German Jordanian University

School of Electrical Engineering and Information Technology

Department of Computer Engineering

Master of Science

Study Plan 2023

I. Program Objectives

Program objectives:

a. Provide master level education that enables our graduates to pursue rewarding professional careers, postgraduate studies, and lifelong learning.
b. Provide the ICT industry with professional engineers who have sound postgraduate qualifications, comprehensive understanding of computer engineering, and ability to tackle complex engineering problems.
c. Create a better understanding of the practical applications and profitability of computer systems among industry managers and professionals.
d. Carry out research to solve problems of the local and global industry and to promote a computer system infrastructure for better productivity and quality.

II. Learning Outcomes

Learning outcomes:

a. Provide a solid theoretical education, practical engineering experience, and a comprehensive curriculum that improves the critical thinking and innovation skills of students.
b. Provide students with the education and training in the field of computer engineering that allows them to make real contributions to society and lead their careers.
c. Build an awareness of computing practices in industry and emerging technologies, emphasizing a working knowledge of current computer design and development techniques.

Course Delivery Methods

Courses are in one of the following three methods:

- **Face-to-Face (F2F) Method**
  Courses using this method are delivered by faculty in person in regularly scheduled class sessions physically on campus.
- **Blended (BLD) Method**
  Courses are delivered in a hybrid mode of physical face-to-face class sessions and asynchronous material including online instructional videos, presentations, projects, and similar learning activities.
- **Online (OL) Method**
  Courses are delivered exclusively online. This method consists of a hybrid of synchronous regularly scheduled class sessions delivered via the Internet, and asynchronous material including online instructional videos, presentations, projects, and similar learning activities. Virtual classrooms utilizing different online platforms are used. No physical face-to-face meetings are required.

III. Admission Requirements

To apply for admission, the following minimum requirements must be met:

a. Obtained a Bachelor of Science degree in the following disciplines with minimum GPA of 70% or equivalent:
    - Computer science
    - Computer Information Systems
    - Management Information Systems
    - Computer Engineering
    - Communications Engineering
    - Software Engineering
    - Electrical/Electronic Engineering
    - Mechanical Engineering
    - Mechatronics Engineering

b. Passed the TOEFL Exam with a minimum score of 500 or equivalent.
c. Relevant work experience is preferable.

Students holding other degrees need to consult with the program director for application. Students are expected to have background spanning the following:

1. Computer Systems Hardware and Software
2. Programming, data and object structures

Above is a minimum foundation of essential prerequisite knowledge needed for all students pursuing this program. Students admitted with B.Sc. in Electrical/Electronic Engineering, Mechanical Engineering, and Mechatronics Engineering may be required to take a set of computer engineering foundation courses. These foundation courses are offered at the graduate level, representing a common body of knowledge, and cover more material at a more conceptual level than comparable undergraduate courses.

IV. Degree Requirements (Credit hours)

Classification	Credit Hours
Compulsory courses	15
Elective courses	09
Thesis	09
Total	**33**

V. Curriculum (Credit hours)

1. Compulsory Requirements: (15 credit hours)

Course ID	Course Name	Credit Hours	ECTS	Contact Hours		Type	Prerequisites / Corequisites
				Lect	Lab		
CE701	Probability and Stochastic Modeling	3		3	0	BLD	
CE702	Parallel and distributed systems	3		3	0	BLD	
CE706	Big Data Analysis	3		3	0	OL	
CE707	Embedded Systems	3		3	0	BLD	
CE716	Machine learning and Pattern Recognition	3		3	0	BLD	
	Total	**15**		**15**	**00**		

2. Elective Courses: (09 credit hours out of the following)

2.1 Electives for the General Track

Course ID	Course Name	Credit Hours	ECTS	Contact Hours		Type	Prerequisites / Corequisites
				Lect	Lab		
CE704	Network and Communication Systems	3		3	0	F2F	
CE705	Real-time Systems	3		3	0	F2F	
CE713	Mathematics for Robotics and Control	3		3	0	F2F	
CE715	Computer Vision	3		3	0	F2F	
CE717	Image Processing	3		3	0	F2F	
CE718	Optimization Methods	3		3	0	F2F	
CE719	Linear Algebra with Applications	3		3	0	F2F	
CE722	Parallel Architectures and Parallel Algorithms	3		3	0	F2F	
CE723	Advanced Digital Systems	3		3	0	F2F	
CE724	Hardware/Software Co-design	3		3	0	F2F	
CE731	Computer Communications and Networks	3		3	0	F2F	
CE732	Fundamentals of Telecommunication Networks	3		3	0	F2F	
CE736	Fault-Tolerant Distributed Systems	3		3	0	F2F	
CE737	Wireless Communications	3		3	0	F2F	
CE741	Advanced Operating Systems	3		3	0	F2F	
CE742	Systems Requirements	3		3	0	F2F	
CE743	Advanced software analysis and design	3		3	0	F2F	

CE761	Reinforcement Learning	3		3	0	F2F	
CE762	Natural Language Processing	3		3	0	F2F	
CE763	Deep Learning	3		3	0	F2F	
CE764	Digital Signal Processing	3		3	0	F2F	
CE771	Internet of Things	3		3	0	F2F	
CE772	Computer Security	3		3	0	F2F	
CE773	Human Machine Interaction	3		3	0	F2F	
CE744	Innovation and Entrepreneurship	3		3	0	F2F	
13755	Enterprise Mobile Computing	3		3	0	F2F	
13789	IT Project Management	3		3	0	F2F	
CE791	Special Topics in Computer Engineering	3		3	0	F2F	
	Minimum required	**09**		**09**	**00**		

2.2 Electives for the Artificial Intelligence Track

Course ID	Course Name	Credit Hours	ECTS	Contact Hours		Type	Prerequisites / Corequisites
				Lect	Lab		
CE713	Mathematics for Robotics and Control	3		3	0	F2F	
CE715	Computer Vision	3		3	0	F2F	
CE717	Image Processing	3		3	0	F2F	
CE718	Optimization Methods	3		3	0	F2F	
CE719	Linear Algebra with Applications	3		3	0	F2F	
CE722	Parallel Architectures and Parallel Algorithms	3		3	0	F2F	
CE741	Advanced Operating Systems	3		3	0	F2F	
CE742	Systems Requirements	3		3	0	F2F	
CE743	Advanced software analysis and design	3		3	0	F2F	
CE761	Reinforcement Learning	3		3	0	F2F	
CE762	Natural Language Processing	3		3	0	F2F	
CE763	Deep Learning	3		3	0	F2F	
CE764	Digital Signal Processing	3		3	0	F2F	
CE773	Human Machine Interaction	3		3	0	F2F	
CE791	Special Topics in Computer Engineering	3		3	0	F2F	
	Minimum required	**09**		**09**	**00**		

2.3 Electives for the Cyber Physical Systems Track

Course ID	Course Name	Credit Hours	ECTS	Contact Hours		Type	Prerequisites / Corequisites
				Lect	Lab		
CE704	Network and Communication Systems	3		3	0	F2F	
CE705	Real-time Systems	3		3	0	F2F	
CE715	Computer Vision	3		3	0	F2F	
CE717	Image Processing	3		3	0	F2F	
CE718	Optimization Methods	3		3	0	F2F	
CE723	Advanced Digital Systems	3		3	0	F2F	
CE724	Hardware/Software Co-design	3		3	0	F2F	
CE731	Computer Communications and Networks	3		3	0	F2F	

CE732	Fundamentals of Telecommunication Networks	3		3	0	F2F	
CE736	Fault-Tolerant Distributed Systems	3		3	0	F2F	
CE737	Wireless Communications	3		3	0	F2F	
CE741	Advanced Operating Systems	3		3	0	F2F	
CE742	Systems Requirements	3		3	0	F2F	
CE743	Advanced software analysis and design	3		3	0	F2F	
CE762	Natural Language Processing	3		3	0	F2F	
CE764	Digital Signal Processing	3		3	0	F2F	
CE771	Internet of Things	3		3	0	F2F	
CE772	Computer Security	3		3	0	F2F	
CE773	Human Machine Interaction	3		3	0	F2F	
CE744	Innovation and Entrepreneurship	3		3	0	F2F	
13755	Enterprise Mobile Computing	3		3	0	F2F	
13789	IT Project Management	3		3	0	F2F	
CE791	Special Topics in Computer Engineering	3		3	0	F2F	
	Minimum required	**09**		**09**	**00**		

3. Thesis/Comprehensive Exam/Other: (09 credit hours)

Course ID	Course Name	Credit Hours	ECTS	Contact Hours		Type	Prerequisites / Corequisites
				Lect	Lab		
CE751	Master Thesis A	0				F2F	
CE752	Master Thesis B	3				BLD	
CE753	Master Thesis C	6				F2F	
CE754	Master Thesis D	9				F2F	
	Minimum required	**00**		**00**	**00**		

VI. Study Plan Guide

First Year							
First Semester							
Course ID	**Course Name**	**Credit Hours**	**ECTS**	**Contact Hours**		**Type**	**Prerequisites / Corequisites**
				Lect	**Lab**		
CE701	Probability and Stochastic Modeling	3		3	0	F2F	
CE702	Parallel and distributed systems	3		3	0	BLD	
	Technical Elective	3		3	0		
	Total	**9**	**0**	**9**	**0**		

First Year							
Second Semester							
Course ID	**Course Name**	**Credit Hours**	**ECTS**	**Contact Hours**		**Type**	**Prerequisites / Corequisites**
				Lect	**Lab**		
CE706	Big Data Analysis	3		3	0	OL	
CE716	Machine learning and Pattern Recognition	3		3	0	F2F	
CE707	Embedded Systems	3		3	0	BLD	
	Total	**9**	**0**	**9**	**0**		

First Year							
Summer Semester							
Course ID	**Course Name**	**Credit Hours**	**ECTS**	**Contact Hours**		**Type**	**Prerequisites / Corequisites**
				Lect	**Lab**		
	Total	**0**	**0**	**0**	**0**		

Second Year							
First Semester							
Course ID	Course Name	Credit Hours	ECTS	Contact Hours		Type	Prerequisites / Corequisites
				Lect	Lab		
	Technical Elective	3		3	0		
	Technical Elective	3		3	0		
CE752	Master Thesis B	3		3	0	F2F	
	Total	**9**	**0**	**9**	**0**		

Second Year							
Second Semester							
Course ID	Course Name	Credit Hours	ECTS	Contact Hours		Type	Prerequisites / Corequisites
				Lect	Lab		
CE753	Master Thesis C	6		6	0	F2F	
	Total	**6**	**0**	**6**	**0**		

First Year							
Summer Semester							
Course ID	Course Name	Credit Hours	ECTS	Contact Hours		Type	Prerequisites / Corequisites
				Lect	Lab		
	Total	**0**	**0**	**0**	**0**		

VII. Course Descriptions

1. Compulsory Courses

CE701 Probability and Stochastic Modeling **03 Cr Hr** **00 ECTS**

Random variables, probability distribution and density functions, functions of random variables, Markov chains, Chapman-Kolmogorov equations, classification of states, limiting probabilities, branching processes, time-reversible processes, Poisson processes, continuous-time Markov chains, birth and death processes, transition probabilities.

Prerequisites:
Corequisites:

CE702 Parallel and distributed systems **03 Cr Hr** **00 ECTS**

This course covers various fundamental aspects of parallel and distributed computing systems and the techniques used for software development on these systems. The topics covered in the course include parallel hardware architecture such as multi-core, computer cluster, distributed and shared memory, hierarchical memory, graphics processing unit (GPU); multi-thread (OpenMP), multi-process, message passing (MPI); scheduling and synchronization; parallel algorithm design and multithreaded programs development; high-performance software engineering techniques; parallel applications such as matrix multiplication, matrix transposition, fast Fourier transform, sorting algorithms.

Prerequisites:
Corequisites:

CE706 Big Data Analysis **03 Cr Hr** **00 ECTS**

The recent advancements in network bandwidths, the popularity in social networks, and the ubiquity of smartphones resulted in creating a large volume of mostly unstructured data (e.g., weblogs, videos/images, recorded speech, e-mails, tweets, etc.). This course's key objective is to familiarize the students with the essential information technologies used to manipulate, store, and analyze big data. In general, the course includes the following topics: big data introduction (definition and taxonomy), relationships and representations, Graph Databases, NoSQL, MapReduce (Hadoop/HBase/Hive/HiveQL), Introduction to Spark, Analysis of Streaming Data with Spark, Spark ML Library, Analysis of Streaming Data with Neural Network and Tensor Flow, analysis of massive graphs (social networks), link analysis, page rank.

Prerequisites:
Corequisites:

CE707 Embedded Systems **03 Cr Hr** **00 ECTS**

This course focuses on learning the techniques to design and program ARM-based embedded systems and implementing them using both assembly language and the standard C language. In this course, the student will learn what are the constraints, software design principles (common schedulers and real time operating systems), and common development flow principles in embedded system design. The student will learn the difference between the different ARM architectures and ARM processors. The student will also learn the concepts, programming, and hardware interfacing of interrupts, General Purpose Input Output (GPIO), analog interfaces (ADCs and DACs), timers, counters, Pulse Width Modulation (PWM) outputs, and serial communication interfaces (UART, I2C, and SPI). Additional topics include, Real-time operating systems, compilers and C code as converted to assembly language, and performance optimization concepts including Direct Memory Access (DMA).

Prerequisites:
Corequisites:

CE716 Machine Learning and Pattern Recognition **03 Cr Hr** **00 ECTS**

This course provides a broad introduction to machine learning and statistical pattern recognition. The topics covered in this course include supervised learning (generative/discriminative learning, parametric/non-parametric learning, neural networks, and support vector machines); unsupervised learning (clustering, dimensionality

reduction, kernel methods); learning theory (bias/variance tradeoffs; VC theory; large margins); reinforcement learning and adaptive control. The course will also discuss recent applications of machine learning, such as robotic control, data mining, autonomous navigation, bioinformatics, speech recognition, and text and web data processing

Prerequisites:
Corequisites:

2. Elective Courses

CE704 Network and communication systems **03 Cr Hr** **00 ECTS**

Fundamentals of network technology based on a layered protocol stack (OSI and IP models), telephone network and Internet architecture, transport protocols (UDP, TCP), upper application layer protocols (such as HTTP, FTP, and SMTP), analysis of link layer protocols and their performance. Wireless LANs, framing and error detection in the data link layer, ARQ protocols, introduction to queuing theory, collision protocols (e.g., ALOHA, CSMA), fast packet switching, routing in data Networks, optimal routing, flow and congestion control, network management fundamentals.

Prerequisites:
Corequisites:

CE705 Real-time systems **03 Cr Hr** **00 ECTS**

Introduction to real-time systems, real-time scheduling including multiprocessor scheduling, real-time operating systems (kernels), real-time communication, real-time programming languages, reliability and fault-tolerance, and real-time system requirements and design methods; Design, analysis, and implementation of real-time kernel mechanisms and real-time applications using kernels such as Linux and programming languages such as C++.

Prerequisites:
Corequisites:

CE713 Mathematics for Robotics and Control **03 Cr Hr** **00 ECTS**

Mathematical introduction to modeling, analysis and control of robotic systems; Theoretical frameworks for modeling, analysis (kinematics and dynamics) and control of generic robotic mechanical systems, rooted in rich traditions of mechanics and geometry; Serial-chain and parallel-chain manipulators, wheeled mobile robots (and hybrid combinations of these systems).

Prerequisites:
Corequisites:

CE715 Computer Vision **03 Cr Hr** **00 ECTS**

This course covers various algorithms and methods that enable a machine to understand images and videos. The topics covered in this course include image formation, feature detection, segmentation, multiple view geometry, camera geometry, 3-D reconstruction, recognition and learning, and video processing.

Prerequisites:
Corequisites:

CE717 Image processing **03 Cr Hr** **00 ECTS**

This course provides a solid background in the fundamentals of digital image processing. It covers various image processing techniques, including image representation, 2D linear systems theory, 2D Fourier analysis, digital filtering, image enhancement, and segmentation. Students in this course will be exposed to real-world applications of image processing in industry, science, engineering, and medicine. Through assignments and course projects, students will become familiar with the image processing facilities available in the MATLAB numeric computation environment as well as the Open-Source Computer Vision (OpenCV) library.

Prerequisites:
Corequisites:

CE718 Optimization Methods **03 Cr Hr** **00 ECTS**

This course provides an introduction to various optimization methods and algorithms, including Unconstrained Optimization Methods (One-dimensional Search Methods, Gradient Methods, Newton's Method, Conjugate Direction Methods, Quasi-Newton Methods, Solving Linear Equations, Global Search Algorithms (e.g., Simulated Annealing Algorithm, Particle Swarm Optimization, and Genetic algorithms)), Linear Programming (Simplex Method, Duality, Non-simplex Methods), and Nonlinear Constrained Optimization Methods (Problems with Equality Constraints, Problems with Inequality Constraints, Convex Optimization Problems, and Algorithms for Constrained Optimization).

Prerequisites:
Corequisites:

CE719 Linear Algebra with Applications **03 Cr Hr** **00 ECTS**

General vector spaces over the real and complex numbers, and linear maps (including related subspaces kernel and image and representations in matrix form given bases). Operators on finite dimensional vector spaces by looking at eigenvectors, eigenspaces, generalized eigenspaces, aiming for the Cayley-Hamilton theorem and normal forms. Inner product spaces are a concept generalizing the dot product. Orthogonal bases are constructed by using the Gram Schmidt algorithm. Various types of operators on inner product spaces are studied (orthogonal, real symmetric, unitary, normal, self-adjoint), including the corresponding matrices. Advanced concepts from linear algebra, such as dual spaces, bilinear forms and quotient spaces. Several applications are illustrated; Examples: Markov chains, population growth (Leslie matrices), game theory, systems of differential equations, Fourier analysis, and fractals.

Prerequisites:
Corequisites:

CE722 Parallel Architectures and Parallel Algorithms **03 Cr Hr** **00 ECTS**

Parallelism in processors; multi-core processors; classification of parallel architectures; multiprocessor architectures; interconnections networks; Amdahl's law; abstract parallel machine models; templates for parallel algorithms; searching, merging, sorting; graph algorithms (traversing, spanning trees, connected components); numerical algorithms (matrix algorithms, linear equations). Data dependencies; shared memory computing (threads, Open MP); message passing computing; parallelization strategies (embarrassingly parallel, partitioning, pipelined, synchronous); load balance.

Prerequisites:
Corequisites:

CE723 Advanced Digital Systems **03 Cr Hr** **00 ECTS**

The course covers advanced topics in digital design, with a special emphasis on how to model, simulate, synthesize and optimize large and complex subsystems. It also covers some of the practical industrial aspects of modern design, including the use of hardware description languages (e.g., VHDL) for structured modeling and simulation. Other topics include controller synthesis and optimization, iterative circuits, high-speed combinational arithmetic circuits, fault tolerance and soft error mitigation, power optimization strategies, asynchronous design, FPGA structures, and floating-point arithmetic.

Prerequisites:
Corequisites:

CE724 Hardware/Software Co-design **03 Cr Hr** **00 ECTS**

The foundations of this lecture lie in the areas of sensors, signal processing, microcontrollers and hardware design. HW/SW co-design deals with the question of which parts of an algorithm should go into software and which into hardware.

Prerequisites:
Corequisites:

CE731 Computer Communications and Networks **03 Cr Hr** **00 ECTS**

Framing and error detection in the data link layer, ARQ protocols, introduction to queuing theory, Burke's theorem and networks of queues, packet multiple access and the Aloha protocol, fast packet switching, routing in data Networks, optimal routing, flow and congestion control.

Prerequisites:
Corequisites:

CE732 Fundamentals of Telecommunication Networks **03 Cr Hr** **00 ECTS**

Fundamentals of network technology based on a layered protocol stack, telephone network and Internet architecture, network protocols (IP), transport protocols (UDP, TCP), upper layer protocols (such as HTTP, FTP, and SMTP), analysis of link layer protocols and their performance, Wireless LANs and their protocols such as CSMA/CD and CSMA/CA.

Prerequisites:
Corequisites:

CE736 Fault-Tolerant Distributed Systems **03 Cr Hr** **00 ECTS**

Fundamentals of the design and analysis of fault-tolerant systems, Models for distributed systems, Fault/error models, Techniques for providing hardware/software redundancy, Fault-detection in multiprocessors, Stable storage, Recovery strategies for multiprocessors (check pointing), System diagnosis, Software design faults, Experimental validation techniques, Case studies in fault-tolerant distributed systems.

Prerequisites:
Corequisites:

CE737 Wireless Communications **03 Cr Hr** **00 ECTS**

Prerequisites (Fundamentals of Telecommunication networks): Transmission media, analog transmission and multiplexing, digital transmission and multiplexing, link calculations, satellite transmission, microwave transmission, fading channels, nonlinear channels, intermodulation, multiple-access techniques: TDMA, FDMA, point-to-multipoint communications systems, performance objectives, measurement techniques, mobile communications systems.

Prerequisites:
Corequisites:

CE741 Advanced Operating Systems **03 Cr Hr** **00 ECTS**

This course focuses on advanced operating system topics and recent developments in operating systems research, including advanced concepts of Process/Thread Management, inter-process communication, Kernel memory functions, device drivers, and interrupts. The course also involves readings and lectures on classic and new papers. Topics: virtual memory management, synchronization and communication, file systems, protection and security, operating system structure and extension techniques, fault tolerance, and history and experience of systems programming.

Prerequisites:
Corequisites:

CE742 Systems Requirements **03 Cr Hr** **00 ECTS**

This course covers the use of systems requirements engineering to develop and maintain large-scale software systems. The topics included in the course include introduction to requirements engineering, project initiation, operation modeling, verification and validation, risks managing, requirements selection, requirements prioritization, requirements managing, requirements engineering, and software design.

Prerequisites:
Corequisites:

CE743 Advanced Software Analysis and Design **03 Cr Hr** **00 ECTS**

This course covers the theoretical and practical aspects of software systems architecture and design. The topics of the course include covers software specification, software analysis and design, software architecture modeling and design patterns, advanced object-oriented analysis and design. The course provides students with extensive understanding of unified modeling language (UML), design patterns and architectural styles, designing and describing a software system architecture using design patterns, and applying semi-formal notations to specify a software system architecture, design structure, and design behavior.

Prerequisites:
Corequisites:

CE761 Reinforcement Learning **03 Cr Hr** **00 ECTS**

Main topics to be covered include the following (see course website for more details): Reinforcement learning framework, Bandit problems and action selection, Dynamic programming, Monte Carlo methods, Temporal difference learning, Planning in RL, Function approximation for generalization, Actor-critic and gradient-based optimization, Multi-agent reinforcement learning, Training agents and evaluating performance.

Relevant QAA Computing Curriculum Sections: Artificial Intelligence, Data Structures and Algorithms, Intelligent Information Systems Technologies, Simulation and Modelling

Prerequisites:
Corequisites:

CE762 Natural Language Processing **03 Cr Hr** **00 ECTS**

This course will cover the following aspects of Natural Language Processing (NLP): tokenization, tagging, parsing, morphology, electronic dictionaries, problems in homonyms and disambiguation in general, machine translation, syntax, grammatical theories, CD structures, RTNs, ATNs, electronic grammar checking, statistical language processing: Bayes Rules and Hidden Markov Models. The course provides students with understanding the relevance of Natural Language Processing (NLP) as a sub-field of Artificial Intelligence, the complexity of NLP applications, and on the basis of a detailed analysis, point at the problem and become sensible w.r.t a solution, getting familiar with NLP tools and apply them, acquiring knowledge in the subfields of NLP: morphology, Tokenization, Tagging, electronic dictionaries, Syntax, Semantics, Machine Translation (rule-based and statistical), Text Mining, and Speech Recognition, understanding the connection between NLP and Computational Linguistics, i.e. different views on the same field, become sensible to problems in the NLP field - focusing on disambiguation on different levels (word-, sentence-, text-, web), have acquired theoretical skills across the entire field of NLP and will be able to apply them and be able to analyze an NLP problem, design & implement a prototypical solution and document the work.

Prerequisites:
Corequisites:

CE763 Deep Learning **03 Cr Hr** **00 ECTS**

This course concerns the latest techniques in deep learning and representation learning, focusing on supervised and unsupervised deep learning, embedding methods, metric learning, convolutional and recurrent nets, with applications to computer vision, natural language understanding, and speech recognition.

Prerequisites:
Corequisites:

CE764 Digital Signal Processing **03 Cr Hr** **00 ECTS**

Theory and algorithms for processing deterministic and stochastic signals. Topics include sampling theory, discrete-time signals, systems, and transforms, digital filtering, spectrum estimation, autoregressive modeling, efficient sampling rate alteration, perfect reconstruction filter banks, transmultiplexers, and Minimum Mean Square Error Estimation.

Prerequisites:
Corequisites:

CE771 Internet of Things **03 Cr Hr** **00 ECTS**

This course provides a sound introduction to the Internet of Things (IoT) technologies and system design concepts. The course will focus on important IoT topics, which includes: industrial standards, sensor/actuator/data devices, hardware, software, security, system design and performance analysis techniques.

Prerequisites:
Corequisites:

CE772 Computer Security **03 Cr Hr** **00 ECTS**

Methods and techniques for the design of computer networks, management and business perspectives on network design, estimation of traffic demand and application requirements, network cost analysis, topological design, capacity planning and network optimization, availability analysis and survivable network design. Furthermore, this course covers the following main security topics: Cryptography algorithms: Computer Networks concepts. Data encryption algorithms DES, Advanced encryption AES, Hash functions, Trusting issues, Legal and ethical issues in computer security. Access control, System management, User authentication, files protection, designing trusted OS. Writing secure code, Malicious Software, Viruses, static and dynamic buffer overflow attacks, data encapsulation, coupling and cohesion concepts, e-mail security. Threats in networks, network security controls, firewalls, intrusion detection, VPN networks, Key management, RSA algorithm, Digital signature, IPSec, Certificate authorities CA, Denial of service attacks DoS, High-speed network and cloud security (e.g., MPLS Security).

Prerequisites:
Corequisites:

CE773 Human Machine Interaction **03 Cr Hr** **00 ECTS**

The course highlights the design, development, and evaluation of human-computer interfaces, with an emphasis on usability, interaction paradigms, computer-mediated human activities, and implications to society. These issues are studied from a number of perspectives including that of the engineer and end-user. A team-based project applies your knowledge and skills to the full life cycle of an interactive human-computer interface.

Prerequisites:
Corequisites:

CE774 Innovation and Entrepreneurship **03 Cr Hr** **00 ECTS**

This course aims to provide students with an understanding of the nature of enterprise and entrepreneurship and introduces the role of the entrepreneur, innovation and technology in the entrepreneurial process. It is not about small business or life style businesses but instead the development of growth-oriented businesses - whether for-profit or not-for-profit. Entrepreneurship is both a way of thinking and of doing. It involves "building something from nothing" and successful entrepreneurs know how to manage and mitigate uncertainty and risk. The course content is relevant to those individuals thinking about starting a business or who are already in business - large or small, those who are interested in commercializing their own innovations or of others, and those who advise entrepreneurs or engage in policy making in the entrepreneurship area.

Prerequisites:
Corequisites:

13755 Enterprise Mobile Computing **03 Cr Hr** **00 ECTS**

The goal of this course is to provide an in depth understanding of the fundamental problems in the area of integration of Mobile Devices into Enterprise Systems and study the existing and proposed solutions for these problems from both research and development perspective. This course will introduce students to mobile computing and mobile application development. Topics covered include: mobile and wireless environment; mobile device technology; mobile computing architecture and protocols; mobile computing security; and applications in wireless and mobile computing, including distribution applications, mobile middleware, mobile information and database access, mobile multimedia, remote execution, user interface and user experience. Students will be expected to learn at least one mobile application development framework (Android) and use it to implement their assignments and course project.

Prerequisites:
Corequisites:

13789 IT Project Management **03 Cr Hr** **00 ECTS**

The main goal of this course is to gain a clear understanding of the five IT Project Management Process Groups (Initiating, Planning, Executing, Monitoring and controlling, and Closing) and learn how these processes interact with each other to successfully achieve project objectives. Discover how to integrate the ten Knowledge Area processes, tools and templates in the work place. Concepts include stakeholders, scope, quality, time, cost, human resources, communication, risk, procurement and project integration management. Students will also apply techniques such as stakeholder analysis, work breakdown structure, scheduling, estimating, risk assessments, contracts and change control. Students will have opportunity to apply project management principles to real-world situations.

Prerequisites:
Corequisites:

CE791 Special Topics in Computer Engineering **03 Cr Hr** **00 ECTS**

This course is offered to graduate level students in computer engineering. It gives them exposure to special topics in computer engineering. Topics may vary each time the course is offered. Details of the course will be advertised by the department at the time of offering.

Prerequisites:
Corequisites:

3. Thesis/Comprehensive Exam/Other

CE751 Master thesis A **00 Cr Hr** **00 ECTS**

During the master thesis, students are expected to conduct extensive research on topics related to the field of computer engineering. Moreover, a defense examination will be conducted to evaluate the student's capabilities of carrying out research, with a focus on the analysis and interpretation of the results obtained during the period of the master thesis.

Prerequisites:
Corequisites:

CE752 Master thesis B **03 Cr Hr** **00 ECTS**

During the master thesis, students are expected to conduct extensive research on topics related to the field of computer engineering. Moreover, a defense examination will be conducted to evaluate the student's capabilities of carrying out research, with a focus on the analysis and interpretation of the results obtained during the period of the master thesis.

Prerequisites:
Corequisites:

CE753 Master thesis C **06 Cr Hr** **00 ECTS**

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CE754 Master thesis D **09 Cr Hr** **00 ECTS**

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