

New BSc. Program in Computer Engineering

Department: Computer Engineering

 18/12/2011

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**DEPARTMENT OF COMPUTER ENGINEERING**

***Chairman***

Dr. Basem Al-Madani

***Faculty***

|  |  |  |
| --- | --- | --- |
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***Chair Professor***

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# Introduction

The computer engineering department (COE) was established in 1986 at the College of Computer Sciences and Engineering (CCSE) at King Fahd University of Petroleum and Minerals (KFUPM). It offers a program leading to a BS degree in Computer Engineering, a program leading to an MS degree in Computer Engineering, a program leading to an MS degree in Computer Networks and a joint Ph.D. program with the Information and Computer Science Department.

***What is Computer Engineering?***

Computer Engineering (COE) is the discipline concerned with the design, analysis, modeling and implementation of computers and networks systems. Both the software and the hardware aspects of these systems are studied in a balanced and coherent manner. As such, it is of interest and demand locally in Saudi Arabia, regionally in the Middle East and internationally worldwide.

***Computer Engineering at KFUPM***

The Computer Engineering program at KFUPM develops the necessary skills and competences required to design and implement computer systems and networks. The two focus areas of computer systems and computer networks are deemed as most important for the local job market (present and future). All COE core courses establish the required foundation for these two areas. Students can pursue one or a combination of these areas through electives which are all aligned with these two areas. In addition, sufficient emphasis is given to the study of computer science to provide a coherent view of computer systems and an understanding of the interdependencies of hardware and software components and their interfaces and tradeoffs. Furthermore, the COE program equips the students with many non-technical engineering skills and knowledge essential for their professional practice.

The Computer Engineering program is serving the Kingdom's critical need for computer professionals who can design and implement computer systems and networks. The graduates of the COE program are expected to play a key role in the Kingdom's transition to a *knowledge-based* economy by harnessing the benefits of the IT technology in different fields of governmental administrations, manufacturing and service sectors.

# Vision

The vision of the COE department is to become a recognized center of excellence in providing quality education and technical services, as well as in advancing computing technologies through innovative research.

# Mission

The mission of the computer engineering department is:

1. To prepare competent professionals in the area of Computer Engineering who are competitive worldwide and prepared to be the leaders in the Saudi industry, academia and government.
2. To conduct original research that contributes to the advancement of computing technologies worldwide, solves local problems and leads to the transfer and dissemination of knowledge to the Saudi society at large.
3. To provide the Saudi society with high quality technical services in areas related to Computer engineering in terms of consultation, training and applied projects.

# Strategic Goals

1. To provide the best possible quality undergraduate learning environment in Computer Engineering by:
* Attracting highly motivated and intellec­tual students to COE department
* Providing a comprehensive broad-based under­graduate program
* Maintaining a conducive environment for develop­ing ethics and technical and leadership skills
* Provide a strong hands-on-experience through laboratory experiments and projects
* Maintaining a set of labs that support teaching and research which are second to none world-wide and employ latest technologies and expertise
* Providing strong design and analysis compo­nents in the program
* Maintaining an internal review/audit process that guarantees the continuous improvements of all aspect of the COE program (Courses, Labs, Textbooks, and faculty)
1. To attract and retain high quality COE faculty members
2. To produce world-class research in the different disciplines of computer engineering
3. To establish strong, fruitful and continu­ous relationship with the Saudi industry and government agencies. This includes engaging the local industries and gov­ernmental agencies in the all aspects of the department’s activities such as curriculum development, program out­comes and objectives, research direc­tions, etc
4. To participate actively in establishing interdisciplinary programs

# Program Objectives

The Objective of the COE program is to produce graduates who, after few years from graduation, will have:

1. Established themselves as successful professional computer engineers with demonstrated leadership capabilities,
2. Demonstrated an ability to pursue a successful professional and career growth, and
3. Enrolled and succeeded in graduate and professional studies/programs if they chose to do so

# Program Outcomes

The Computer Engineering Program Outcomes are:

1. an ability to apply knowledge of mathematics, science, and engineering.
2. an ability to design and conduct experiments, as well as to analyze and interpret data.
3. an ability to design a system, component, or process to meet desired needs.
4. an ability to function on multi-disciplinary teams (*Our interpretation of multidisciplinary teams includes teams of individuals with similar educational backgrounds focusing on different aspects of a project as well as teams of individuals with different educational backgrounds*).
5. an ability to identify, formulate, and solve engineering problems.
6. an understanding of professional and ethical responsibility.
7. an ability to communicate effectively.
8. the broad education necessary to understand the impact of engineering solutions in a global and societal context.
9. a recognition of the need for, and an ability to engage in life-long learning (*Our interpretation of this includes teaching students that the underlying theory is important because the technology changes, coupled with enhancing their self-learning ability*).
10. knowledge of contemporary issues (*Our interpretation of this includes presenting students with issues such as the impact of globalization, the outsourcing of both engineering and other support jobs as practiced by modern international companies*).
11. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
12. The ability to design a system that involves the integration of hardware and software components.

# Guidelines on Electives

There are several types of electives in the COE program are: two General Studies (GS) electives, one Depth Elective, four (two) COE electives for non-coop (coop) option and two Technical Electives for non-coop option.

* A GS elective can be any 3-credit hour GS course
* The Depth Elective must be one of the following two courses: COE 405 Design and Modeling of Digital Systems or COE 444 Internetwork Design and Management
* A COE elective is any 400-level COE course other than COE 485
* A Technical Elective is selected from a list of courses from other KFUPM departments. The full list is published and maintained by the COE department

# Requirements for the B.S. Degree in Computer Engineering (Non-Coop Option)

1. **General Education Requirements (52 credit hours)**

|  |  |  |
| --- | --- | --- |
| Communication Skills | ENGL 214, IAS 101, 201, 301 | 9 |
| Computer Programming | ICS 102 | 3 |
| Chemistry | CHEM 101 | 4 |
| English | ENGL 101, 102 | 6 |
| Islamic and Arabic Studies | IAS 111, 212, 322 | 6 |
| Mathematics | MATH 101, 102, 201, 260 | 14 |
| Physical Education | PE 101, 102 | 2 |
| Physics | PHYS 101, 102 | 8 |
|  |  | **52** |

1. **Core Requirement (53 credit hours)**

|  |  |  |
| --- | --- | --- |
| COE | 202, 203, 241, 300, 301, 306, 344, 485 | 24 |
| ICS | 201, 202, 253, 431 | 15 |
| EE | 201, 203 | 8 |
| SE | 307 | 3 |
| STAT | 319 | 3 |
|  |  | **53** |

1. **Electives**

|  |  |  |
| --- | --- | --- |
| COE Depth Elective | COE 405 or COE 444 | 3 |
| COE Electives | COE 4xx, 4yy, 4zz, 4ww | 12 |
| Technical Electives (from the list) | XXX, YYY | 6 |
| General Studies | GS xxx, yyy | 6 |
|  |  | **27** |

1. **Summer training (Co-operative Work)**

|  |  |  |
| --- | --- | --- |
| Summer Training (Cooperative work) | COE 399 | 0 |
|  |  | **0** |
| **The total number of credit hours required is** |  | **132** |

# Computer Engineering Curriculum (Non-Coop Option)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **COURSE** | **TITLE** | **LT** | **LB** | **CR** | **COURSE** | **TITLE** | **LT** | **LB** | **CR** |
| **Preparatory Year** |
| ENGL 001 | Prep. English I | 15 | 5 | 8 | ENGL 002 | Prep. English II | 15 | 5 | 8 |
| MATH 001 | Prep. Math I | 3 | 1 | 4 | MATH 002 | Prep. Math II | 3 | 1 | 4 |
| PYP 001 | Prep. Physical Science | 2 | 0 | 2 | PYP 002 | Prep. Computer Science | 0 | 2 | 1 |
| PYP 003 | University Study Skills | 0 | 2 | 1 | ME 003 | Prep. Eng. Technology | 0 | 2 | 1 |
| PE 001 | Prep. Health and Physical Educ. I | 0 | 2 | 1 | PE 002 | Prep. Health and Physical Educ. II | 0 | 2 | 1 |
|  | **20** | **10** | **16** |  | **18** | **12** | **15** |
| **Total credit hours required in Preparatory Program:**  |
| **First Year (Freshman)** |
| MATH 101 | Calculus I | 4 | 0 | 4 | MATH 102 | Calculus II | 4 | 0 | 4 |
| PHYS 101 | General Physics I | 3 | 3 | 4 | PHYS 102 | General Physics II | 3 | 3 | 4 |
| ENGL 101 | An Intro to   Academic Discourse | 3 | 0 | 3 | ENGL 102 | Intro to Report Writing | 3 | 0 | 3 |
| CHEM 101 | General Chemistry I | 3 | 4 | 4 | ICS 102 | Intro. To Computing I | 2 | 3 | 3 |
| IAS 111 | Belief & its Consequences | 2 | 0 | 2 | IAS 101 | Practical Grammar | 2 | 0 | 2 |
| PE 101 | Physical Education I | 0 | 2 | 1 | PE 102 | Physical Education II | 0 | 2 | 1 |
|  | **15** | **9** | **18** |  | **14** | **8** | **17** |
| **Second Year (Sophomore)** |
| COE 202 | Digital Logic Design | 3 | 0 | 3 | ICS 202 | Data Structures | 3 | 3 | 4 |
| COE 203 | Digital Logic Design Lab | 0 | 3 | 1 | EE 203 | Electronics I | 3 | 3 | 4 |
| ICS 201 | Intro. To Computing II | 3 | 3 | 4 | IAS 212 | Professional Ethics | 2 | 0 | 2 |
| EE 201 | Electric Circuits I | 3 | 3 | 4 | COE 241 | Data & Computer Communications | 3 | 0 | 3 |
| MATH 201 | Calculus III | 3 | 0 | 3 | STAT 319 | Prob.& Stat. for Engineers | 3 | 0 | 3 |
| IAS 201 | Objective Writing | 2 | 0 | 2 |  |  |  |  |  |
|  |  | **14** | **9** | **17** |  |  | **14** | **6** | **16** |
| **Third Year (Junior)** |
| MATH 260 | Differential Eqs. & Lin. Algebra | 3 | 0 | 3 | COE 306 | Introduction to Embedded Systems | 3 | 3 | 4 |
| ICS 253 | Discrete Structures I | 3 | 0 | 3 | IAS 301 | Language Comm. Skills | 2 | 0 | 2 |
| ENGL 214 | Academic & Professional Comm. | 3 | 0 | 3 | D.E.  | COE 444 or COE 405 | 3 | 0 | 3 |
| COE 301 | Computer Organization | 3 | 3 | 4 | T.E.  | Technical Elective 1 | 3 | 0 | 3 |
| COE 344 | Computer Networks | 3 | 3 | 4 | COE 300 | Principles of Comp. Eng. Design | 1 | 3 | 2 |
|  |  |  |  |  | SE 307 | Eng. Economy Analysis | 3 | 0 | 3 |
|  | **15** | **6** | **17** |  | **15** | **6** | **17** |
| **Summer Session** | COE 399 | Summer Training | **0** | **0** | **0** |
| **Fourth Year (Senior)** |
| ICS 431 | Operating Systems | 3 | 3 | 4 | COE 485 | Senior Design Project | 1 | 6 | 3 |
| COE 4xx | COE Elective 1 | 3 | 0 | 3 | IAS 322 | Human Rights in Islam2 | 2 | 0 | 2 |
| COE 4xx | COE Elective 2 | 3 | 0 | 3 | COE 4xx | COE Elective 3 | 3 | 0 | 3 |
| T.E.  | Technical Elective 2 | 3 | 0 | 3 | COE 4xx | COE Elective 4 | 3 | 0 | 3 |
| GS xxx | GS Elective 1 | 3 | 0 | 3 | GS xxx | GS Elective 2 | 3 | 0 | 3 |
|  | **15** | **3** | **16** |  | **12** | **6** | **14** |
| **Total credit hours required in Degree Program : 132** |

# Requirements for the B.S. Degree in Computer Engineering (Coop Option)

1. **General Education Requirements (52 credit hours)**

|  |  |  |
| --- | --- | --- |
| Communication Skills | ENGL 214, IAS 101, 201, 301 | 9 |
| Computer Programming | ICS 102 | 3 |
| Chemistry | CHEM 101 | 4 |
| English | ENGL 101, 102 | 6 |
| Islamic and Arabic Studies | IAS 111, 212, 322 | 6 |
| Mathematics | MATH 101, 102, 201, 260 | 14 |
| Physical Education | PE 101, 102 | 2 |
| Physics | PHYS 101, 102 | 8 |
|  |  | **52** |

1. **Core Requirement (57 credit hours)**

|  |  |  |
| --- | --- | --- |
| COE | 202, 203, 241, 300, 301, 306, 344, 485 | 24 |
| ICS | 201, 202, 253, 324, 431 | 19 |
| EE | 201, 203 | 8 |
| SE | 307 | 3 |
| STAT | 319 | 3 |
|  |  | **57** |

1. **Electives**

|  |  |  |
| --- | --- | --- |
| COE Depth Elective | COE 444 or COE 405 | 3 |
| COE Elective | COE 4xx, 4yy | 6 |
| General Studies | GS xxx, yyy | 6 |
|  |  | **15** |

1. **Co-operative Work**

|  |  |  |
| --- | --- | --- |
| Cooperative work | COE 350, 351 | 9 |
|  |  | **9** |
| **The total number of credit hours required is** |  | **133** |

# Computer Engineering Curriculum (Coop Option)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **COURSE** | **TITLE** | **LT** | **LB** | **CR** | **COURSE** | **TITLE** | **LT** | **LB** | **CR** |
| **Preparatory Year** |
| ENGL 001 | Prep. English I | 15 | 5 | 8 | ENGL 002 | Prep. English II | 15 | 5 | 8 |
| MATH 001 | Prep. Math I | 3 | 1 | 4 | MATH 002 | Prep. Math II | 3 | 1 | 4 |
| PYP 001 | Prep. Physical Science | 2 | 0 | 2 | PYP 002 | Prep. Computer Science | 0 | 2 | 1 |
| PYP 003 | University Study Skills | 0 | 2 | 1 | ME 003 | Prep. Eng. Technology | 0 | 2 | 1 |
| PE 001 | Prep. Health and Physical Educ. I | 0 | 2 | 1 | PE 002 | Prep. Health and Physical Educ. II | 0 | 2 | 1 |
|  | **20** | **10** | **16** |  | **18** | **12** | **15** |
| **Total credit hours required in Preparatory Program:**  |
| **First Year (Freshman)** |
| MATH 101 | Calculus I | 4 | 0 | 4 | MATH 102 | Calculus II | 4 | 0 | 4 |
| PHYS 101 | General Physics I | 3 | 3 | 4 | PHYS 102 | General Physics II | 3 | 3 | 4 |
| ENGL 101 | An Intro to   Academic Discourse | 3 | 0 | 3 | ENGL 102 | Intro to Report Writing | 3 | 0 | 3 |
| CHEM 101 | General Chemistry I | 3 | 4 | 4 | ICS 102 | Intro. To Computing I | 2 | 3 | 3 |
| IAS 111 | Belief & its Consequences | 2 | 0 | 2 | IAS 101 | Practical Grammar | 2 | 0 | 2 |
| PE 101 | Physical Education I | 0 | 2 | 1 | PE 102 | Physical Education II | 0 | 2 | 1 |
|  | **15** | **9** | **18** |  | **14** | **8** | **17** |
| **Second Year (Sophomore)** |
| COE 202 | Digital Logic Design | 3 | 0 | 3 | ICS 202 | Data Structures | 3 | 3 | 4 |
| COE 203 | Digital Logic Design Lab | 0 | 3 | 1 | ICS 253 | Discrete Structures I | 3 | 0 | 3 |
| ICS 201 | Intro. To Computing II | 3 | 3 | 4 | EE 203 | Electronics I | 3 | 3 | 4 |
| EE 201 | Electric Circuits I | 3 | 3 | 4 | IAS 212 | Professional Ethics | 2 | 0 | 2 |
| MATH 201 | Calculus III | 3 | 0 | 3 | COE 241 | Data & Computer Communications | 3 | 0 | 3 |
| IAS 201 | Objective Writing | 2 | 0 | 2 | STAT 319 | Prob.& Stat. for Engineers | 3 | 0 | 3 |
|  |  | **14** | **9** | **17** |  |  | **17** | **6** | **19** |
| **Third Year (Junior)** |
| MATH 260 | Differential Eqs. & Lin. Algebra | 3 | 0 | 3 | COE 306 | Introduction to Embedded Systems | 3 | 3 | 4 |
| ENGL 214 | Academic & Professional Comm. | 3 | 0 | 3 | D.E.  | COE 444 or COE 405 | 3 | 0 | 3 |
| IAS 301 | Language Comm. Skills | 2 | 0 | 2 | GS xxx | GS Elective 1 | 3 | 0 | 3 |
| COE 301 | Computer Organization | 3 | 3 | 4 | COE 300 | Principles of Comp. Eng. Design | 1 | 3 | 2 |
| COE 344 | Computer Networks | 3 | 3 | 4 | ICS 324 | Database | 3 | 3 | 4 |
| SE 307 | Eng. Economy Analysis | 3 | 0 | 3 | IAS 322 | Human Rights in Islam | 2 | 0 | 2 |
|  | **17** | **6** | **19** |  | **15** | **9** | **18** |
| **Summer Session** | COE 350 | Start of COOP | **0** | **0** | **0** |
| **Fourth Year (Senior)** |
| COE 351 | COOP | 9 | 0 | 9 | COE 485 | Senior Design Project | 1 | 6 | 3 |
|  |  |  |  |  | ICS 431 | Operating Systems | 3 | 3 | 4 |
|  |  |  |  |  | COE 4xx | COE Elective 1 | 3 | 0 | 3 |
|  |  |  |  |  | COE 4xx | COE Elective 2 | 3 | 0 | 3 |
|  |  |  |  |  | GS xxx | GS Elective 2 | 3 | 0 | 3 |
|  | **9** | **0** | **9** |  | **13** | **9** | **16** |
| **Total credit hours required in Degree Program : 133** |

# Course Description

|  |  |
| --- | --- |
| **COE 202 Digital Logic Design** | **(3-0-3)** |

Introduction to information representation and number systems. Boolean algebra and switching theory. Manipulation and minimization of completely and incompletely specified Boolean functions. Physical properties of gates: fan-in, fan-out, propagation delay, timing diagrams and tri-state drivers. Combinational circuits design using multiplexers, decoders, comparators and adders. Sequential circuit analysis and design, basic flip-flops, clocking and timing diagrams. Registers, counters, RAMs, ROMs, PLAs, PLDs, and FPGA’s.

Note: COE 202 and COE 203 together are equivalent to EE 200. Students who take EE 200 cannot take COE 202 or COE 203 for credit.

**Prerequisite:** PHYS 102

|  |  |
| --- | --- |
| **COE 203 Digital Logic Design Lab** | **(0-3-1)** |

Introduction to information representation, Signals and bits, Logic implementation using discrete logic components (TTL, CMOS). Introduction to Field Programmable Logic Arrays (FPGAs) design flow: design capture (schematic capture, HDL design entry, design verification and test, implementation (including some of its practical aspects), and debugging. Students will use CAD software tools in the lab to design, simulate and implement digital logic circuits on FPGA prototyping boards.

**Co-requisites:** COE 202

|  |  |
| --- | --- |
| **COE 241 Data and Computer Communications** | **(3-0-3)** |

Information representation and signals. Introduction to data communication. Frequency response, bandwidth, filtering, and noise. Fourier series and transform. Introduction to the Z-transform. Information theory concepts such as Nyquist theorem, Shannon theorem, and Sampling theorem. Analog and digital modulation techniques. Pulse Code Modulation (PCM). Communication systems circuits and devices. Data encoding. Physical Layer Protocols. Data Link Control (point to point communication; design issues; link management; error control; flow control). Multiplexing Techniques.

**Prerequisites:** MATH 102

|  |  |
| --- | --- |
| **COE 300 Principles of Computer Engineering Design** | **(1-3-2)** |

Practical and professional skills necessary for the COE practice. Design projects successful execution steps. Team work, project management and professional communication skills. Codes of professional conduct, ethics & responsibility.

**Prerequisite***: Junior Standing*

|  |  |
| --- | --- |
| **COE 301 Computer Organization** | **(3-3-4)** |

Introduction to computer organization, machine instructions, addressing modes, assembly language programming, integer and floating-point arithmetic, CPU performance and metrics, non-pipelined and pipelined processor design, datapath and control unit, pipeline hazards, memory system and cache memory.

**Prerequisites:** COE 202 and ICS 102

|  |  |
| --- | --- |
| **COE 306 Introduction to Embedded Systems** | **(3-3-4)** |

Introduction to Embedded Systems. Microcontroller Hardware. ARM Processor. CPU Programming. Memory and I/O. Interfacing: Parallel and Serial Communication. A/D and D/A conversion Embedded system design methodologies. Specifications. Designing robust software for embedded systems. RTOS features.

**Prerequisites:** COE 301 & COE 203

|  |  |
| --- | --- |
| **COE 350 Cooperative Work** | **(0-0-0)** |

The starting of the cooperative work in the summer just preceding the senior year. Description is as given in COE 351.

**Prerequisites:** ENGL 214, Completion of 90 credit-hours and Departmental Approval

|  |  |
| --- | --- |
| **COE 351 Cooperative Work (continued)** | **(0-0-9)** |

A continuous period of 28 weeks spent in industry with the purpose of acquiring practical experience in different areas of Computer Engineering. During this period, a student is exposed to the profession of Computer Engineering by working in the field. Students are required to submit a finalreportandgiveapresentationabouttheirexperienceandtheknowledge they gained during their cooperative work.

**Prerequisite:** COE 350

|  |  |
| --- | --- |
| **COE 352 Cooperative Work (continued)** | **(0-0-9)** |

This course is the same as COE351. The only difference is that COE352 is for students who choose to start their coop program during the second term of the academic year.

**Prerequisites:** ENGL 214, Completion of 90 credit-hours

|  |  |
| --- | --- |
| **COE 353 Fundamentals of Computer Communications** | **(3-0-3)** |

Digital communications fundamentals. Voice and data transmission equipment. Communications channels. Data coding and modulation. Multiplexing. Modems. Transmission media. Data transmission codes and protocols. Software packages. Data networks. Planning and design of communication networks.

**Note:** This course is NOT open for COE students. It cannot be taken for credit with COE 241.

**Prerequisite:** Junior Standing

|  |  |
| --- | --- |
| **COE 399 Summer Training** | **(0-0-0)** |

The aim of the summer training is to provide students with direct on-the-job experience working with professionals in the field. This training provides an opportunity to expose students to the reality of professional practice. Students are required to submit a report and make a presentation on their summer training experience and the knowledge gained.

**Prerequisites:** ENGL 214, Junior Standing, Approval of the Department

|  |  |
| --- | --- |
| **COE 402 Computer System Performance Evaluation** | **(3-0-3)** |

Introduction to computer system performance analysis and evaluation. Review of basic probability distributions and basic concepts of statistics. Performance measures and measurement techniques. Performance analysis, performance prediction, asymptotic bounds on performance. Simulation and modeling of computer systems. Experimental and analytical approaches. Introduction to queuing network modeling. Case studies.

**Prerequisite:**  STAT 319 or Consent of the Instructor

|  |  |
| --- | --- |
| **COE 403 Computer Architecture** | **(3-0-3)** |

Fundamentals of computer design, power, cost, performance, instruction set principles, instruction and arithmetic pipelines, dynamic and speculative execution, precise exception, memory hierarchy, multilevel caches, virtual memory, storage and I/O, multicores, multiprocessors, and clusters, New trends in computer architecture.

**Prerequisites:** COE 301

|  |  |
| --- | --- |
| **COE 405 Design and Modeling of Digital Systems** | **(3-0-3)** |

Review of sequential circuits design and analysis, Data path and control unit design, Design with Hardware Description languages, Design with Field-Programmable Gate Arrays (FPGAs), Block interfacing, and high-level-synthesis.

**Prerequisites:** COE 202

|  |  |
| --- | --- |
| **COE 408 Reconfigurable Computing** | **(3-0-3)** |

Review of Digital System Design, Software-Hardware partitioning, FPGA architectures, Schematic Design Entry, Design with HDL, Simulations, Design issues, Dynamic Re-configuration and applications.

**Prerequisites:** COE 405

|  |  |
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| **COE 420 Parallel Computing** | **(3-0-3)** |

Introduction to parallel computing. Parallel architectures: MIMD, SIMD, communication, and mapping. Performance measures, speedup, efficiency, and limitations of parallel processing. Problem decomposition and parallel algorithm design. Basic communications. Modeling of parallel programs: granularity, scalability, and execution time. Parallel programming: message-passing and threads. Examples of parallel algorithms and applications: matrix, sorting, graph, and search. New trends in parallel computing.

**Prerequisites:** COE 301

|  |  |
| --- | --- |
| **COE 421 Fault Tolerant Computing** | **(3-0-3)** |

Introduction to fault-tolerant computing (FTC).  Goals of fault tolerance (FT).  Design techniques to achieve FT. Evaluation of FT systems. Reliability modeling and analysis of FT systems. Availability modeling. Logic-level fault testing and tolerance. Error detection and correction. Diagnosis and reconfiguration for system-level malfunctions. Case studies of practical fault tolerant systems.

**Prerequisites:** Senior Standing

|  |  |
| --- | --- |
| **COE 422 Real Time Systems** | **(3-0-3)** |

Introduction to real-time systems. Uniprocessor scheduling of independent tasks, hard versus soft real time, reference model, dynamic scheduling, utilization-based schedulability, demand-based scheduling, static priority systems, deadlines, and fairness. Basic operating-system functions needed for real-time computing, real-time and non-real-time operating systems. Advanced scheduling: preemptive versus non-preemptive scheduling, dynamic versus static priorities, synchronous versus asynchronous job releases. Multiprocessors and distributed systems, priority ceiling protocol and end-to-end scheduling.

**Prerequisites:** COE 306

|  |  |
| --- | --- |
| **COE 423 Distributed Systems** | **(3-0-3)** |

Theory and practice in the design and implementation of distributed computing systems are covered, including interprocess communication, remote procedure calls, distributed file systems, synchronization, distributed transactions, replicated data, security and specifications for distributed programs. Programming assignments include using current distributed technologies (sockets). Real-world distributed systems case studies, and examples ranging from the Internet to file systems. This course is intended to prepare students to work on corporate software development teams developing enterprise applications.

**Prerequisites:** Senior Standing

|  |  |
| --- | --- |
| **COE 424 Introduction to Smart Cards & RFID Technology** | **(3-0-3)** |

 **O**verview of different types of smart cards, smart card applications, architectures, standards, operating systems, security, management and fabrication. RFID concepts and fundamentals including; components of RFID systems, architectures, middleware functionality, and related standards. RFID RLTS (Real Time Location Systems) and ubiquitous computing. Privacy and security techniques, engineering design tradeoffs in designing both smart card and RFID systems.

**Prerequisites:** Senior standing or Consent of Instructor

|  |  |
| --- | --- |
| **COE 425 Data Management Systems** | **(3-0-3)** |

Introduction to the fundamental theories and practices of Data Acquisition, Distribution and Warehousing. Industrial and Business Automation Levels. Most commonly used standards and technologies.

**Prerequisites:** Senior standing or Consent of Instructor

|  |  |
| --- | --- |
| **COE 441 Local Area Networks** | **(3-0-3)** |

Introduction to Local Area Networks (LANs). Classes of LANs. LAN design issues. LAN topologies. LAN transmission media. LAN protocols: Medium Access Control (MAC) and Logic Link Control (LLC). LAN standards. Network software: Network operating systems. LAN performance modeling and analysis. Internetworking: Bridges, Routers, and Gateways. Reliability, availability, survivability, and security. Case studies.

**Prerequisite:** COE 341 or Consent of the Instructor

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| **COE 443 High Speed Networks** | **(3-0-3)** |

Introduction to high speed networking. Impact of high speed on communication protocols. Multiple traffic types integration, and quality-of-service differentiation. Design and performance issues of high speed networks. Standard high speed protocols and networks. Examples of high speed networks such as Gigabit Ethernet, Terabit networks, and Photonic networks. Case studies. Future directions.

**Prerequisite:** COE 344

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| **COE 444 Internetwork Design and Management** | **(3-0-3)** |

Overview of computer networks. Principles of internetworking. Internetworking hardware. Bridging and switching technologies. Virtual LANs. Routing strategies. The network development life cycle. Network analysis and design methodology. Enterprise network design model. Backbone design concepts. Network security design.Structured cabling systems. Network design algorithms. Traffic flow analysis. Network reliability. Network management (SNMP). Network administration. Case studies.

**Prerequisites:** COE 344

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| **COE 445 Internet Engineering and Technologies** | **(3-0-3)** |

Overview of current internet challenges and its next generation architecture. Overview of modern Internet protocols and supporting algorithms for delivery of multimedia content and communications. Information retrieval architecture, design, and performance evaluation: search engines, proxy servers, and content distribution networks. Network programming: socket and advanced socket programming.

**Prerequisites:** COE 344

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| **COE 446 Mobile Computing** | **(3-0-3)** |

Introduction to different types of mobile computing; cellular networks, wireless mobile ad hoc and sensor networks, wireless LAN and so on. Discussion of different IEEE standardized protocols and their implementation and performances. New wireless technologies such as LTE and LTE advance. Quality of Service (QoS) issues. Modeling and optimization methods of wireless protocols.

**Prerequisite:** COE 344

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| **COE 447 Fundamentals of Optical Networking** | **(3-0-3)** |

Passive and Active Optical Components. Optical Modulation and Demodulation. Transmission System Design. SONET/SDH and other Client Layers. WDM Networks. Routing and Wavelength Assignment. Control and Management. Protection and Restoration. Access Techniques. Traffic Grooming. Optical Packet/Burst Switching.

**Prerequisite:** COE 344 or consent of professor

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| **COE 451 Computer & Network Security** | **(3-0-3)** |

Introduction to computer security (concepts, threats, attacks, assets, scope, trends). Cryptographic Protocols (Public Key Infrastructure, Symmetric Shared Keys), and standards (AES, DES, Blowfish, ElGamal, etc.). Integrity verification mechanisms (Hash functions, Message Authentication Codes, etc.). Wireless network security and associated protocols (IPSEC). Software tools to apply security in user environments (symmetric key, public key, hash functions). Access Control models and mechanisms (RBAC, Subject-based). Database security, Intrusion detection systems, Firewalls. Malicious software, DoS attacks, Trusted computing and multilevel security.

**Prerequisites:** COE 344

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| **COE 461 Principles of VLSI Design** | **(3-0-3)** |

State-of-the-artMOS Transistors, their operation and limitations. CMOS digital circuits, static & dynamic logic, combinational and sequential circuits. Circuit design and propagation delay. CMOS fabrication technology, layout and design rules, stick diagrams, IC Design and Verification Tools, subsystem design and case studies, and practical considerations.

**Prerequisites:** EE 203

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| **COE 462 Design Automation of VLSI Circuits** | **(3-0-3)** |

Introduction to computer-aided design of integrated circuits. Design approaches, design steps and corresponding design automation problems and tools. Logical and physical partitioning. Solution techniques for floor planning, placement, global routing and detailed routing. Strategies for grid and channel routing. Layout generation problem and solutions. Symbolic layout, layout editors and compaction. Silicon compilation.

**Prerequisites:** COE 461 or Consent of the Instructor

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| **COE 464 Testing of Digital Circuits** | **(3-0-3)** |

Introduction to the testing problem, fault modeling: stuck-at, bridging, transistor-open and transistor-short faults, delay faults. Fault simulation, Test generation for Combinational circuits, Test generation for sequential circuits, Design for testability, Built-in self test, Delay fault testing. New trends in testing.

**Prerequisite:** Senior Standing

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| **COE 465 VLSI System Design Methodology** | **(3-0-3)** |

CMOS VLSI system design options; Full-custom and semicustom designs. Design flows of ASICs; front-end and back-end design flows. Design & verification CAD tools. Chip Layout, place and route and design rules checking. Concepts and tools in floor planning, placement and routing, layout generation and design synthesis. The course stresses hands-on experience of VLSI design using CAD tools.

**Prerequisite:** COE 405

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| **COE 482 Pervasive and Ubiquitous Computing** | **(3-0-3)** |

Introduction to ubiquitous and pervasive computing. Designing, building and evaluatingubiquitous computing technologies in order to create novel user experiences. Capturing and disseminating context information through sensors and sensor networks. Sensor network coverage, localization, synchronization, sleep scheduling, connectivity, routing, energy efficiency, data centric and transport protocols, Context-aware applications and intelligent objects and applications.

##### Prerequisites: COE 344

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| **COE 484 Introduction to Robotics** | **(3-0-3)** |

Taxonomy of robots, Internet robotics, autonomous robots, robotic sensor networks, and applications. Motion, linear algebra, motion coordination, singularities, and multiple solutions. Vision, sensing and perception, robot vision and programming, self-localization, Kalman and Monte-Carlo approaches. Intelligence, Autonomous robotics, robot mechanisms and control, control and planning architectures, reactive, subsumptive, and deliberative control behaviors, behavior-based control programming. Humanoid robots. Introduction to multi-robot systems.

**Prerequisites:** Senior Standing

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| **COE 485 Senior Design Project** | **(1-6-3)** |

Various design phases leading to a practical engineering solution. Feasibility study, preparation of specifications, and the methodology for the design. Detailed design and implementation, testing, debugging, and documentation.

**Prerequisite:** Senior Standing

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| **COE 487 Computer Vision Processing** | **(3-0-3)** |

Introduction to the concepts and applications in computer vision. Cameras and projection models, low-level image processing methods such as filtering and edge detection; mid-level vision topics such as segmentation and clustering; shape reconstruction from stereo, as well as high-level vision tasks such as object recognition, scene recognition, face detection and human motion categorization.

**Prerequisite:** Senior Standing

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| **COE 488 Data Acquisition Interfacing** | **(3-0-3)** |

Data acquisition systems, basic sampling concepts, data collection fundamentals. Interfaces. Special instruments. IEEE 488 standard. RS 232C data acquisition software technique. I/O operation queuing. Hardware for data acquisition systems. Multibus. VME bus. Examples and designs.

**Prerequisite:** COE 301