Computer Engineering Program

Mission

The mission of the Computer Engineering (CE) Program is to prepare students for rewarding careers and higher education, engage in scientific research pushing the frontiers of the field even further, and get involved in local community issues requiring specialist participation.

Objectives

The Computer Engineering Program is designed such that its students upon graduation will:

1. Possess the highest level of technical robustness in the field of computer engineering that will earn them recognition and esteem among their colleagues.
2. Have the knowledge and skills to invent novel technology, provide creative designs, and suggest innovative solutions to challenging problems.
3. Stay abreast of emerging technologies, continually learning new theory and skills to nourish ever-developing careers.
4. Demonstrate good citizenship, fulfilling their professional responsibilities towards their communities, Lebanon, and the World at large.
5. Excel on multi-disciplinary and multi-cultural teams, and effectively employ their oral and written communication skills to resolve problems.

Learning Outcomes

UPON COMPLETION OF THE PROGRAM GRADUATES SHALL HAVE:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

Degree Requirements

The undergraduate curriculum for the degree of Bachelor of Engineering in Computer Engineering consists of 150 credit-hours of course work + IC003, where the standard duration of study is 10 semesters.

Career Opportunities

The Computer Engineering career encompasses opportunities in a wide range of areas such as industry, military, communications, aerospace, business, government, medicine, to name but a few. Computer engineering is in steady progress with an ever-expanding job market. Specific jobs include the functions of designing, analyzing, and maintaining computer systems. Furthermore, graduates can analyze, design, test, and evaluate network systems. In addition, they can develop, create, and modify general information security schemes. In addition, they can develop, and test systems and application software programs. Trending areas in computer engineering comprise artificial intelligence and machine learning, cybersecurity, smart cities, autonomous driving, vehicular networks, and more. Indeed, computer engineers enjoy high job satisfaction as reflected in market studies. In modern terms, computer engineers are digital transformation and world smartification leaders, believers in sustainable development, technology entrepreneurs and professionals with an engineering mindset!

Program Overview

The Bachelor of Computer Engineering consists of 150 credit-hours of course work. The **Student's Study Plan** is given to every CE student upon his/her enrollment. The CE curriculum consists of the following components:

I. Common Requirements	**Credits**
General Education Requirements	20
Basic Sciences and Mathematics	26
General Engineering topics	9
II. CE Program-Specific Requirements	**Credits**
A. Engineering topics from outside the program	9
B. CE Core	74
C. Technical Electives	12

I. Common Requirements

The list of the Common Requirement courses and their descriptions are presented in the introductory pages of the Faculty of Engineering section in this catalog.

II. CE Program-Specific Requirements

A. Engineering Topics from outside the major

This part of the CE curriculum includes 9 credits courses offered by other engineering programs. These courses are listed in the table below.

Course	**Title**	**Credits**	**Pre-/Co-requisites**
POWE 212	Electric Circuits I	3	
COME 223	Digital Electronics	3	POWE 212
COME 411	Instrumentation	3	COME 221 or COME 223
		9	

Description of the Courses:

POWE 212 ELECTRIC CIRCUITS I (3 Crs.: 3 Lec, 0 lab): Circuit variables: voltage, current, power, and energy. Circuit elements: resistors, inductors, capacitors, voltage sources, and current sources. Circuit reduction techniques: series and parallel resistors and delta-to-wye transformation. Ohm's law. Kirchhoff's laws. DC and AC circuit analysis techniques: node-voltage and mesh-current methods, source transformations, Thévenin and Norton equivalent circuits, and maximum power transfer. Self and mutual inductances. AC steady-state power calculations. Balanced three-phase circuits.

COME 223 DIGITAL ELECTRONICS (3 Crs.:2 Lec, 2 Lab): Characteristics of bipolar and field effect transistors. Switching mode of operation. BJT digital families: TTL, Schottky TTL, ECL. MOS digital families: NMOS, CMOS. A/D and D/A converters. ***Pre-req.: POWE 212.***

COME 411 INSTRUMENTATION (3 Crs.: 2 lec, 2 lab): Different types of transducers and their applications. Instruments used in measuring electrical quantities. Display instruments. Signal generators. Digital to analog and analog to digital conversion. Data acquisition systems components, hardware and software. ***Pre-requisite: COME 221 or COME 223***

B. Computer Engineering Program Core

The CE program core courses are listed in the following table:

Course	Title	Credits	Pre-/Co-requisites
ENGR 002	Introduction to Engineering	2	
COMP 210	Programming II	3	Pre: COMP 208
COMP 215	Programming for Engineers	3	Pre: COMP 208
COMP 225	Digital Systems I	3	
COMP 226	Digital Systems II	3	Pre: COMP 225
COMP 231	Discrete Structures	3	Pre: MATH 282
COMP 232	Data Structures	3	Pre: COMP 210, COMP 231
COMP 311	Object Oriented Programming	3	Pre: COMP 210
COMP 325	Microprocessor Organization and Design	3	Pre: COMP 226
COMP 337	Analysis and Design of Algorithms	3	Pre: COMP 232
COMP 344	Database Systems	3	Pre: COMP 232
COMP 361	Control Systems for Computer Engineers	3	Pre: MATH 283, POWE 212
COMP 364	Introduction to Artificial Intelligence and Machine Learning	3	COMP 215
COMP 423	Computer Architecture	3	Pre: COMP 325 or COMP 326 or COMP 328 or COMP 335
COMP 428	Digital Systems Design	3	Pre: COMP 226
COMP 442	Software Engineering	3	Pre: COMP 311
COMP 443	Operating Systems	3	Pre: COMP 423
COMP 452	Compilers	3	Pre: COMP 311
COMP 453	Transmission and Processing of Digital Signals	3	Pre: COMP 231
COMP 454	Computer Networks	3	Pre: COMP 225
COMP 454L	Computer Networks Lab	1	Co: COMP 454
COMP 499	Internship	1	
COMP 500	Research Methodology	2	ENGL 300
COMP 501	Final Year Project I	1	Pre/Co: COMP 500 Pre: INME 221*
COMP 502	Final Year Project II	3	Pre: COMP 500
COMP 525	Embedded and Microprocessor Systems	3	Pre: COMP 325
COMP 543	Cryptography and Information Security	3	Pre: COMP 232
COMP 543L	Cryptography and Information Security Lab	1	Co: COMP 543
		74	

***** INME 221 is pre. for COMP 501 starting from Spring 2023/2024

C. Computer Engineering Tracks

The CE program provides the following track options:

1. Artificial Intelligence and Machine Learning (19 Credits):
    a. Mandatory track base (10 Credits): COMP 215, COMP 364, and COMP 501 and COMP 502 (A Capstone Design Project in Machine Learning and Artificial Intelligence)
    b. Track cap (9 Credits): Select three elective courses rom the following mandatory list: COMP 474, COMP 477, COMP 533, COMP 534, COMP535, COMP551, COMP 560, COMP 564, COMP 565, COMP 568
2. Networks and Cybersecurity (19 Credits):
    a. Mandatory track base (10 Credits): COMP 454, COMP 543, and COMP 501 and COMP 502 (A Capstone Design Project in Networks and Cybersecurity)
    b. Track cap (9 Credits), select three elective courses from the following mandatory list: COMP 431, COMP 455, COMP 477, COMP 505, COMP 510, COMP 512, COMP 529, COMP 532, COMP 554, COMP 555, COMP 556, COMP 559, and COMP 567

Students not joining a track can freely select their major elective courses.

Description of Core Courses

ENGR 002 INTODUCTION TO ENGINEERING (2Crs.: 2Lec, 0Lab): Introducing the student to the engineering profession in general and the learning objectives that new students should attain, as aligned with the ABET requirements. Covering the basics of the engineering profession and engineering ethics. Introduction to the different engineering majors and to the learning objectives as specified by ABET. Insight into different engineering courses that are not technical in nature (e.g., engineering economy). Engineering design tasks that allow the student to start thinking as engineers: problem definition, specification of constraints, investigation of different solution alternatives, implementation of best solution, writing technical reports. Fundamental tools and numerical software used in engineering.

COMP 210 PROGRAMMING II (3Crs.: 2Lec, 2Lab): Recursion. Arrays, basic sorting and searching. Pointers. Functions (call by reference). Character and strings. Structures, union, and bit manipulation. File operations, sequential and random. Preprocessing directives. ***Pre-req.: COMP 208.***

COMP 215 PROGRAMMING FOR ENGINEERS (3Crs.: 2Lec, 2Lab): Programming in Python for engineers: language, use of external libraries, runtime analysis, applications from data analysis and engineering. Topics include: Control statement and program development, functions, sequences: list and tuples, dictionaries and sets, a deeper look on strings, Array-Oriented Programming with NumPy, and plotting using Matplotlib. ***Pre-req.: COMP 208.***

COMP 225 DIGITAL SYSTEMS I (3Crs.: 2Lec, 2Lab): Number systems and coding, Binary systems. Conversion from decimal to other bases. BCD numbers. Boolean algebra. Logic gates. Function minimization, Tabular method, Karnaugh mapping. Arithmetic functions and circuit design (HA, FA, and ALU). Combinational functions and circuit design (decoder, encoder, multiplexer and de-multiplexer). Sequential circuits components (Latches, RS-FF, D-FF, JK-FF, T-FF). Several laboratory experiments will be based on simple logic gates.

COMP 226 DIGITAL SYSTEMS II (3Crs.: 2Lec, 2Lab): Latches and flip-flops. Synchronous and asynchronous sequential systems. Design of sequential circuits using state diagrams. Registers and Counters. Programmable logic devices (PAL and PLA). Control and Datapath units. Cache memory concept. Serial data transfer for multiple registers. Types of RAM and ROM. Cache memory concept. ALU functions and circuits. Binary multipliers. BCD functions and circuits. Several laboratory experiments and projects will be based on course topics. ***Pre-req.: COMP 225.***

COMP 231 DISCRETE STRUCTURES (3Crs.: 3Lec, 0Lab): Logic statements, Conditional statements and Arguments. Digital Logic Circuits and Boolean algebra. Quantified Statements, Universal and Existential Quantification. Methods of Proof and Reasoning, Direct and Indirect Proof. Mathematical induction and Recurrence relations. Sequences, Counting and Functions generation. Sets and Power sets. Functions and Relations. Trees and Graphs. ***Pre-req.: MATH 282.***

COMP 232 DATA STRUCTURES (3Crs.: 2Lec, 2Lab): Elementary data types. Arrays. Study of complexity of algorithms. Linked lists. Queues. Stacks. Trees: traversal, Binary search trees. Binary heaps, Balanced trees: AVL trees, B trees. Binomial queues. Fibonacci queue. Hashing. File Structure ***Pre-req.: COMP 210, COMP 231.***

COMP 311 OBJECT ORIENTED PROGRAMMING (3Crs.: 2Lec, 2Lab): Object–oriented design versus structured design. Classes and objects. Inheritance. Polymorphism. Information hiding and abstract data types. Overloading. Abstract classes. Exception handling. ***Pre-req.: COMP 210.***

COMP 325 MICROPROCESSOR ORGANIZATION AND DESIGN (3Crs.: 2Lec, 2Lab): This course introduces the organization and gradual design of generic central processing units (CPUs), focusing on the role of a CPU as the core of computer systems. Topics include arithmetic logic unit design; control unit design; registers; and address, data and control buses. Organization of single and multi-core processors. Machine and assembly languages of a standard microprocessor are used to illustrate the design and its interface with upper layers such as operating systems. Labels. Flags. Masking. Time Delays. Serial versus parallel I/O. Handshaking. Several laboratory experiments will be based on microcontrollers. ***Pre-req.: COMP 226.***

COMP 337 DESIGN AND ANALYSIS OF ALGORITHMS (3Crs.: 2Lec, 2Lab): Algorithm design and analysis. Simple Sorting and Searching Algorithms. Theory of NP completeness and tools for analyzing efficiency; Design of data structures, insert, search and delete functions. Advanced Sorting and Searching Algorithms, including recurrence, divide-and-conquer, dynamic programming, and greedy algorithms. Trees and graph algorithms. ***Pre-req.: COMP 232.***

COMP 344 DATABASE SYSTEMS (3Crs.: 2Lec, 2Lab): Components of database systems: DBMS functions. Database architecture and data integrity. Data modeling: conceptual models, relational data model, conceptual schema, relational schema, relational algebra and relational calculus. Database query languages: SQL functional dependency, decomposition, normal forms. Higher normal forms. Storage and file structure, Indexing. ***Pre-req.: COMP 232.***

COMP 361 CONTROL SYSTEMS FOR COMPUTER ENGINEERS (3Crs.: 2Lec, 2Lab): Types of control systems. Advantages and limitations of using digital processors in control systems. System representation: transfer function, block diagram, signal-flow-graph. Time domain analysis: steady state and transient analysis. Frequency domain analysis. Practical implementations using MATLAB. ***Pre-req.: MATH 283, POWE 212***

COMP 364 INTRODUCTION TO ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING (3Crs.: 2Lec, 2Lab): Introduction to AI and Machine Learning. Supervised and unsupervised learning. Rule-based, Goal-based Agents vs intelligent systems. Data Analytics and Knowledge representation and reasoning. Linear Algebra for AI. Introduction to regression algorithms. Introduction to neural networks. Design of Shallow neural nets. Implementation of various AI and machine learning Algorithms. ***Pre-req.: COMP 215***

COMP 423 COMPUTER ARCHITECTURE (3Crs.: 2Lec, 2Lab): Organization vs Architecture. Fundamentals of computer design, Von-Neuman machine. Computer evolution and performance. Computer function and interconnection. Memory systems (Internal, external and cache). Input/Output modules. Instruction Sets: Characteristics, functions, addressing modes and formats. RISC and CISC. Assembly and machine languages. Processor implementation techniques. Pipelining. Performance enhancements. ***Pre-req.: COMP 325 or COMP 326 or COMP 328 or COMP 335***

COMP 428 DIGITAL SYSTEMS DESIGN (3Crs.: 2Lec, 2Lab): Overview of different design styles and abstraction methods of digital system design. VHDL: The program language aspects for modelling and specification. The abstraction levels of the VHDL language, high-level synthesis tools. FPGA, PLA, and PAL. Components, Instantiation, Parallel expressions, Functions and Procedures using different approaches to writing VHDL architectures: dataflow, behavioral, and structural models. Using VHDL for Sequential Circuits, registers, counters, multipliers, and shifters. FSM (Finite State Machine), and describing replicated Logic. ***Pre-req.: COMP 226***

COMP 442 SOFTWARE ENGINEERING (3Crs.: 3Lec, 0Lab): Concepts of software development. Lifecycle of software. Requirements and specification. Data models. Process models. Design and coding. Verification, validation and testing. Software evolution. ***Pre-req.: COMP 311.***

COMP 443 OPERATING SYSTEMS (3Crs.: 2Lec, 2Lab): Basic operating systems and their components; concurrency, scheduling and dispatch, memory and device management, file systems and performance evaluation, real-time operating systems, operating systems for mobile devices. Practical experience with state-of-the-art Linux/Unix kernels. ***Pre-req.: COMP 423.***

COMP 452 COMPILERS (3Crs.: 2Lec, 2Lab): Introduction to language translation. Language translation phases. Generators. Lexical analysis: Regular expressions; NFA; DFA. Syntactic analysis: Formal definition of grammars; BNF and EBNF; bottom-up vs. top-down parsing; Tabular vs. recursive-descent parsers; Error handling; Models of execution control. Declaration, modularity, and storage management. Code generation. Emphasis on automatic compiler generation and compiler-compiler tools. ***Pre-req.: COMP 311.***

COMP 453 TRANSMISSION AND PROCESSING OF DIGITAL SIGNALS (3Crs.: 2Lec, 2Lab): Sampling and discrete time signals. The z-transform. Quantization. Histograms. Recursive and non- recursive digital filters. Frequency response and the Discrete Fourier Transform. Processing in 2 dimensions. Finite precision implementation errors. Encoding digital signals. Modulation. Multiplexing. The physical layer of the OSI model. Synchronous and asynchronous transmission. ***Pre-req.: COMP 231.***

COMP 454 COMPUTER NETWORKS (3Crs.: 3Lec, 0Lab): The OSI Model. The TCP/IP stack. Application Layer protocols. Transport Layer protocols. Network Layer protocols. Data Link Layer protocols. Frame format: character stuffing, bit stuffing. Error control. Automatic-repeat request and sliding-window protocols. Local area networks: Ethernet, token ring and FDDI, wireless LANs. Circuit switching versus packet switching. Routing and forwarding algorithms. Network Address Translation (NAT). SSH Port Forwarding/Tunneling. ***Pre-req.: COMP 225.***

COMP 454L COMPUTER NETWORKS Lab (1Cr.: 0Lec, 3Lab): The lab materials cover topics discussed in COMP 454. ***Co-req.: COMP 454.***

COMP 499 INTERNSHIP (1Cr): This is a professional training which should not be less than four weeks. The training is followed by a presentation session where the students are supposed to present what they have learned.

Refer to the department policy for further details.

COMP 500 RESEARCH METHODOLOGY (2Crs.: 2Lec, 0Lab): Why to Conduct Scientific Research, Stepping in: Research Methodology, Formulating a research problem, conceptualizing a research design, constructing an instrument for data collection, Selecting samples, writing a research proposal, collecting data, processing & displaying data, writing a research report. Conducting Scientific Research at the faculty of Engineering. ***Pre-req.: ENGL 300***

COMP 501 FINAL YEAR PROJECT I (1Cr) / COMP 502 FINAL YEAR PROJECT II (3Crs): After completing 110 credits of course work, the student becomes eligible to sign up for the Final Year Project (FYP) that extends over two semesters; beginning in Fall-semester and ending in the following Spring-semester. The FYP experience requires students to work in teams to complete a specific project, submit a technical report, and give a presentation on a significant, relevant, and comprehensive engineering problem. The FYP is intended to stimulate student creativity and critical thinking, and build skills in formulating, designing, developing, building, communicating, and managing engineering projects. The project aims to provide students with a transitional experience from the academic world to the professional world. ***Pre/Co-req.: COMP 500, Pre: INME 221****
(* INME 221 is pre. for COMP 501 starting from Spring 2023/2024)

Refer to the Final Year Project Policy for more details.

COMP 525 EMBEDDED AND MICROPROCESSOR SYSTEMS (3Crs.: 2Lec, 2Lab): Microprocessor-based embedded systems, synchronous and asynchronous serial communication, interfacing, interrupt handling, data acquisition, real-time processing. Several laboratory experiments will be based on microprocessors and microcontrollers. ***Pre-req.: COMP 325***

COMP 543 CRYPTOGRAPHY AND INFORMATION SECURITY (3Crs.: 3Lec, 0Lab): Measures of information. Elementary ciphers. Complexity measures. Designing a generic block cipher. Modes of operation. Attacks against block ciphers. Message digests. Cryptographic hash functions. Public key. cryptography. Diffie-Hellman key exchange. RSA. Digital signature schemes. Pseudo-random bit generators. Authentication techniques. Applications. ***Pre-req.: COMP232***
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COMP 543L CRYPTOGRAPHY AND INFORMATION SECURITY LAB (1Cr.: 0Lec, 2Lab): The lab materials cover topics discussed in COMP 543. ***Co-req.: COMP 543.***

A. Computer Engineering Program Technical Electives

The CE curriculum includes 12 credits as technical electives. The courses are chosen from the courses listed in the following table:

Course	Title	Credits	Pre-/Co-requisites
COMP 431	Queuing and Modeling	3	Pre: MATH 381
COMP 438	Performance Evaluation	3	Pre: COMP 325 and MATH 283
COMP 444	System Programming	3	Pre: COMP 443
COMP 455	Mobile Computing	3	Pre: COMP 210
COMP 464	Operations Research for Computer Engineering	3	Pre: COMP 231
COMP 474	Introduction to Robotics	3	Pre: COMP 325, or COMP 326, or COMP 328 or COMP 335
COMP 477	Emerging Trends in Computer Engineering	3	Pre: COMP 325 or COMP 232
COMP 505	Cybersecurity 1	3	Pre: COMP 454 or COME 580
COMP 510	Internet Engineering	3	Pre: COMP 454 or COME580
COMP 512	Web Programming	3	Pre: COMP 344
COMP 529	Hardware Security	3	Pre-req.: COMP 454 or COME580
COMP 530	Hardware/Software Co-Design	3	Pre: COMP225
COMP 532	Information Theory & Coding	3	Pre: COMP 337, MATH 381
COMP 533	Computer Graphics	3	Pre: COMP 311
COMP 534	Pattern Recognition	3	Pre: COMP 231
COMP 535	Digital Image Processing	3	Pre: COMP 453
COMP 541	Software Development	3	Pre: COMP 442
COMP 551	Machine Learning	3	Pre: COMP 364
COMP 554	IoT Platform Design and Implementation	3	Pre: COMP 454 or COME580
COMP 555	Wireless Security	3	Pre: COMP 454 or COME580
COMP 556	Sensor Networks	3	Pre: COMP 454 or COME580
COMP 559	Internet Security	3	Pre: COMP 454 or COME580
COMP 560	Deep Learning	3	Pre: COMP 364
COMP 561	Digital Control	3	Pre: COMP 361
COMP 564	Natural Language Processing	3	Pre: COMP 364
COMP 565	Computer Vision	3	Pre: COMP 364
COMP 567	Blockchain Network Programming	3	Pre: COMP 454 or COME580
COMP 568	Soft Computing	3	Pre: COMP 232
ENGR 003	Engineering Project Management	3	Pre: ENGL 300
COME 221	Electronic Circuits I	3	Pre: POWE 212.

Computer Engineering Program Technical Electives

The CE curriculum includes 12 credits as technical electives. The courses are chosen from the courses listed in the following table:

COMP 431 QUEUING AND MODELING (3Crs.: 2Lec, 2Lab): Random variables, Performance measures. Markov processes. Birth/death processes. Solving Markov models. Continuous and discrete queuing models: M/M/1, M/M/m, M/M/m/m, M/M/1/K, M/G/1. Little's law. Networks of queues. Burke's theorem. Jackson's theorem. Stochastic Petri nets. GSPN. ***Pre-req.: MATH 381.***

COMP 438 PERFORMANCE EVALUATION (3Crs.: 2Lec, 2Lab): Workload performance indices. Single and multiple job processing models. Scheduling policies. Paging techniques. Performance of computing systems: hardware and software implementations. Performance of computer system applications: networks (scheduling, protocols, etc.), signal processing, machine learning, cryptography, etc. Benchmarks. Classification performance metrics: statistical and machine learning models. ***Pre-req.: COMP 325 and MATH 283.***

COMP 444 SYSTEM PROGRAMMING (3Crs.: 2Lec, 2Lab): introduce the student to the process of writing low-level programs that interact directly with a computer's operating system and hardware: Programming under UNIX : File I/O, makefiles, advanced debugging (gdb), Signal handling, and Scripting, Concurrent programming. ***Pre-req.: COMP 443.***

COMP 455 MOBILE COMPUTING (3Crs.: 2Lec, 2Lab): A general introduction to mobile computing with a strong focus on application development for the Android operating system. Students will complete a major project with the objective of publishing an application/service on the Google Play store. Android development environment, user interfaces, activities, intents, persistence, networking, location, sensors, graphics, and other Android features, tools, and capabilities. ***Pre-req.: COMP 210.***

COMP 464 OPERATIONS RESEARCH FOR COMPUTER ENGINEERS (3Crs.: 3Lec, 0Tut): Linear programming: Graphical solution; Simplex method; Duality and sensitivity analysis; Polynomial-time solutions. Decision making and game theory. Network flows. Optimization techniques. Non-linear programming. Transportation Model, PERT/CPM. ***Pre-req.: COMP 231.***

COMP 474 INTRODUCTION TO ROBOTICS (3Crs.: 2Lec, 2Lab): Kinematics and dynamics for mobile and articulated robots. Description models applicable for robot system, such as homogeneous transforms etc. Sensors, actuators and other robot hardware. Algorithms for calculation of inverse kinematics, robot dynamics, trajectories and planning. Software architectures for robot systems and simulators. Ethical and industrial aspects. **Pre-req.: COMP 325 or COMP 326 or COMP 328**

COMP 477 EMERGING TRENDS IN COMPUTER ENGINEERING (3Crs.: 2Lec, 2Lab): This course covers current technology in computer Engineering. Topics will vary every year. ***Pre-req.: COMP 325 or COMP 232***

COMP 505 Cybersecurity 1 (3Crs.: 2Lec, 2Lab): The Cyber Security course identifies the networking and computer systems vulnerabilities, to recognize digital exploitation and also prevent damage such as loss of data. The course covers topics such as Cyber Security Essentials, various threats, and the importance of awareness. Additionally, the course includes different types of malwares, as well as methods for detecting/preventing intrusions, implementing Backup & Recovery Solutions, setting up firewalls, VPNs, and proxies. ***Pre-req.: COMP 454 or COME 580***

COMP 510 INTERNET ENGINEERING (3Crs.: 2Lec, 2Lab): This course provides a comprehensive coverage of the major advancements in the Internet architecture with a focus on routing protocols and their design and a deep analysis of the internals of the Transmission Control Protocol (TCP) and the Internet Protocol (IP). The course also discusses recent developments on the Internet such as software-defined networking. ***Pre-req.: COMP 454 or COME580***

COMP 512 WEB PROGRAMMING (3Crs.: 2Lec, 2Lab): Introduction to HTML, CSS and JavaScript. Server-side programming: Web Servers, Web-Server Scripting language (PHP/ASP/JSP), Website development using Content Management Systems. ***Pre-req.: COMP 344.***

COMP 529 HARDWARE SECURITY (3Crs.: 3Lec, 0Lab): Hardware perspective of security and trust: vulnerabilities in modern digital system design flow, physical attacks, building secure and trusted hardware. Development of hardware security cores (special purpose processors, ASIPs, pipelined, and partitioned implementations) with optimized performance characteristics (area, speed, power consumption, etc.). Provably correct hardware security and formal engineering methods. ***Pre-req.: COMP 454 or COME580***

COMP 530 HARDWARE/SOFTWARE CO-DESIGN (3Crs.: 2Lec, 2Lab): Design models: state machines, concurrent process models, dataflow diagrams, communicating sequential processes (CSP) notation, etc. Co-design principles: partitioning, co-synthesis, co-simulation, modern tools. Methodologies: transformational derivation, formal models, testing, verification, correctness, functional programming in hardware design, concurrency frameworks, synthesis of parallel algorithms. Rapid prototyping: hardware compilers, code generators and IDE design. Review of state-of-the-art published research. This course has a project component that targets applications from computer, communication, power, and biomedical engineering. ***Pre-req.: COMP 225***

COMP 532 INFORMATION THEORY AND CODING (3Crs.: 3Lec, 0Lab): Zero-memory and Markov information sources. Entropy. Block codes. Minimum-redundancy codes. Bounds on the average length of the code. Information channels. Channel capacity. Error detection. Shannon's fundamental theorem. Hamming distance. Decoding schemes. Error correcting codes: parity check codes, cyclic codes. ***Pre-req.: COMP 337, MATH 381***.

COMP 533 COMPUTER GRAPHICS (3Crs.: 2Lec, 2Lab): Introduction to Computer graphics. Linear Algebra for Computer graphics. Raster Images. Ray tracing. 2-D, 3-D and Affine Transformations. Viewing and Projections. Graphics pipeline, Rasterization, Clipping and Hidden surface removal. Surface shading, Shadows and Color. Open-GL applications ***Pre-req.: COMP 311.***

COMP 534 PATTERN RECOGNITION (3Crs.: 2Lec, 2Lab): Pattern recognition techniques are used to design automated systems that improve their own performance through experience. This course covers the methodologies, technologies, and algorithms of statistical pattern recognition from a variety of perspectives. Topics including feature extraction, Bayesian decision theory, nearest-neighbor rules, clustering, support vector machines, neural networks, classifier combination, and syntactic pattern recognition techniques such as stochastic context-free grammars will be presented. ***Pre-req.: COMP 231.***

COMP 535 DIGITAL IMAGE PROCESSING (3Crs.: 2Lec, 2Lab): Image formation and perception. Image representation. Transformations on digital images. Enhancement and restoration. Segmentation. Encoding and data compression. ***Pre-req.: COMP 453.***

COMP 541 SOFTWARE DEVELOPMENT (3Crs.: 1Lec, 4Lab): Covers current technology in computer software. Software engineering management, cost and quality metrics and estimation. Project team organization and management. Students will work in teams on a substantial programming project. ***Pre-req.: COMP 442***.

COMP 551 MACHINE LEARNING (3Crs.: 2Lec,2Lab*):* Machine learning and statistical pattern recognition. Applications of machine learning in robotic control, data mining, autonomous navigation, bioinformatics, speech recognition, and text and web data processing. Also, includes supervised learning, generative/discriminative learning, parametric/non-parametric learning, neural networks, support vector machines; unsupervised learning, clustering, dimensionality reduction, kernel methods. ***Pre-req.: COMP 364***

COMP 554 IOT PLATFORM DESIGN AND IMPLEMENTATION (3Crs.: 2Lec, 2Lab): Overview of IoT prominent architectures and blueprint designs. Setting up IoT scenarios and workflow models. IoT sensor design with Arduino and Wi-Fi-controlled microchips. IoT and Cloud integration. Developing IoT applications with Raspberry Pi and Android. Python programming in IoT implementations. IoT Protocols: HTTP, CoAP, MQTT, AMQP, 6LoWPAN. Artificial Intelligence and machine learning models in IoT automation. Designing for Quality of Service and security in IoT architectures. ***Pre-req.: COMP 454 or COME580***

COMP 555 WIRELESS SECURITY (3Crs.: 2Lec, 2Lab): A course that discusses wireless network security protocols and applications. Security challenges in mobile and cellular networks. Security problems facing current and future wireless networks. Security attacks on mobile adhoc networks, vehicular networks, naming, addressing, and routing. Trust and privacy in the context of wireless networks. Wireless sensor network security challenges and solutions. ***Pre-req.: COMP 454 or COME580***

COMP 556 SENSOR NETWORKS (3Crs.: 2Lec, 2Lab): Wireless communication fundamentals, Short range radio communication standards (IEEE802.15.x protocols, e.g., Bluetooth, ZigBee), Architecture of wireless sensor networks (Node structure, types, network topologies), Operating systems for wireless sensor networks (TinyOS, Contiki), Network supported process measurements, MAC protocols for sensor networks, Routing protocols for sensor networks, Transport protocols for sensor networks. ***Pre-req.: COMP 454 or COME580***

COMP 559 INTERNET SECURITY (3Crs.: 3Lec, 0Lab): This course covers advanced concepts in network security and the different attack models at the 5 TCP/IP network layers. It comprehensively discusses the various security threats, the vulnerabilities in networking protocols and the attacks that exploit such vulnerabilities. The main topics covered in the course include the following: the security of Email and Web applications, the SSL protocol, the IPSec protocol, VPNs, SNMP security, intrusion detection mechanisms, intrusion backtracking, and firewalls. Practical attack generation, defense, and system hardening components will be considered in student projects as well as some Internet security research aspects. ***Pre-req.: COMP 454 or COME580***

COMP 560 DEEP LEARNING (3Crs.: 2Lec, 2Lab): Introduction to artificial neural networks. Logistic regression as an artificial neuron. Concept of Convolutional and Recurrent architectures. Mathematical representations and High-dimensional vectorization. Shallow vs Deep neural networks. Practical aspects of Deep Learning with applications using modern programming tools. Methods of Optimization and Hyper-Parameters Tuning. Real-world case studies and applications using python. ***Pre-req.: COMP 364.***

COMP 561 DIGITAL CONTROL (3Crs.: 2Lec, 2Lab): Compensation of control system. Design of compensators. Nonlinear control systems: phase-plane analysis and describing-function analysis. State-space representations. Linear state-space equations and their solutions. Computing the fundamental matrix. Properties of the state-space models: stability, controllability, observability. Pole placement and observers principles. Digital systems: advantages and disadvantages of using a digital processor. Sampling and reconstruction. Analysis of discrete-time systems. Design of digital controllers. ***Pre-req.: COMP 361.***

COMP 564 NATURAL LANGUAGE PROCESSING (3Crs.: 3Lec, 0Lab): Language modeling, part-of-speech tagging, speech recognition, speech synthesis, prosodic analysis, conversational dialogue, context-free grammars, syntactic parsing, coreference, text classification, sentiment analysis, and machine translation. Applications on Arabic, English and other languages. Programming in Python. ***Pre-req.: COMP 364***.

COMP 565 COMPUTER VISION (3Crs.: 3Lec, 0Lab): Computer vision fundamentals: image formation, camera imaging geometry, feature detection and matching, stereo, motion estimation and tracking, image classification, scene understanding, and deep learning with neural networks. Methods for applications: finding known models in images, depth recovery from stereo, camera calibration, image stabilization, automated alignment, tracking, boundary detection, and recognition. Practical implementations using tools, such as MATLAB and Python. ***Pre-req.: COMP 364***.

COMP 567 BLOCKCHAIN NETWORK PROGRAMMING (3Crs.: 2Lec, 2Lab): The course presents a general overview of Blockchain, from applications and administration to programming and infrastructure. Its main emphasis is on programming techniques for Blockchain decentralized distributed systems. The topics include overview of Blockchain, decentralized apps and smart contracts, Ethereum, IBM Hyperledger, Blockchain storage systems, Digital Currency systems. ***Pre-req.: COMP 454 or COME580***

COMP 568 SOFT COMPUTING (3Crs.: 3Lec, 0Lab): Soft computing techniques. Fuzzy sets, membership functions, fuzzy logic, fuzzy rules, fuzzy reasoning, fuzzification and defuzzification. Probabilistic reasoning, Bayesian network, evolutionary computation, genetic algorithms, simulated annealing, swarm intelligence, continuous optimization, combinatorial optimization, real-world problems. Practical implementations under MATLAB and Python. ***Pre-req.: COMP 232***.

Electrical and Computer Engineering Technical Electives

CE students have the opportunity to take up to 6 credits technical elective from the Electrical and Computer Engineering Department as long as the pre-requisite of the specified course is already taken, and the courses serve their major.

COME 221 (3Crs.: 3Lec, 0Lab): Introduction to semiconductor physics, junction diodes: construction, I-V characteristics, circuit models, applications, special purpose diodes: Zener diodes. Bipolar junction transistors (BJT) and field effect transistors (FET): types, physical structures, basic configurations, characteristic curves, circuit models, biasing circuits, small-signal amplifiers. **Pre-req.: POWE 212.**

Study Plan
Bachelor of Engineering in Computer Engineering (150 Credits)

First Semester (16 Credits)		**Crs.**	**Pre/Co-requisites**
MATH 281	Linear Algebra	**3**	MATH112
MATH 282	Calculus	**3**	MATH111
PHYS 281	Electricity and Magnetism	**3**	
ENGR 002	Introduction to Engineering	**2**	
MCHE 213	Dynamics	**3**	
ARAB 001	Arabic Language	**2**	

Second Semester (17 Credits)		**Crs.**	**Pre/Co-requisites**
PHYS 282	Material Properties and Heat	**3**	
MATH 283	Differential Equations	**3**	Pre: MATH 281, MATH 282
COMP 208	Programming I	**3**	
COMP 225	Digital Systems I	**3**	
POWE 212	Electric Circuits I	**3**	
ENGL 001	English Language	**2**	

Summer I (9 Credits)		**Crs.**	**Pre/Co-requisites**
ENGL 211	Advanced Writing	**2**	Pre: ENGL001
CHEM 241	Principles of Chemistry	**3**	
BLAW 001	Human Rights	**1**	
	General Elective	**3**	

Third Semester (17 Credits)		**Crs.**	**Pre/Co-requisites**
COMP 210	Programming II	**3**	Pre: COMP 208
COMP 215	Programming for Engineers	**3**	Pre: COMP 208
COME 223	Digital Electronics	**3**	Pre: POWE 212
COMP 226	Digital Systems II	**3**	Pre: COMP 225
COMP 231	Discrete Structures	**3**	Pre: MATH 282
ENGL 300	Speech Communications	**2**	Pre: ENGL211

Fourth Semester (18 Credits)		**Crs.**	**Pre/Co-requisites**
MATH 284	Numerical Analysis	**3**	Pre: MATH 283
MATH 381	Probability and Statistics	**3**	Pre: MATH 282
COMP 232	Data Structures	**3**	Pre: COMP 210, COMP 231
COMP 311	Object Oriented Programming	**3**	Pre: COMP 210
COMP 325	Microprocessor Organization and Design	**3**	Pre: COMP 226
INME 221	Engineering Economy	**3**	

Summer II (9 Credits)		**Crs.**	**Pre/Co-requisites**
MGMT 002	Entrepreneurship	**2**	
CHEM 405	Solid State Chemistry	**2**	
ENGR 001	Engineering Ethics	**1**	
	General Elective	**4**	

Fifth Semester (18 Credits)		**Crs.**	**Pre/Co-requisites**
COMP 337	Analysis and Design of Algorithms	**3**	Pre: COMP 232
COME 411	Instrumentation	**3**	COME 221 or COME 223
COMP 361	Control Systems for Computer Engineers	**3**	Pre: MATH 283, POWE 212
COMP 453	Transmission and Processing of Digital Signals	**3**	Pre: COMP 231
COMP 423	Computer Architecture	**3**	Pre: COMP 325 or COMP 326 or COMP 328 or COMP 335
	Technical Elective 1	**3**	

Sixth Semester (17 Credits)		**Crs.**	**Pre/Co-requisites**
COMP 364	Introduction to Artificial Intelligence and Machine Learning	**3**	Pre: COMP 215
COMP 428	Digital Systems Design	**3**	Pre: COMP 226
COMP 442	Software Engineering	**3**	Pre: COMP 311
COMP 454	Computer Networks	**3**	Pre: COMP 225
COMP 454L	Computer Networks Lab	**1**	Co: COMP 454
COMP 344	Database Systems	**3**	Pre: COMP 232
	General Elective	**1**	

Summer III (1 Credit)		**Crs.**	**Pre/Co-requisites**
COMP 499	Internship (Approved Experience / Independent Study)	**1**	

Seventh Semester (13 Credits)		**Crs.**	**Pre/Co-requisites**
COMP 500	Research Methodology	**2**	Pre: ENGL 300
COMP 501	Final Year Project I	**1**	Pre/Co: COMP 500, Pre: INME 221*
COMP 543	Cryptography and Information Security	**3**	Pre: COMP 232
COMP 543L	Cryptography and Information Security Lab	**1**	Co: COMP 543
	Technical Elective 2	**3**	
	Technical Elective 3	**3**	

Eighth Semester (15 Credits)		**Crs.**	**Pre/Co-requisites**
COMP 452	Compilers	**3**	Pre: COMP 311
COMP 502	Final Year Project II	**3**	Pre: COMP 500
COMP 525	Embedded and Microprocessor Systems	**3**	Pre: COMP 325
COMP 443	Operating Systems	**3**	Pre: COMP 423
	Technical Elective 4	**3**	

***** INME 221 is pre. for COMP 501 starting from Spring 2023/2024

Courses offered for other programs

The CE program offers four courses for other engineering majors. The courses are described below.

COMP 208 PROGRAMMING I (3Crs.: 2Lec, 2Lab): Computer fundamentals. Computer system components: hardware and software. Problem solving and flowcharts/pseudocode. High level programming: data types, structured programming constructs, input and output, expressions and assignments, selection, repetition, functions (call by value), introduction to arrays.

COMP 210 PROGRAMMING II (3Crs.: 2Lec, 2Lab): Recursion. Arrays, basic sorting and searching. Pointers. Functions (call by reference). Character and strings. Structures, union, and bit manipulation. File operations, sequential and random. Preprocessing directives. ***Pre-req.: COMP 208.***

COMP 225 DIGITAL SYSTEMS I (3Crs.: 2Lec, 2Lab): Number systems and coding, Binary systems. Conversion from decimal to other bases. BCD numbers. Boolean algebra. Logic gates. Function minimization, Tabular method, Karnaugh mapping. Arithmetic functions and circuit design (HA, FA, and ALU). Combinational functions and circuit design (decoder, encoder, multiplexer and de-multiplexer). Sequential circuits components (Latches, RS-FF, D-FF, JK-FF, T-FF). Introduction to VHDL. Several laboratory experiments will be based on the simple logic gates.

COMP 226 DIGITAL SYSTEMS II (3Crs.: 2Lec, 2Lab): Latches and flip-flops. Synchronous and Asynchronous sequential systems. Design of sequential circuits using state diagrams. Registers and Counters. Programmable logic devices (PAL and PLA). Control and Datapath units. Cache memory concept. Serial data transfer for multiple registers. Types of RAM and ROM. Cache memory concept. ALU functions and circuits. Binary multipliers. BCD functions and circuits. Several laboratory experiments and projects will be based on course topics. ***Pre-req.: COMP 225.***

COMP 326 INTRODUCTION TO MICROPROCESSOR WITH APPLICATIONS (3Crs.: 3Lec, 0Lab): An introduction to basic computer organizations: Memory, Registers and Counters. Control and Data path units. Data transfer for multiple register. RAM and ROM. Instruction sets; assembly and machine languages. Detailed study of a microcomputer architecture and instruction set; assembly language programming and techniques; interrupt control systems; parallel and serial interfaces; the design of various types of digital as well as analog interfaces. **Pre-req: COMP 225.**

COMP 326L INTRODUCTION TO MICROPROCESSOR WITH APPLICATIONS Lab (1Crs.: 0Lec, 2Lab): Laboratory provides practical hands-on experience with microprocessor and/or microcontrollers software application and interfacing techniques. **Pre-req: COMP 225 & Co-req: COMP 226.**

COMP 328 CPU DESIGN (3Crs.:2Lec, 2Lab): This course introduces the design of a generic central processing unit (CPU), focusing on its role as the core of computer systems. Topics include arithmetic logic unit design, control unit design, registers, address, data, and control buses, with reference to standard implementations. Single and multi-core processors. Machine and assembly languages of a standard microprocessor are used to illustrate the design and its interface with upper layers such as operating systems, control drivers, and compilers. Several laboratory experiments will be based on microcontrollers. ***Pre-requisite.: COMP 226***.

COMP 426 MICROPROCESSOR INTERFACING (3Crs.: 2Lec, 2Lab): Topics include assembly language programming, microprocessor software applications, PPI and interfacing techniques: I/O port design and handshaking protocols; I/O programming, I/O interface design, Direct Memory Access, data communications, interrupt control systems; parallel and serial interfaces; timers. Several laboratory experiments will be based on microprocessors and/or microcontrollers. ***Pre-req: COMP 324 or COMP 328***

COMP 335 MICROPROCESSORS FOR BIOMEDICAL ENGINEERING (3Crs.: 2Lec, 2Lab): The course focuses on the principle of microprocessors and microcontrollers and their applications in Biomedical Engineering. Introduction to hardware system: CPU, Memory, Input/Output Interfacing, and System Bus. Instruction sets; assembly and machine languages. Fetch Cycle, Execution cycle, Instruction cycle. Detailed study of a particular Microprocessor or Microcontroller architecture: Instruction set; assembly language programming, Programming techniques, Loops, Delays, parallel and serial interfaces, interrupt control systems; Timers. **Pre-req: COMP 226.**

Courses offered as university electives

The CE program offers two courses as General (University) Electives. The courses are described below.

COMP 005 INTRODUCTION TO HEALTH INFORMATICS (2Crs.: 2Lec, 0Lab): Introduction to health informatics and its fields: biomedical informatics, public health informatics, consumer and informatics. Infrastructure and basic technological tools. Application of health informatics tools in public health. Emerging technologies.

COMP 007 WEBSITE DEVELOPMENT (2Crs.: 2Lec, 0Lab): This course covers the basic concepts needed to develop a website. The topics include: Internet and Web concepts, creating web pages, configuring images and multimedia on web pages, Web design best practices, Accessibility, usability and search engine optimizations, obtaining a domain name and web host, Publishing to the Web.

COMP 008 PROGRAMMING BASICS (2Crs.: 2Lec, 0Lab): This course introduces the craft of computer basics: organization, architecture and programming. This course introduces newest developments of digital systems. Analyze problems, prepare flow charts and write, run and debug structured programs. Build application program for educational purposes.

Courses offered as BE Electives

The following course is offered as BE elective for all engineering majors except for Computer Engineering

COMP 424 Artificial Intelligence and Robotics for Engineers (3 Crs.: 2 Lec, 2Lab): Introduction to artificial intelligence and machine learning. Introduction to robotics. Programming in Python: data type, expressions, functions, loops and control. Data plotting and analysis. Smart agent models. Supervised and unsupervised learning. Knowledge representation and reasoning. ***Pre-requisite: COMP 208.***

Courses offered as TE to ECE

Computer Engineering Core Courses						
Course	**Title**	**Cr**	**Pre-/Co-requisites**	**Com**	**Pow**	**Bio**
COMP 215	Programming for Engineers	3	COMP 208	X	X	X
COMP 423	Computer Architecture	3	COMP 325 or COMP 326 or COMP 328 or COMP 335	X	X	X
COMP 428	Digital Systems Design	3	COMP 226	X		X
COMP454	Computer Networks	3	Pre: COMP 225		X	X
COMP454L	Computer Networks Lab	1	CO: COMP454		X	X
Computer Engineering Technical Electives						
Course	**Title**	**Cr**	**Pre-/Co-requisites**	**Com**	**Pow**	**Bio**
COMP 455	Mobile Computing	3	COMP 210	X		X
COMP 474	Introduction to Robotics	3	COMP 325 or COMP 326 or COMP 328 or COMP 335	X	X	X
COMP 510	Internet Engineering	3	COMP 454 or COME 580	X		X
COMP 529	Hardware Security	3	COMP 454 or COME 580	X		X
COMP 530	Hardware/Software Co-Design	3	COMP 225	X	X	X
COMP 554	IoT Platform Design and Implementation	3	COMP 454 or COME 580	X		X
COMP 555	Wireless Security	3	COMP 454 or COME 580	X		X
COMP 556	Sensor Networks	3	COMP 454 or COME 580	X		X
COMP 559	Internet Security	3	COMP 454 or COME 580	X		X
COMP 567	Blockchain Network Programming	3	COMP 454 or COME 580	X		X
Courses for all Engineer except CE						
COMP 424	Artificial Intelligence and Robotics for Engineers	3	COMP 208	X	X	X