronologically (1) explain why planning is unique and different from other social science disciplines; (2) discuss the purpose of defining a body of thought as planning theory by explaining the character and object of theory in the literature; (3) discuss the evolution of planning by describing how different theories influenced planning scholarship and practice and how the integration of some of these traditions form the current theoretical framework that shapes contemporary planning as it is practiced today; and (4) discuss how the concept of sustainability can be considered a compelling normative position to organize and better delineate the central tasks for planning theory in city design, implementation processes, and decision making.

The second batch of lectures, on the other hand, will (1) discuss the content/subjects of planning (physical planning) emphasizing sustainable urban form design and planning principles; (2) recognize and assess the suitability of universally acknowledged planning principles and interventions to UAE's political and social norms (3) Introduce Abu Dhabi community facility codes, standards, and zoning strategies; and (4) discuss different approaches and policies in city planning through multiple case studies including: Portland, Chicago, Hamburg, Tokyo, Dubai, San Francisco etc.

SCIN 606 Geographic Information Systems (3-0-3)
Prerequisite: Undergraduate knowledge of statistics.

This course introduces the basic elements of Geographic Information Systems (GIS) and its application in general management activities including resource management. The application of GIS as a tool to collect, store, manage, and analyze spatial data for strategic decision making has been explored in all fields of study. Recent improvement in GIS provides researchers to perform spatial statistical analysis. However, the potential of GIS in dealing with urban issues is still evolving. As a tool of analysis, GIS can be used to for informed decision making to deal with demands of and both current and emerging issues at local, regional and global scale. As a basis from

which to pursue these objectives, GIS introduces the current and potential future roles of GIS in support of infrastructure management. The course provides a framework for understanding the real-world application of GIS for crisis management and for addressing the applied research needed to enable more effective GIS application in this context.

SCIN 607 Infrastructure and Development (3-0-3)
Prerequisite: Undergraduate knowledge of microeconomics.

What is the relationship between infrastructure and economic growth and development? How does energy security affect geopolitical relations among nations as well as socioeconomic relations within nations? This seminar will cover some of these timely and complex questions linking infrastructure, energy, and their technologies.

SCIN 608 Urban Planning and Design Studio (3-0-3)
Prerequisite: Graduate standing.

This class is a studio course that gives hands-on experience in the actual development of a site plan. This course incorporates community design and site planning in concert with geological constraints, aesthetic values, environmental concerns, and legal issues (e.g. zoning). Another important key of this class is to learn the design of "space". Students learn various aspects of community design and site planning through a semester-long site plan project that designs a residential community that incorporates the principles of design.

SCIN 609 Comparative Land Use and Transportation Planning (3-0-3)
Prerequisite: Graduate standing.
This course focuses on the land use-transportation "interaction space" in metropolitan settings. The course aims to develop an understanding of relevant theories and analytical techniques, through the exploration of various cases drawn from different parts of the world. During the first part of the course, students will develop a basic understanding of: the major forces, patterns and trends of metropolitan growth today; conceptual and analytical models of urban development and the role of transportation; and the relevant planning institutions. The second part of the course will introduce the concept of accessibility and related issues of individual travel demand.

Building on these foundations, in the third part of the course students will explore the influence of the metropolitan built environment on travel behavior, including historical interest and evidence, relevant theories and analytical approaches, techniques for measuring relevant aspects of the "built environment," and implications for planning tools and policies.

The fourth part of the course turns to the other side of the land use-transportation "interaction space;" that is, the role of transportation on metropolitan land development. Students will learn about historical influences and then study in more detail the effects as they relate to provision of both public transportation infrastructure and roadways. We will also examine the implications for various financial instruments and institutional structures. Finally, the fifth part of the course will take a prospective perspective, looking at the implications of the land use-transportation interaction space for metropolitan futures, and our abilities to forecast them.

SCIN 610 Public Transportation Systems (3-0-3)
Prerequisite: Undergraduate knowledge of transportation system analysis, and finance.

Evolution and role of urban public transportation modes, systems, and services, focusing on bus and rail. Description of technological characteristics and their impacts on capacity,

service quality, and cost. Current practice and new methods for data collection and analysis, performance monitoring, route design, frequency determination, and vehicle and crew scheduling. Effect of pricing policy and service quality on ridership. Methods for estimating costs associated with proposed service changes. Organizational models for delivering public transportation service including finance and operations. Select transit management topics including labor relations, fare policy/technology, marketing and operations management.

SCIN 611 Thermal Energy in Buildings (3-0-3)
Prerequisite: Undergraduate knowledge of thermodynamics, environmental control or equivalent.

Worldwide, a significant portion of the demand for energy can be traced back to buildings. The building sector is therefore an ideal target for the implementation of energy efficiency enhancement initiatives.

This course focuses on the technical and, to some extent, financial feasibility of energy efficiency in buildings. It examines the flow of energy in a building and the function of a building's envelope. The course also covers the building systems in charge of maintaining indoor comfort conditions as well as the modeling and lifecycle analysis of building's energy performance. Upon culmination of the course, students would be able to apply their knowledge to the optimal design of new construction and the marginal enhancement ('retrofit') of existing buildings. Advanced topics such as building performance diagnostics and interaction with the urban microclimate and systems will also be covered. The main emphasis of the course will be on challenges posed by hot and humid climate.

At the outset, the course describes the fundamental heat, moisture and mass transfer phenomena occurring in buildings and presents methods and techniques used at different stages of a building's life-cycle—design, operation, retrofit—to strike an optimal balance between indoor thermal comfort and energy efficiency.

The role of the building envelope (foundation, wall, roof, glazing) in separating indoor space from outdoor climate will be investigated in depth. Interactions between building envelope components and building systems (heating ventilation and air-conditioning, lighting, building management system) are of particular interest. In the final section of the course, students learn to accurately model said interactions and develop life-cycle analysis of buildings. These models are used to inform and support real life engineering decisions.

SCIN 612 Sustainable Building Science:
Fundamentals, Tools, and Applications (3-0-3)
Prerequisite: Undergraduate knowledge of thermal energy in buildings.

This course explores the multidisciplinary challenges and opportunities to make the built environment more sustainable, by covering building science fundamentals, tools, and applications. Various topics are covered including green building design principles, methods to assess building energy performance, life-cycle analysis, the relationship and interaction of buildings with their inhabitants, and finally, the study of buildings in respect to their urban environment and infrastructure. This course adopts a practical and holistic approach by introducing students to contemporary solutions and trends both in the industry and in academia. It also teaches them fundamental tools to assess and critique sustainability solutions from a life-cycle perspective, while accounting for how these solutions affect – and are affected by – building users. This is expected to prepare

students to work on multi-disciplinary teams with professionals from various fields including engineers, urban planners, human factors and ergonomics experts, social scientists, and architects.

SCIN 694 Selected Topics in Sustainable Critical Infrastructure (3-0-3)
Prerequisite: Will be specified according to the particular topics offered.

This course covers selected contemporary topics in Sustainable Critical Infrastructure. The topics will vary from semester to semester depending on faculty availability, and faculty and student interests. Proposed course descriptions are considered by the Department of Industrial and Systems Engineering on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the Graduate Studies Committee. The Course may be repeated once with change of contents to earn a maximum of 6 credit hours.

SCIN 699 Master's Thesis (minimum 12)
Corequisite: ENGR 695 Seminar in Research Methods, approval of the Department Chair and the Associate Dean for Graduate Studies.

In the Master's Thesis, the student is required to independently conduct original research-oriented work related to important chemical engineering problems under the direct supervision of a main advisor, who must be a full-time faculty in the Industrial & Systems Engineering Department, and at least one other full-time faculty who acts as co-advisor. The outcome of the research should demonstrate the synthesis of information into knowledge in a form that may be used by others and lead to publications in suitable journals/conferences. The student's research findings must be documented in a formal thesis and defended through a viva voce examination. The student must register for a minimum of 12 credit hours of Master's Thesis.

WATER AND ENVIRONMENTAL ENGINEERING (WENV)

WENV 601 Chemicals in the Environment: Fate and Transport (3-0-3)
Prerequisite: Undergraduate general chemistry and differential equations, or consent of instructor.

Behavior of chemicals in the environment. Emphasis on man-made chemicals, and their movement and fate in natural environmental media (water, air, soil) and engineered environments. Physical transport, as well as chemical and biological sources and sinks, are discussed. Linkages to health effects, sources and control, and policy aspects are explored.

WENV 602 Industrial Ecology (3-0-3)
Prerequisite: None.

Engineers can fundamentally change the environmental footprint of modernity. To effect change, engineers require tools to identify "better" design and operational options. This course examines the use of life-cycle thinking and assessment tools to identify product and system design options that balance environmental and economic performance. While this is very relevant, as a core course, to Water and Environmental Engineering students, it is also very helpful to students from other disciplines.

WENV 604 / CHEG 604 Desalination (3-0-3)
Prerequisite: Undergraduate courses in heat transfer, thermodynamics, fluid mechanics, mass transfer.

The course will cover in-depth the commonly adapted thermal and membrane based desalination technologies. This includes reverse osmosis, electrodialysis, flash-related desalination processes, and evaporation-

related desalination processes. Renewable energy technologies coupled with desalination processes will be also presented. Additionally, fouling/scaling, corrosion, materials used and environmental impacts related issues will be covered. Finally, environmental, sustainability and economic factors of desalination systems for fresh water production and reuse will be presented.

WENV 606 / CHEG 606 Wastewater Treatment Engineering (3-0-3)
Prerequisite: None.

This course is an overview of engineering approaches to protecting water quality with an emphasis on the application of fundamental principles. Theory and conceptual design of systems for treating municipal and industrial wastewater are discussed. These include reactor theory, models, (bio)reaction stoichiometry and kinetics. Physical, chemical and biological processes are also studied.

WENV 611 Hydrologic Analysis (3-0-3)
Prerequisite: Undergraduate course in thermodynamics, elementary hydraulics. Basic probability and statistics background.

This graduate course is to give students an advanced and practical approach to the various facets of the subject of Hydrology. Therefore, students will have the opportunity to use advanced modeling techniques to understand the dynamics of hydrological processes. A special focus will be given to the application of hydrological theory and concepts for the solution of practical engineering problems in an arid region context. In addition, a number of open-source and commercial models will be presented to students.

WENV 622 Data Analysis for Environmental Modeling (3-0-3)
Prerequisite: Linear algebra, probability and statistics (or equivalent).

This course provides an overview of statistical methods commonly utilized in environment modeling to provide students with training in analytical approaches. Course topics will include approaches for data manipulation, quantitative analysis based on descriptive statistics, linear models, non-linear models, time series, and spatial data analysis. Examples and problem sets will utilize MATLAB to analyze data. There will be an emphasis on exploring and plotting data, and presenting model results.

WENV 623 Global Climate Change: Impacts and Adaptation (3-0-3)
Prerequisite: Undergraduate level calculus and physics, basic probability and statistics (or equivalents), with consent of instructor.

This graduate course provides students with an overview on global environmental, social and economic impacts of climate change, with a particular focus on the arid and semi-arid regions of the world and their criticalities. The first part of the course addresses the scientific basis of global climate change, the different sources of uncertainty in predicted climate scenarios, and the interpretation of results from the recently issued (IPCC) Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change. Special emphasis is given to the effects of climate variability on water resources, food security and human health, and to the role of renewable energy sources in mitigating climate change and supporting sustainable development. Students are also guided through the understanding and assessment of adaptation strategies that human communities already adopted and those they will most likely have to implement under future climate change scenarios. The final part of the course is devoted to measures / technologies / policies for climate change mitigation, again with a regional prospective and main emphasis on water-limited climates.

WENV 694 Selected Topics in Water and Environmental Engineering (3-0-3)
Prerequisite: Will be specified according to the particular topics offered.

This course covers selected contemporary topics in Water and Environmental Engineering. The topics will vary from semester to semester depending on faculty availability and student interests. Proposed course descriptions are considered by the program on an ad hoc basis and the course will be offered according to demand. The proposed course content will need to be approved by the College of Engineering Graduate Studies Committee. The Course may be repeated once with change of contents to earn a maximum of 6 credit hours.

WENV 699 Master's Thesis (minimum 12)
Co-requisite: ENGR 695 Seminar in Research Methods, approval of the Department Chair and the Associate Dean for Graduate Studies.

In the Master's Thesis, the student is required to independently conduct original research-oriented work related to important water and environmental engineering problems under the direct supervision of the main advisor, who must be a full-time faculty in either the CIVIL Engineering Department or the Chemical Engineering Department, and at least one other full-time faculty who acts as co-advisor. The outcome of the research should demonstrate the synthesis of information into knowledge in a form that may be used by others and lead to publications in suitable reputable journals/ conferences. The student's research findings must be documented in a formal thesis and defended through a viva voce examination. The student must register for a minimum of 12 credit hours of Master's Thesis.

LIST OF FACULTY

COLLEGE OF ARTS AND SCIENCES

A

ABBAS, ELRASHID YOUSIF,
Ph.D., Omdurman Islamic University, Sudan, 2007; Assistant Professor of Humanities and Social Sciences.

ABDELJABBAR, ALRAZI,
Ph.D., University of South Florida, USA, 2012; Assistant Professor of Mathematics.

ABDUL-LATIF, ZAKARYA,
M.S., Framingham State University, USA, 2014; Lecturer in Pre-Medicine Bridge Program.

ABEDRABBO, SUFIAN,
Ph.D., New Jersey Institute of Technology, USA, 1998; Associate Professor of Physics.

ABI JAOUDE, MAGUY,
Ph.D., University of Claude Bernard Lyon 1, France, 2011; Assistant Professor of Chemistry.

ABOSALEM, YOUSEF,
Ph.D., BUID Birmingham University, UK, 2013; Senior Lecturer in Preparatory Program.

ABUALRUB, MARWAN,
Ph.D., University of Illinois at Chicago, USA, 1992; Senior Lecturer in Preparatory Program.

ABU HAIJA, MOHAMMAD,
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AJHAR, HAKIM,
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AL ARYDAH, MO'TASSEM,
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AL BUSAEEDI, ABDULLA,
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AL HANAI, MARIAM HILAL,
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AL HOMOUZ, DIRAR,
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AL KHALEEL, MOHAMMAD,
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ALI, MOHAMMED,
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AL SUWAIDI, AISHA,
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AMEUR, AHMED,
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ANDERSON, ALLIYA,
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ANDREW, MATTHEW,
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ANJUM, DALAVER,
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ARCHBOLD, RICARDO,
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ASHRAF, SYED SALMAN,
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AYISH, NADER,
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AYNEDJIAN, HAGOP,
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BENNELL, ROBERT,
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BILDSTEN, MERIEM,
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BLOUIN, DENIS,
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BRADLEY, CURTIS,
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BSOUL, LABEEB,
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CANNON, BRENDON,
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CARBONELL, CURTIS,
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CERIANI, ANDREA,
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CHEN, WEI,
Ph.D., Chinese Academy of Sciences, China, 2012; Lecturer in Pre-Medicine Bridge Program.

CRAIG, ROBERT,
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D

DALTON, DAVID,
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DAS, GOBIND,
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DEAIBES, MUTASIM,
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DECARLIS, ALESSANDRO,
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DEVECI, TANJU,
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DIB, KHALED,
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DIMMITT, NICHOLAS,
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DRESSMAN, MARK,
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ELKADI, MIRELLA,
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EL KORK, NAYLA,
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EL SOKARY, WAEL,
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LIN, JANG-SHEE BARRY,
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LING, HWEE LIM,
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MOHAMED, SHARMARKE,
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Z

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ZHAO, RUIKUN,
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ZHOU, BING,
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ZIKKOS, ELIAS,
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ZUBELLI, JORGE PASSAMANI,
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COLLEGE OF ENGINEERING

A

ABDERRAHMANE, HAMID AIT,
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ABOU KHOUSA, MOHAMMED,
Ph.D., Missouri University of Science and Technology, USA, 2009; Associate Professor of Electrical Engineering and Computer Science.

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ABU ZAHRA, MOHAMMAD,
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AFGAN, IMRAN,
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AHMAD, JAMAL,
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