King Fahd University of Petroleum & Minerals

College of Computer Sciences and Engineering

Computer Engineering Department

Proposal for

A Revised BS Program in

Computer Engineering

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Executive Summary

The Computer Engineering discipline has seen an enormous growth in the past few years. It has come to include many different areas such as Computer Architecture, Embedded Systems, Computer Networks, Secure Architectures, Wireless and Mobile Computing, Non-Conventional Computing, Electronics and Electronic Design Automation, and IT Security Systems. It is expected that a Computer Engineering program shall cover all core aspects of the discipline. As a result of the rapid growth of this field and the ever changing local needs, the Computer Engineering Department (COE) has undertaken the task of a major program revision.

The objectives of this revision are: (1) To update the mission, objectives and outcomes of the program based on the recent changes in the field and the local market needs of KSA, and (2) to update the curriculum by following the IEEE/ACM Computer Engineering 2004 guidelines to meet international standards and maintain ABET's Engineering Accreditation Criteria (EAC) while following the guidelines for course development as specified by the Deanship of Academic Development (DAD).

The program review was conducted by a mother committee formed by the department that enlisted the help of several specialized sub-committees (one for each core sub-area). For an efficient curriculum design/review, the committee followed a top-down approach; 1st determining the broad lines of the curriculum, objectives, outcomes, major options and components then proceeding with the detailed implementation.

The mission and vision of the COE department have been outlined in Sections 3.3 and 3.4 respectively. Sections 3.5 and 3.6 contain the mission and objectives of the Computer Engineering program. The program's learning outcomes are presented in Section 4.

All courses were reviewed and updated in light of the newly updated program mission and outcomes. Table I lists current courses that had undergone any changes in the new proposed curriculum (e.g. in the title, contents, credit and hour assignment etc.). Table II lists all newly proposed courses while Table III lists the new COE electives.

Following is a brief account of the major changes introduced by the new proposed curriculum:

- COE 205 (3-3-4) Computer Organization and Assembly Language and COE 308 (3-0-3) Computer Architecture were replaced by the new course; COE 208 (3-3-4) Computer Organization and Architecture.
- EE 203 (3-3-4) Electronics I and COE 360 (3-0-3) Principles of VLSI Design were replaced by the new course; COE 361 (3-3-4) Fundamentals of Computer Electronics.
- ICS 431 (3-3-4) Operating systems was eliminated from the curriculum and the required material was added to the new course COE 307 (3-0-3) Computer Systems.
- A new core course, SE 307 (3-0-3) Engineering Economic Analysis, was added in response to feedback from local employers.
- A new course COE 240 (2-3-3) Probability and statistic for Computer engineers is to replace STAT 319 (2-3-3) Probability and Statistics for Engineers and Scientists.
- The title of the course COE 341 (3-0-3) was changed to Information Representation and Systems and the content was updated accordingly to reflect the new emphasis on information engineering.

- COE 305 (3-3-4) Microcomputer System Design was changed to COE 305 (3-3-4) Microprocessor System Design. COE 400 (1-6-3) System Design Laboratory was changed to COE 400 (2-3-3) Embedded Systems.
- The COE 485 (1-6-3) Senior Design Project course, which was required by non-coop students only, was changed to a full-fledged structured capstone course (2-3-3) that is required by all students.
- The IAS 4xx elective was replaced by two GS xxx elective to allow for more flexibility and address the problem of low humanities component in the present curriculum which was pointed out by ABET. This also satisfies the university general education requirements.
- A new elective track on Computer Security has been established with six new electives; COE4xx (3-0-3) Information Security, COE4xx (3-0-3) Cyber & Computer Security, COE 4xx (3-0-3) Implementation of Security Protocols, COE4xx (3-0-3) Computer Security & Crypto Architectures, COE4xx (3-0-3) Network Security Engineering, and COE 4xx (3-0-3) Special Topics on Computer Security.
- One new elective, COE 4xx (3-0-3) Network Planning and Optimization, was added to the Networking area and another, COE4xx (3-0-3) Pervasive and Ubiquitous Computing was added to the applications area. The elective COE 445 (3-0-3) Internet Information Services was changed to COE 445 (3-0-3) Internet Engineering & Technologies. Also, COE 499 (3-0-3) Special Topics on Computer Engineering was changed to a (2-3-3) course under the same title to facilitate offering electives with labs.
- For the coop option of the program, the Coop training will replace 2 COE electives and a general elective (a total of 9 credit hours) instead of currently replacing 2 electives and the senior project.

The proposed program consists of 132 hours (a 1-hour increase from the current program). The curriculum has also been revised in light of relevant recommendations by professional societies including ACM, IEEE-CS and ABET.

Tables I to III summarize the changes introduced by the proposed new curriculum for both core and elective courses.

Table I. Changes proposed to existing courses

Old Course Number & Title	New Course Number & Title	Change
COE 205 (3-3-4) Computer Organization and Assembly Language & COE 308 (3-0-3) Computer Architecture	COE 208 (3-3-4) Computer Organization and Architecture	Combined both courses under a new title
COE 305 (3-3-4) Microcomputer System Design	COE 305 (3-3-4) Embedded Microprocessor System Design	Title to reflect the new emphasis on embedded system
COE 400 (1-6-3) System Design Laboratory	COE 400 (3-3-4) Embedded Systems	Title, credit assignment and contents. Transformed into a regularly structured course
COE 360 (3-0-3) Principles of VLSI Design	COE 361 (3-3-4) Fundamentals of Computer Electronics	Number, Title, credit hours and contents. Replaces EE 203 and COE 360 in the existing program

COE 445 (3-0-3) Internet Information Services	COE 445 (2-3-3) Internet Engineering and Technologies	Title was changed to accurately depict the contents and credit assignment was changed to introduce a lab for practical experiments
COE 485 (1-6-3) Senior Design Project	COE 485 (2-3-3) COE Capstone Project	Title and credit assignment. Transformed into a structured capstone course that will be required by all COE students
COE 499 (3-0-3) Special Topics on Computer Engineering	COE 499 (**2-3-3**) Special Topics on Computer Engineering	Credit assignment. A lab is added to allow electives with labs
Courses with changed title and/or number as an effect of the CS		
ICS 102 Introduction to Computing	ICS 102 Introduction to Computing I	Title
ICS 201 Introduction to Computer Science	ICS 201 Introduction to Computing II	Title

Table II. Listing of new and obsolete core courses in the COE program

New Courses	Obsolete Courses
COE 208 (3-3-4) Computer Organization & Architecture	COE 205 (3-3-4) Computer Organization and Assembly Language & COE 308 (3-0-3) Computer Architecture
COE 240 (2-3-3) Probability and statistic for Computer engineers	STAT 319 (2-3-3) Probability and Statistics for Engineers and Scientists
COE 307 (3-0-3) Computer Systems	ICS 431 (3-3-4) Operating Systems
SE 307 (3-0-3) Engineering Economic Analysis	
COE 361 (3-3-4) Fundamentals of Computer Electronics	EE 203 (3-3-4) Electronics I and COE 360 (3-0-3) Principles of VLSI Design

Table III. Listing of new COE electives

New Courses	Area
COE 470 (3-0-3) Information Security	Computer Security
COE 471 (3-0-3) Cyber & Computer Security	Computer Security
COE 472 (3-0-3) Implementation of Security Protocols	Computer Security
COE 473 (3-0-3) Computer Security & Crypto Architectures	Computer Security
COE 474 (3-0-3) Network Security Engineering	Computer Security
COE 479 (3-0-3) Special Topics on Computer Security	Computer Security
COE 481 (3-0-3) Design and Implementation of Smart Access Systems	Applications
COE 482 (3-0-3) Pervasive and Ubiquitous Computing	Applications
COE 483 (3-0-3) Data Management Systems	Applications

COE 448 (3-0-3) Network Planning and Optimization	Networking
COE 407 (3-0-3) Reconfigurable Computing	Architecture

1. Introduction

As part of the continuous endeavor to improve the Computer Engineering program at KFUPM, a major program revision has been underway at the Computer Engineering Department for the past three years. The objectives of this revision were: (1) Update the mission, objectives and outcomes of the program, and (2) Revise the curriculum by following the IEEE/ACM Computing Curricula for Computer Engineering 2004 (CE 2004) guidelines and to meet ABET's Engineering Accreditation Criteria (EAC), in addition to following the guidelines for course development as specified by the Deanship of Academic Development (DAD). This revision is also intended to accommodate the rapid evolution and fast growing industrial needs of computer engineering.

The mother committee started the process by adopting the following guiding principles; **Computer Engineering** is an internationally recognized discipline. Therefore, a credible program in Computer Engineering should follow internationally accepted standards for curriculum contents and methods of delivery. Moreover, **Engineering** is a profession with internationally recognized requirements and characteristics. In developing the new proposed curricula, two standards were adopted: 1) The IEEE/ACM Computer Engineering Curriculum as detailed and published in their Computing Curricula report (revised in 2004), and 2) The ABET guidelines for Engineering programs (New ABET2000 criteria). The committee noted that these standards allow for flexibility in implementation and for including additional components in the curriculum that are tailored for a specific environment (e.g. that of Saudi Arabia). In addition, the revision incorporated the following guidelines and feedback:

1. Guidelines for course development specified by the Deanship of Academic Development (DAD).
2. Curricula of reputable international universities.
3. Input from faculty, employer, alumni and graduating student surveys
4. Input from the Industrial Advisory Board for the department.

All courses in the program have been updated, as appropriate, to conform to the above guidelines. Courses were revised and designed by sub-committees that included all faculty members specialized in their respective areas. Faculty members provided detailed course syllabi for courses in their respective areas.

An analysis of the program needs is presented in Section 2 along with strategies adopted to satisfy such needs. This is followed by a listing of the newly developed/revised program objectives and learning outcomes in section 3. Section 3 also includes mappings between the COE program objectives and outcomes. Mappings of these objectives to the college's objectives and the university's objectives are also provided in section 3. Section 4 shows the detailed development of the new COE program. This includes areas of depth and breadth, how credit assignments were worked out, changes to current courses and their justification, the newly proposed program and the new degree plan. Finally section 5 summarizes the new program requirements.

Further details are given in the following four appendices:

Appendix A: Detailed listing of IEEE/ACM 2004 COE Body of Knowledge
Appendix B: Catalog Description of the new COE Courses.
Appendix C: Benchmarking Results.
Appendix D: Syllabi of new COE Core Courses

2. Program Needs and Adopted Strategy

Since its inception in 1983, the computer engineering program at KFUPM has gone through many cycles of revisions and evaluations. Two major forces driven these cycles of development; COE being a rapidly developing field and the rapid development in the Kingdom of Saudi Arabia which meant that the market needs themselves are constantly changing. Since the last curriculum revision, a general consensus arose within the COE department that the COE program needs a new and improved focus; namely the embedded systems area. This is to accommodate the tremendous international growth in this area, match the giant industrial leaps in KSA and capitalize on the maturity of the COE program in other areas such as networking, software development, computer architecture and hardware design. Also, based on numerous feedbacks from local industry leaders, there was a need to emphasis certain skills such as team work, problem solving, communication skills, and critical thinking.

The adopted strategy to satisfy the identified needs can be summarized as follows:

1. First the program's mission, objectives and learning outcomes are to be reviewed and modified to reflect the new needs and to conform to the university's mission and objectives,
2. Then, identify the required areas of breadth and depth within the new curriculum based on IEEE/ACM2004 Areas of Knowledge, ABET2000 criteria, benchmarking with similar programs in reputable universities and feedback from all stakeholders (Faculty, Students, Alumni, employers and advisory board). All breadth areas are to be core,
3. Next, identify which of the depth areas are to be core and which to be elective,
4. Credit hours are then assigned for each of the identified core areas,
5. Finally, design the courses accordingly and benchmark against the IEEE/ACM2004 Areas of Knowledge and similar programs in reputable universities.

3. Program Objectives

The mission of both the university and the college are first reviewed below.

3.1 University Mission

The university mission is stated in the paragraph below:

> "KFUPM is an institution of higher learning committed to:
> - Preparing professionals empowered with the knowledge, skills, values and confidence to take a leadership role in the development of the Kingdom in the fields of science, engineering, environmental design and business.
> - Producing research that contributes to the knowledge and sustainable development of the Kingdom and region by providing innovative solutions to identified economic and technical problems and opportunities.
> - Providing a stimulating campus environment for the welfare of its students, faculty and staff, and offering outstanding professional services and out-reach programs to the society at large."

3.2 College of Computer Science and Engineering Mission Statement

The mission of the college of Computer Sciences and Engineering is:

- To prepare competent professionals in the areas specified in the college line of business who are competitive worldwide and will be the leaders in Saudi industry, academia and government.
- To conduct innovative basic and applied research that advances the frontiers of knowledge and addresses local problems.
- To provide high quality service to society in the areas of applied projects, consultation and training.

These missions require the COE program to equip the students with:

1. Up-to-date knowledge of the field,
2. Professional skills related to the field of COE as well as general skills pertinent to any work environment. Emphasis is also placed on leadership and innovation, requiring critical thinking and communication skills.

3.3 COE Department Vision, Mission and Goals

The COE departmental vision is shown in the paragraph below because of its relevance to the revision process:

> **"To become a recognized center of excellence in providing quality education and technical services, as well as in advancing computing technologies through innovation and research"**

Department Mission

- To prepare competent professionals in the area of Computer Engineering who are competitive worldwide and prepared to be the leaders in Saudi industry, academia and government
- 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
- To provide the Saudi society with high quality technical services in areas related to Computer Engineering in terms of consultation, training and applied projects

Department Goals

- To provide the best possible quality undergraduate learning environment in Computer Engineering by providing:
    - Comprehensive, breadth-based undergraduate program
    - Conducive environment for developing technical, ethical, and leadership skills
    - Strong hands-on experience through laboratory experiments and projects
    - Strong design and analysis components in education
- Attract and retain high quality COE faculty members
- Produce world-class research in the various disciplines of Computer Engineering
    - Establish strong, fruitful and continuous relationship with the Saudi industry and government agencies

Clearly, maintaining an internal review/audit process that guarantees the continuous improvements of all aspect of the COE program (Courses, Labs, Textbooks, and faculty) is essential for achieving the above goals.

3.4 Computer Engineering Program Educational Objectives (PEOs)

The main objective of the COE program at KFUPM is to develop and train the human intellect needed for meeting the continued technological advances in the discipline of Computer Engineering. This includes graduating well-trained computer engineers to participate in the industrial development which is taking place in the Kingdom of Saudi Arabia. In line with the mission of the University and the CCSE objectives, the following Educational Objectives were adopted for the Computer Engineering Program:

The objectives of the **computer engineering program** are to produce computer engineering graduates who are properly equipped to:

1. Practice their profession with confidence and global competitiveness and make intellectual contributions to it.
2. Pursue a life-long career of personal and professional growth with superior work ethics and character.
3. Pursue advanced study and research at the graduate level.

These PEOs were formulated in light of the declared university mission and college objectives. They were adopted by the COE department council on Sunday November 12, 2006 following an elaborate discussion of an initial set of PEOs that were proposed by a departmental subcommittee commissioned for this task. It is the responsibility of the department to graduate students with a firm grasp of the fundamentals of mathematics, science, and engineering in sufficient breadth and depth. This accomplished through the following measures:

a. Performance in Mathematics: Students should be versed in the basic mathematical tools and should acquire specific skills that would help them tackle typical computer engineering problems.
b. Performance in Science: Students should be able to identify the involvement of science in the computer engineering discipline. They should be able to successfully apply both classical and modern scientific concepts to obtain solutions to relevant computer engineering problems.
c. Performance in Engineering: Students should be able to demonstrate skillful ability in integrating their knowledge in both mathematics and science in developing solutions to complex engineering problems.

3.5 COE Program Learning Outcomes

Following a critical review of the ABET Criteria and the program objectives, the COE faculty have decided that the ABET Criteria (a-k) encompass the spirit of our educational vision, and therefore, have chosen these criteria in addition to three more outcomes (l-n) recommended by ABET for computer engineering programs as the outcomes of the computer engineering program. After numerous discussions and consultation with the advisory board, the COE department has chosen the following set of program outcomes:

(a) Ability to apply knowledge of mathematics, science, and engineering

(b) Ability to design and conduct experiments, as well as to analyze and interpret data

(c) Ability to design a system, component, or process to meet desired needs

(d) 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.

(e) Ability to identify, formulate, and solve engineering problems

(f) Understanding of professional and ethical responsibility

(g) Ability to communicate effectively

(h) Broad education that is necessary to understand the impact of engineering solutions in a global and societal context

(i) Recognition of the need for, and an ability to engage in life-long learning

Our intrepretation of this outcome includes teaching students that the underlying theory is important because the technology will change, coupled with enahncing their self-learning ability, drive and skills.

(j) knowledge of contemporary issues

Our interpretation of this outcome 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, etc.

(k) Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

(l) Knowledge of Probability and Statistics and their applications in Computer Engineering

(m) Knowledge of Discrete Mathematics

(n) The ability to design a system that involves the integration of hardware and software components

It should be noted that outcomes (l) and (m) were added to the program outcomes as recommended by ABET for computer engineering programs since knowledge of probability and statistics and knowledge of discrete mathematics are considered important for computer engineers. Outcome (n) was added to the program outcomes in order to emphasize in our program the integration of hardware and software components in the design process. This is different from outcome (c) which focuses on design aspects in general which may not involve the integration of both hardware and software components.

3.6 Program Objectives Aligned with College and University Mission Statements

The main aim of the COE program, as the program objectives state, is to graduate students with a sound understanding of computer engineering principles, practices and skills needed for the professional practice of computer engineering, with knowledge of state-of-the-art computing systems and tools and a deep appreciation of professional and ethical issues. This should enable our graduates to be competent professionals in the theory and practice of computer engineering who are capable of meeting the demands of Saudi industry and providing leadership in academia, government circles, and in industry. Conformity of the adopted objectives to international standards means that our graduates will be competitive both locally and internationally. Furthermore, the Computer Engineering PEOs are conducive to and consistent with the KFUPM mission. For instance, the first and second objectives directly serve item (i) of KFUPM's mission while the third objective directly serves item (ii). Likewise, the COE PEOs are directly related to and serve the CCSE objectives. For instance, the first and second PEOs directly serve CCSE's first and third objectives while the third PEO serves CCSE's second and fourth objectives.

3.7 Mapping Program Objectives, Outcomes and Courses

The Computer Engineering program educational objectives are served by the program learning outcomes. The mapping of program learning outcomes serving each program educational objective is given in Table 3.1. A detailed description of the relationship between program educational objectives and learning outcomes is provided below.

Objective 1: Practice profession with confidence and global competitiveness and make intellectual contributions to it

For computer engineering graduates to be able to practice their profession with confidence and global competitiveness students must have the basic and fundamental knowledge of mathematics, science and engineering and they should be able to apply it in formulating and solving computer-engineering problems. They should be able to design the required experimental setup and know how to interpret the collected data to help them analyze the problem they are solving and formulate effective solutions. The students must have the required skills and experience with modern tools to enable them to perform the required tasks. The computer engineering profession often involves design tasks that need to meet specified criterion, e.g. in terms of cost, speed, power consumption, etc. Practice is often based on teamwork that demands skills on how to work effectively within a team to maintain global competitiveness. Thus, our program focuses on enhancing the design abilities of our students by integrating design aspects into many courses and includes system design issues that focus on integration of hardware and software components, which is a prime concern nowadays in computer systems design. In addition, teamwork is encouraged throughout the program in lab work and in all course projects and the senior design project. A necessary aspect of successful engineers is their abilities to communicate their ideas effectively through presenting their work to others or sharing information with other team members. This is one of the important outcomes addressed by our new program. Preparing the students in all these aspects will give them the confidence to practice the computer engineering profession and be able to make contributions to it.

Objective 2: Pursue a life-long career of personal and professional growth with superior work ethics and character

The computer engineering field is one of the fields that are growing rapidly. This puts a requirement on engineers to develop their knowledge and skills to remain up to date and to grow in their profession. Thus, it is important to train the students on how to continue acquiring new knowledge and skills. In addition to keeping abreast with new developments in the field, computer engineers often need to learn a new programming language or a new engineering tool. The ability to engage in life-long learning is an important aspect of our new program, with most courses incorporating a self learning assignment. For our students to be able to grow professionally in their career, they must be trained to practice their profession with superior work ethics and character. In addition, they must be aware of the impact of engineering solutions in global and societal context and be aware of contemporary issues affecting their career, e.g. the economy, the environment, etc..

3: Pursue advanced study and research at the graduate level

This objective is aligned with one of the university objectives in preparing our students for pursuing advanced study and research at the graduate level. For students to be well-prepared for pursuing graduate studies, they must have the necessary foundation in mathematic, science and engineering to formulate and solve research problems. They should be skillful in using necessary tools to allow them to perform necessary experiments to evaluate proposed solutions. In addition, they must have excellent self-learning abilities for reading and understanding other published work. Excellent writing skill is an important aspect of graduate studies to help the student in his thesis write-up and in publishing his research work.

Table 3.1. Program outcomes related to program educational objectives.

Program Educational Objectives	Program Outcomes
1. Practice profession with confidence and global competitiveness and make intellectual contributions to it	a, b, c, d, e, g, k, l, m , n
2. Pursue a life-long career of personal and professional growth with superior work ethics and character	f, i, h, j
3. Pursue advanced study and research at the graduate level	a, b, e, g, i, k

To ensure that the learning outcomes of the computer engineering program are achieved by students at the end of their program of study, it is necessary that these outcomes are adequately covered by the program curriculum. We have decided that the program outcomes should be covered by core courses in the program. Each program outcome is addressed by a set of core courses in the program to enhance its achievement by the end of the program. Thus, the learning outcomes of each core course are mapped to the program outcomes with a level of emphasis which is low (L), medium (M), or High (H). The level of emphasis is related to the weight used for assessing an outcome in each course. For each core course, faculty members have agreed on a minimum weight that should be used in the assessment of each course outcome. This minimum weight guarantees a minimum level of coverage for an outcome in a course and is used for deciding the level of coverage for the program outcome corresponding to the course outcome.

Table 3.2 shows the mapping between course outcomes and program outcomes. The program outcomes are covered in an overlapping manner over the core courses in the program curriculum. Design capabilities are well covered in several courses. The ability to apply knowledge of math, science and engineering to solve engineering problems are also well addressed in several courses. Teamwork is encouraged in all courses with lab work and/or projects. The ability to design and conduct experiments is covered in courses involving lab work and other related courses. The use of engineering tools is also emphasized in all courses with lab work and those having a course project. Students are also trained on self learning skills in several courses. Communication skills are emphasized in all courses with a project in addition to the seminar course, coop and summer training.

The seminar course (COE 390) focuses on enhancing students' oral presentation skills. In addition, a focused course on technical report writing (ENGL 214) is taken by all students and focuses on enhancing their writing skills. A dedicated course (IAS 211) that educates students on ethical issues and professional ethics is taken by all students. In addition, computing ethics aspects are covered in the seminar course (COE 390). Impact of engineering solutions on global and societal context is addressed in the seminar course (COE 390) and in the senior design project. Knowledge of contemporary issues is also addressed in the seminar course (COE 390), the senior design project and in other courses taken by the students from the Islamic and Arabic Studies Department.

Table 3.2. Coverage of program outcomes by core COE courses in the new program.

	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**
COE 202	H		H								L			
COE 203		M	H	L			L				H			
COE 205			H	L					L		L			
COE241												H		
COE 305	M	L	H	L	H				L		L			
COE 308	H		H		L				L		L			
COE 341	M		H		H				L		L			
COE 344	M	L			H					L	L			
COE 361	L	L	H	L			L				M			
COE 390						M	H	L	M	M				
COE 400	M	M		M	L		M		L		L			H
COE 485	L	M	H	M	L	L	M	L	L	L	M			
COE 351			H	M		M	H		M		M			
COE 399				M		M	H		M		H			
ICS 252													H	
IAS 211						H								
ENGL 214							H							

4. Development of the New Curriculum

As was explained in section 2 above, the committee followed a top-down approach in designing the new curriculum. The first decision that had to be made is how much breadth should the new program have and how much depth. Answers to these questions are addressed below.

4.1. Breadth versus Depth

The following discussion on breadth versus depth is extracted from the IEEE/ACM Task Force on Computing Curricula.

4.1.1. Breadth of Knowledge

Because of the breadth of the computer-engineering field, curricular content may vary widely among programs, or even among students in the same program. Computer-related coursework typically comes from computer organization and architecture, algorithms, programming, databases, networks, software engineering, and communications. Electrical engineering related coursework typically comes from circuits, digital logic, microelectronics, signal processing, electromagnetics, and integrated circuit design. Foundational topics typically include basic sciences, mathematics for both discrete and continuous domains, and applications of probability and statistics.

One common measure for differentiating among computer engineering programs is the relative amount of emphasis placed on topics that are commonly associated with either electrical engineering or computer science programs.

Breadth versus Depth

- **At one extreme, a degree program in computer engineering might provide opportunities for its students to study a wide range of topics spanning the entire field.**
- **At another extreme, there may be programs that focus on one specific aspect of computer engineering and cover it in great depth. The graduates from such programs will typically tend to seek opportunities in the specialist area they studied, whether it is multimedia systems development, computer design, network design, safety-critical systems, pervasive computing, or whatever other specialties emerge and become important.**

4.1.2. High-Level Perspective

From a higher-level perspective, several characteristics are expected of all computer engineering graduates. These include:

System Level Perspective – Graduates must appreciate the concept of a computer system, the design of the hardware and software for that system, and the processes involved in constructing or analyzing it. They must have an understanding of its operation that goes to a greater depth than a mere external appreciation of what the system does or the way(s) in which one uses it.

Depth and Breadth – Graduates should have familiarity with topics across the breadth of the discipline, with advanced knowledge in one or more areas.

Design Experiences – Graduates should have completed a sequence of design experiences, encompassing hardware and software elements, building on prior work, and including at least one major project.

Use of Tools – Graduates should be capable of utilizing a variety of computer-based and laboratory tools for the analysis and design of computer systems, including both hardware and software elements.

Professional Practice – Graduates should understand the societal context in which engineering is practiced, as well as the effects of engineering projects on society.

Communication Skills – Graduates should be able to communicate their work in appropriate formats (written, oral, graphical) and to critically evaluate materials presented by others in those formats.

The curriculum committee has reached the following conclusions on the subject of breadth and depth:

1. Breadth refers to the basic profession-specific knowledge (Math, Science and common Engineering-profession related courses) and Discipline-specific material provided by the program. For breadth, the program can also draw from other departments (specifically ICS and EE)

2. "Every breadth is a core but not every core is a breadth"
3. Any chain of more than 2 courses in the same area constitutes depth rather than breadth (i.e. breadth material should be covered within two course levels)
4. Depth can be achieved by core and/or elective courses
5. Breadth can be divided into core and elective (i.e. there is a compulsory set of breadth topics and optional breadth areas that the student can elect to have through general electives xxx courses)

4.1.3. Areas of Breadth

The following areas have been identified as breadth components of the new curriculum:

1. Math and Science profession-specific)
2. Professional and Personal skills (i.e. Engineering-profession related)
3. Computer Organization and Architecture (Discipline-specific)
4. Digital System Design (Discipline-specific)
5. Embedded Systems (Discipline-specific)
6. Electronic Circuits/VLSI (Discipline-specific)
7. Computer Networks (Discipline-specific)
8. Information Representation, Processing and Security (Discipline-specific)
9. Software (Programming, Algorithms ….) (Discipline-specific)

In all, discipline-specific areas, there would be a clear, distinguishable and measurable emphasis on complete systems rather than just components. COE Graduates must appreciate the concept of a computer system, the design of the hardware and software for that system, and the processes involved in constructing or analyzing it. They must have an understanding of its operation that goes to a greater depth than a mere external appreciation of what the system does or the way(s) in which one uses it.

4.1.4. Areas of Depth

The following areas have been identified as depth components for the new curriculum:

1. **Advanced Networking**
   - Integrated Network/Service management
   - Internet Engineering & Web Service Technology
   - Wireless and Mobile Computing (including Mesh, Ad-Hoc and sensor networks)
   - Optical Networks

2. **VLSI**
   - VLSI Design, Testing and Verification
   - Software-Hardware Co-design
   - Systems on Chips
   - Electronic Design Automation

3. **High performance computing**
   - Grid Computing
   - Fault-Tolerant Computing

4. **Non-Conventional Computing**
   - Configurable Computing
   - Pervasive Computing
   - Bio-Informatics
   - Optical Computing

5. **Computer Systems Applications**
   - Control-Dependent Applications (e.g. Robotics)
   - Data-Dependent Applications (Multimedia Systems, Computer Vision, Data Management Systems …)
   - Intelligent Access Control (Smart Cards and RFID Technologies)
   - IT Security Systems

4.2 Credit Assignment for Breadth Areas

Following extensive study of the IEEE/ACM BOKs and the curricula of similar programs in reputable north American universities, the committee came up with the credit assignment shown in Table 4.1 below. Roughly, each 40 hours of lectures specified by the IEEE/ACM BOKs are mapped to 3 credits. The detailed listing of the IEEE/ACM BOKs for COE are presented in Appendix A.

Table 4.1. Credit Assignment for Breadth Areas

Breadth Area	**Cr. Hrs.**	**IEEE/ACM BOKs (Core Hrs. and comments)**
Total Math, Science, and core IAS	52 (including the ICS's Discrete Math)	CE-DSC Discrete Structures (33 Hrs. ~ 2.35 Crs.) → Discrete Math from ICS → 3cr CE-PRS Probability and Statistics (33 Hrs. ~ 2.35 Crs.) → (will include introduction to queuing theory) → 3cr + Basic Math and Sciences: 14 Crs. Math + 8 crs. Physics + 4 crs. Chem. + 6 crs. English + 2 crs. Phy. Ed. + 12 crs. IAS = 52 Crs.
Professional and Personal Skills	8	CE-SPR Social and Professional Issues (16 Hrs. ~ 1.1 Crs.) → this is in the seminar course (1 credit) + 1 credit from the capstone course on Project management + 3 credits for Engineering Economy + 3 credits for Technical English writing
Computer Organization and Architecture (including Embedded systems)	15 (3 Labs)	CE-CAO Computer Architecture and Organization (63 Hrs. ~ 4.5 Crs.), CE-CSE Computer Systems Engineering (18 Hrs. ~ 1.3 crs.), CE-OPS Operating Systems (20 Hrs. ~ 1.4 Crs.), CE-ESY Embedded Systems (20 Hrs. ~ 1.4 Crs.)→ 4 courses + 3 labs
Digital Circuit Design	4 (1 Lab)	CE-DIG Digital Logic (57 Hrs. ~ 4 Crs.)
Circuits, Electronics and VLSI	8 (2 Labs)	CE-CSG Circuits and Signals (circuits ~ 40 Hrs. ~ 2.9 Crs.) CE-ELE Electronics (40 Hrs. ~ 2.9 Crs.) CE-VLS VLSI Design and Fabrication (10 Hrs. ~ 0.7 Crs.) → Circuits are covered in one course (4 Crs.) and Electronics and VLSI in another (4Crs.) → possible since Electronics and VLSI total 47 Hrs (with out the overlap) → Interfacing Logic families and standard Busses, Circuit Modeling and simulations topics can be covered in the lab (6 Hrs. Total)
Computer Networks	4 (1 Lab)	CE-NWK Computer Networks (21 Hrs. ~ 1.5 Crs.). Over assignment to accommodate local market needs

Information Representation and Processing	3	CE-DSP Digital Signal Processing (17 Hrs. ~ 1.2 Crs.) CE-CSG Circuits and Signals (the signals part 3 Hrs. ~ 0.2 Crs.) → Less than 1.5 Crs → Some coding, modulation …etc. are included here
Software	14 (2 Labs)	CE-PRF Programming Fundamentals (39 Hrs. ~ 2.8 Crs.) CE-ALG Algorithms and Complexity (30 Hrs. ~ 2.1 Crs.) CE-DBS Database Systems (5 Hrs. ~ 0.35 Crs.) CE-SWE Software Engineering (13 Hrs. ~ 0.9 Crs.) → Total of 7.6 Crs required. Over assignment of 12 Crs. + 2 Labs to accommodate local market needs
Total COE+ICS+EE CORE (including capstone project)	55 for non-coop and 56 for coop students	
Total Core	108 Cr. Hrs.	This leaves 24 Crs. For electives

IEEE/ACM BOK that do not fit in any area: CE-HCI Human-Computer Interaction (8 Core Hrs.).

4.2.1. Benchmarking with COE Programs at Other Universities

To ensure that the assigned core credit hours for each breadth area are adequate, the committee has performed extensive benchmarking with COE programs in several reputable North American universities. These COE curricula were studied in terms of credit assignment to different core areas and the results are summarized in Table 4.2 below. The detailed results are presented in Appendix C.

Table 4.21: Summary of credit assignments for studied universities

University	Communications & Networking	Circuits, Electronics & VLSI	Programming	Computer Science	Computer Organization and Architecture	Digital Logic	Embedded Systems	Person& Professional Skills	Total cr. hrs
U of Minnesota	0	15	8	12	4	6	6	6	126
U of Texas Austin	0	10.5	3	3	4.5	4.5	3	11.5	123
U. of Illinois at Urbana-C	0	5	3	4	7	6	0	4	128
U. of Notre Dame	0	9	8	4	8	6	0	11	130
Carleton University (Ottawa)	7.5	10.5	3	9	21	3	0	12	126
Purdue University	3	20	3	8	4	7	4	15	128
Florida State University	3	8	6	9	3	7	4	N/A	127
U of California San Diego	0	16	4	36	10	6	0	0	171
Arizona State University	0	8	3	21	7	3	8	3	128
Ohio State University (with EE)	0	17	3	17	3	7	6	4	199
Ohio State University (with CS)	0	0	4	34	7	8	2	4	196
U of Washington (HW)	4	10	8	15	4	12	4	7	180

KFUPM (Current)	7	11	8	13	11	4	3	4	131
KFUPM (proposed)[1]	4	8	15 Cr. Total		7	4	8	8	**132**

Quarter system

As Table 4.2, shows, the assigned credit hours for each area in the new program are within the normal range.

4.3. Features of the new Curriculum

The proposed new curriculum satisfies the following desirable features:

1. Maintaining the current levels of basic science courses, English courses and IAS courses
2. No significant changes to sophomore courses (thus allowing students to easily change majors within the college)
3. Reduced focus on ICS areas and increased focus on COE areas. However, the current level of programming is maintained in order to meet the local market needs.
4. Minimum set of core courses in all breadth areas. The committee, through extensive benchmarking (see Section 4.3. above), ensured that this set did not go below the minimum standard for the coverage of an area. This resulted in a maximum of two courses per breadth area.
5. Increased number of electives allowing the student to pick at least two areas of depth. Areas that have been designated as areas of depth are listed in Section 4.1.4 above.
6. Maintaining a good number of un-restricted general electives, allowing the students more breadth of knowledge and more exposure to contemporary issues
7. Coverage of engineering practices, skills and project management through the seminar and capstone project courses
    a. Integration of different COE disciplines through three courses; the first is an introduction to computer systems, embedded systems and the capstone project courses.

4.4. Specific Recommendations/Changes

The committee proposes the following specific changes:

1. Introduce a new course, COE 208 (3-3-4) Computer Organization and Architecture, to replace the two existing courses COE 205 (3-3-4) Computer Organization and Assembly Language and COE 308 (3-0-3) Computer Architecture.

    Justification: The existing COE 205 is mostly Assembly language programming. The students will get plenty of training on assembly programming in the new courses serving the newly founded emphasis on embedded systems. Hence consolidating these two courses would improve the focus on computer Architecture and Organization without sacrificing any knowledge or skills.

[1] With 3 cr. assigned to information representation and processing

2. Introduce a new course COE 307 Computer Systems (3-0-3)

   Justification: This is to fill in an existing gap in the current program; namely system-level perspective. It is very essential to provide the required integration of different computer engineering knowledge in a cohesive manner.

3. Introduce a new course COE 361 (3-3-4), Fundamentals of Computer Electronics, replacing EE203 Electronics I, and COE360 Principles of VLSI Design

   Justification: The current coverage level of circuits, electronics and VLSI is 11 credit hours. This far exceeds the required coverage by IEEE/ACM BOK (47 teaching hours). It is also more than most COE programs in reputable universities. The proposed new course will provide the required coverage of electronics and VLSI.

4. Introduce a new course COE 240 (2-3-3), Probability and statistic for computer engineers, to replace STAT 319.

   Justification: To provide more emphasize on applications related to the COE discipline. Also *queuing theory*, essential for the proper study of computer networks, will be introduced.

5. Introduce a new core course, SE 307 (3-0-3) Engineering Economic Analysis in response to feedback from local employers and the COE industrial advisory board.

6. Change the name of the existing course COE 341 (3-0-3) Data and Computer Communications to Information Representation and Systems, and update the course content accordingly for greater emphasis on information engineering.

7. Change the name of the existing course COE 305 (3-3-4) Microcomputer System Design to COE 305 (3-3-4) Microprocessor System Design and update the course content accordingly for greater emphasis on embedded microprocessors applications.

8. Change the existing course COE 400 (1-6-3) System Design Laboratory to COE 400 (2-3-3) Embedded Systems to allow more structured study of Embedded Systems.

9. Eliminate the existing course ICS 431 (3-3-4) Operating Systems from the program.

   Justification: A COE curriculum (as evident from IEEE/ACM 2004 BOK) only requires 19 teaching hours of operating system material. This does not justifies a 4-credit hour core course. Also emphasis in the new curriculum will be on Embedded Systems which require real time operating systems that are not covered in ICS 431. Finally, all the required operating systems concepts are required much earlier in the program since they are utilized in the new courses on Embedded Systems (COE 305 and COE 400). Therefore, these concepts need to be taught in a junior level course not a 400 senior-level course like the ICS 431. In the new curriculum, these concepts are introduced in an integrated manner in the two new courses COE 307 and COE 305.

10. The chain of courses in the area of computer architecture (COE 205, COE 308, COE 305 and COE 400) is changed as follows to reflect the new focus on Embedded Systems:

    a. COE 208 Computer Architecture and Organization (3-3-4), with COE 202 (Digital Logic Design) as pre-requisite,

    b. COE 307 Computer Systems (3-0-3), with COE 208 as pre-requisite,

c. COE 305 Embedded Microprocessor System Design (3-3-4), with COE 203 (Digital Logic Lab) and COE 208 as pre-requisites,

d. COE 400 Embedded Systems (3-3-4), with COE 305 as pre-requisite,

11. The course COE 485 (1-6-3) Senior Design Project, which was required by non-coop students only, is to become a structured capstone project course (2-3-3) with a structured project and an introduction to engineering practices (project management, communication skills, …etc.). The new course will be required by all students since it replaces the existing COE 400 capstone course.

12. For the coop option of the program, the Coop training (COE 353) will replace 2 COE electives and a general elective (a total of 9 credit hours) instead of currently replacement of 2 electives and the senior project (also a total of 9 credit hours).

13. The IAS 4xx elective was replaced by two GS xxx electives to allow for more flexibility and address the problem of low humanities component in the curriculum that was pointed out by ABET. This also satisfies the university general education requirements.

14. A new elective track on Computer Security has been established with six new electives;
    a. COE 470 (3-0-3) Information Security
    b. COE 471 (3-0-3) Cyber & Computer Security
    c. COE 472 (3-0-3) Implementation of Security Protocols
    d. COE 473 (3-0-3) Computer Security & Crypto Architectures
    e. COE 474 (3-0-3) Network Security Engineering
    f. COE 479 (3-0-3) Special Topics on Computer Security

15. Change the elective course COE 445 (3-0-3) Internet Information Services to COE 445 (3-0-3) Internet Engineering & Technologies to match the recent trends and needs of the local and global job markets.

16. Change the elective course COE 499 (3-0-3) Special Topics on Computer Engineering was changed to a (2-3-3) course under the same title to facilitate offering electives with labs.

17. Introduce the following new electives:

    - In the Applications area:
        - COE 481 (3-0-3) Design and Implementation of Smart Access Systems
        - COE 482 (3-0-3) Pervasive and Ubiquitous Computing
        - COE 483 (3-0-3) Data Management Systems
    - In the Networking Area:
        - COE 448 (3-0-3) Network Planning and Optimization
    - In the Non-Conventional Computing area:
        - COE 407 (3-0-3) Reconfigurable Computing

The catalog descriptions of all new courses proposed in the new program are provided in appendix B.

The committee held frequent presentations to the COE Department Council to get its approval of all the intermediate steps toward implementing the new curriculum. Four reports were generated, sent to all COE faculties for their reviews and feedback, which the committee has incorporated into the curriculum development.

Also, all courses were reviewed in order to ensure they serve the program mission, objectives and outcomes.

4.5. The Proposed Program

Table 4.3 below shows a detailed layout of the proposed curriculum.

Table 4.3 Details of the new proposed COE Curriculum.

a. General Education Requirements (52 credits)

Basic Science	CHEM 101(4),	PHYS 101(4),	PHYS 102(4)	
Mathematics	MATH 101(4),	MATH 102(4),	MATH 201(3),	MATH 260(3),
Isla. & Ara. Stu.	IAS 101(2),	IAS 111(2),	IAS 201(2),	IAS 212(2),
	IAS 301(2),	IAS 322(2)		
English	ENGL 101(3),	ENGL 102(3),	ENGL 214(3)	
SE	SE 307(3)			
Physical Edu.	PE 101(1),	PE 102(1)		

b. Core Requirements (55 credits for non-coop and 56 credits for coop)

EE	EE 201(4),			
ICS	ICS 102(3),	ICS 201(4),	ICS 202(4),	ICS 253(3),
COE	COE 202(3),	COE 203(1),	COE 208(4),	COE 240(3),
	COE 305(4),	COE 307(3),	COE 341(3),	COE 344(4),
	COE 361(4),	COE 390(1),	COE 400(4),	COE 485(3)

c. Elective (24 credits)

GS Electives	GS xxx(3)	GS xxx(3)	
IT Elective	SWE/ICS/COE xxx(3)*		
COE Electives	COE 4xx(3),	COE 4xx(3),	COE 4xx(3),
	COE 4xx(3)		
Free Electives	XE xxx(3),		

*Has to be ICS 334 (3-3-4) for COOP option

d. Summer Training (Pass/Fail grade; No credits) for non-coop option

Prerequisites for the summer training are:

- Student is currently enrolled in the university.
- Student has completed 90 credits or more (including the current semester)
- Students has completed or currently doing ENGL 214 and COE 344.
- Summer training is not in the last semester for the student at the university.

Every student enrolled in the non-coop program is required to take a summer training program of real practical experience, submit a formal written report and make a presentation to a group of faculty on his accomplishments.

e. COE 351 COOP Work (9 credit hours) for students enrolled in the coop program

Prerequisites for the COOP training are:

- Student is currently enrolled in the university.
- Student has completed 90 credits or more (including current semester)
- Students has completed or currently doing ENGL 214, COE 344 and ICS 334.
- Coop training is not in the last semester for the student at the university.

Every student enrolled in the coop program is required to participate in a coop training program of real practical experience, submit 4 formal written progress reports, a final report and make a presentation to a group of faculty on his accomplishments.

f. Total Credit Hour Requirements
The total required credits for the BS degree in Computer Engineering are 132 semester-credit-hours for non-coop option and 133 semester-credit-hours for coop option.

4.6. The New Degree Plan

The degree plan for the new program is shown in Table 4.4 below. LT: Lecture hours, LB: Lab hours, and Cr: Credit hours. As the table indicates, the plan allows a student to finish in five years (including the preparatory year) with a balanced semester load averaging 16 credit hours (the actual loads vary from 15 to 17 credits), with an average of 1 lab per semester. Only one semester would require the student to take 3 labs (the second semester in the third year), however one of these labs is a programming lab. The large number of electives in the new program means that the student will have significant flexibility in his program of study, allowing him to manage his degree plan easily and customize it to his needs.

Table 4.4 The proposed new COE Degree Plan

Course		Title	LT	LB	CR	Course		Title	LT	LB	CR
First Year (Preparatory)											
ENGL	001	Preparatory English I	15	5	8	ENGL	002	Preparatory English II	15	5	8
MATH	001	Preparatory Math I	3	1	4	MATH	002	Preparatory Math II	3	1	4
ME	003	Preparatory Engg. Tech.	0	2	1	PYP	001	Prep Physical Science	2	0	2
PYP	002	Prep Computer Science	0	2	1	PYP	003	University Study Skill	0	2	1
PE	001	Prep Physical Educ. I	0	2	1	PE	002	Prep Physical Educ. II	0	2	1
			18	12	15				20	10	16
Total Credit required in Preparatory Program: 31											
Second 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	101	Practical Grammar	2	0	2	IAS	111	Belief & its Effects	2	0	2
						PE	101	Physical Education I	0	2	1
			15	7	17				14	8	17
Third Year (Sophomore)											
COE	202	Fund. Of Comp. Eng.	3	0	3	ICS	202	Data Structures	3	3	4
ICS	201	Intro. To Computing II	3	3	4	MATH	260	Diff. Eqs. & Lin. Algebra	3	0	3
EE	201	Electric Circuits I	3	3	4	COE	208	Comp. Org. & Arch.	3	3	4
MATH	201	Calculus III	3	0	3	COE	203	Fund. Of Comp. Eng. Lab	0	3	1
IAS	201	Objective Writing	2	0	2	ICS	253	Discrete Structures I	3	0	3
PE	102	Physical Education II	0	2	1	IAS	212	Professional Ethics	2	0	2

			14	8	17				14	9	17
Fourth Year (Junior)											
COE	240	Prob.& Stat. for Comp. Engrs	2	3	3	COE	344	Computer Networks	3	3	4
COE	305	Microprocessor Sys. Des.	3	3	4	COE	307	Computer Systems	3	0	3
COE	341	Info. Representation & Systems	3	0	3	IAS	301	Language Comm. Skills	2	0	2
ENGL	214	Academic & Prof Comm	3	0	3	COE	361	Fund. Of Comp. Electronics	3	3	4
COE	390	Seminar	1	0	1	ICS/ SWE/COE	xxx	IT Elective	3	0	3
IAS	322	Human Rights in Islam	2	0	2						
			14	6	16				14	6	16
Fifth Year (Senior)											
COE	400	Embedded Systems	3	3	4	COE	485	Capstone Design	2	3	3
XE	xxx	Free Elective I	3	0	3	XE	xxx	Free Elective 2	3	0	3
COE	xxx	COE Elective 1	-	-	3	COE	xxx	COE Elective 3	-	-	3
GS	xxx	GS Elective 1	-	-	3	COE	xxx	COE Elective 4	-	-	3
SE	307	Eng. Economics Analysis	3	0	3	GS	xxx	GS Elective2	3	0	3
			15	3	16				14	3	15
Total credits required in Degree Program: 132 (133 for COOP)											

5. Program Support

The proposed new COE program will be supported by existing resources used for the existing program, which are outlined in this section. These resources include faculty, office support, laboratories, technical support, offices, and work instruments.

5.1 Faculty

The COE faculties are committed to program development and course coverage in addition to maintaining continuity and improvement of academic standards. The interest and qualifications of department faculty members are sufficient to plan, teach, modify and update all offered COE courses, and curriculum. The COE faculties collectively present an impressive level of competence in their respective areas of specialty through their academic, research and industrial experiences. The COE program has enough faculty members in all areas of the COE program who are highly qualified in their various areas of specialization. This enables the department to offer courses frequently enough for students to complete the program in a timely manner. The COE department has the following number of faculty members with primary commitment to the program in each academic rank, broken down within rank by tenure status and area of specialization.

Table 5.1: Details of the number of active faculty members at each rank in the various areas of the COE program

Program Area	Academic Rank	Tenure status		Total
		Tenured	Non-Tenured	
Networking/ Data Communications	Professor	0	1	1
	Associate Professor	0	0	0
	Assistant Professor	2	4	6

	Lecturer	٠	1	1
			Total	8
Computer Architecture, Organization & Embedded Systems	Professor	0	1	1
	Associate Professor	0	0	0
	Assistant Professor	1	3	4
	Lecturer	٠	3	3
			Total	8
Digital Circuit Design, Electronics and VLSI	Professor	0	0	0
	Associate Professor	1	1	2
	Assistant Professor	1	2	3
	Lecturer	٠	2	2
			Total	7
Total				23

Note: Tenured members are Saudi faculty. Non-tenured members are expatriates.

5.2 Office Support

The department has three support staff that help in the smooth running of the departmental activities: an administrative assistant to the Chairman, a secretary and a messenger.

5.3 Laboratories and Computing Facilities

The department maintains its own laboratories, servers, and office and research computing facilities. Workstations are provided in the instructional laboratories, and additional systems are supported provided in faculty and graduate student offices, administrative offices, and research labs. Laser printers, scanners, and other peripheral resources are also provided.

The department has access to two types of instructional labs: departmental instructional labs and college instructional labs. Departmental Instructional labs are listed in Table 5.2 below.

Table 5.2: COE Departmental Instructional Labs

#	**Lab Name**	**Location (building/ Room)**	**Purpose**	**Courses served by lab**	**number of students/sessio**	**Lab space (Sq. Ft.)**
1.	Digital Logic Design Lab	22/340-A	Prototyping of logic circuits	COE 203	13	630
2.	Microprocessor Lab	22/340-B	Processor interfacing and building microcomputer systems	COE 305	12	630
3.	Network & Communication Lab	22/347-A	Conduct experiments related to all layers of TCP/IP protocol stack, network management, network architecture, and network security	COE 344, COE 444, COE 445, COE 485	20	820
4.	Digital System Design Lab	22/347-B	Design, implement, debug and document a major microcontroller based system	COE 400	27	630
5.	Printed Circuit Board Lab	23/019	Electronic circuit implementation on printed circuit boards	COE 400	8	930
6.	Robotics Lab	22/339	Conduct experiments on Internet Tele-Robotics using real-time Client-Server network programming	COE 484, COE 584	9	317

7.	Senior Design Project Lab	22/339-1	Teaching & Projects	COE 485, COE 446	10	31 7
8.	FPGA & Design Automation Lab	22/333-1	Research	COE 561	8	42 0
9.	Performance Engineering Lab	22/342	Research	–	3	20 1
10.	Graduate Research Lab	22/401	Research	–	6	29 1

In addition to the existing labs shown in the Table above, a new lab for the new course COE 361 will be required. The existing COE 400 lab will serve as the new Embedded Systems lab.

The College of Computer Science and Engineering (CCSE) provides additional computer labs and server resources. CCSE labs provide Unix and Windows facilities as follows:

1. 22-335: 35 Windows XP Dell GX 240 Pentium IV, 512 MB RAM machines. Open 24 hours.
   Primary function: Instructional and General Purpose Lab.

2. 22-410: 36 Windows XP Dell GX 240 Pentium IV, 512 MB RAM machines. Open 24 hours. One HP 9000 DN printer. Open 24 hours.
   Primary function: Instructional and General Purpose Lab.

3. 23-017: 36 IBM Pentium IV machines running Windows XP. The RAM is 512 MB.
   Primary function: Instructional Lab.

4. 22-418: 24 IBM Pentium IV machines running Windows XP. The RAM is 512 MB. One HP 9000 DN printer.
   Primary function: Instructional and General Purpose Lab.

5. 22-413: 28 HP Pentium IV PCs running Mandrake Linux version 10.1. One HP 9000 DN printer. Open 24 hours.
   Primary function: Instructional and General Purpose Lab.

6. 22-333: 22 HP Compaq Pentium IV machines running Windows XP. The RAM is 512 MB. 2 HP 9000 DN printers. Open 24 hours.
   Primary function: General Purpose Lab.

7. CCSE Unix Network File, print, and computational servers provided by the college include a Sun NAS Server N8400 with 2 TB of disk, several high end SUN and HP servers for Solaris and Linux, respectively, several smaller servers including SUN V120 and V240 servers for remote access by users, and associated backup facilities.

5.4 Technical Support

The department maintains a professional staff of two lab engineers as well as three MS Windows and Unix specialists. Help desk is also available. CCSE labs are maintained by two Unix specialists and two Windows specialists.

5.5 Work Instruments

Each faculty member is provided with a laptop. In addition, most faculty members in our department have a printer and a scanner to help them carry out their assignment diligently and to utilize their time optimally.

6. Conclusions

The Computer Engineering Department has always endeavored to maintain its offered programs of study current, focused, in-line with other reputable universities worldwide, and responsive to the needs of the local job market. This report describes the latest proposed update to the COE BS program. The BS curriculum has been revised to implement the recommendations of the professional societies like ACM, IEEE and ABET and to satisfy the local needs of the Kingdom.

Appendix A: The IEEE/ACM 2004 Computer Engineering Body of Knowledge

Knowledge Areas and Units	*Knowledge Areas and Units*
CE-ALG Algorithms [30 core hours] CE-ALG0 History and overview [1] CE-ALG1 Basic algorithmic analysis [4] * CE-ALG2 Algorithmic strategies [8] * CE-ALG3 Computing algorithms [12] * CE-ALG4 Distributed algorithms [3] * CE-ALG5 Algorithmic complexity [2] * CE-ALG6 Basic computability theory *****	**CE-CAO Computer Architecture and Organization** [63 core hours] CE-CAO0 History and overview [1] CE-CAO1 Fundamentals of computer architecture [10] CE-CAO2 Computer arithmetic [3] CE-CAO3 Memory system organization and architecture [8] CE-CAO4 Interfacing and communication [10] CE-CAO5 Device subsystems [5] CE-CAO6 Processor systems design [10] CE-CAO7 Organization of the CPU [10] CE-CAO8 Performance [3] CE-CAO9 Distributed system models [3] CE-CAO10 Performance enhancements
CE-CSE Computer Systems Engineering [18 core hours] CE-CSE0 History and overview [1] CE-CSE1 Life cycle [2] CE-CSE2 Requirements analysis and elicitation [2] CE-CSE3 Specification [2] CE-CSE4 Architectural design [3] CE-CSE5 Testing [2] CE-CSE6 Maintenance [2] CE-CSE7 Project management [2] CE-CSE8 Concurrent (hardware/software) design [2] CE-CSE9 Implementation CE-CSE10 Specialized systems CE-CSE11 Reliability and fault tolerance	**CE-CSG Circuits and Signals** [43 core hours] CE-CSG0 History and overview [1] CE-CSG1 Electrical Quantities [3] CE-CSG2 Resistive Circuits and Networks [9] CE-CSG3 Reactive Circuits and Networks [12] CE-CSG4 Frequency Response [9] CE-CSG5 Sinusoidal Analysis [6] CE-CSG6 Convolution [3] CE-CSG7 Fourier Analysis CE-CSG8 Filters CE-CSG9 Laplace Transforms
CE-DBS Database Systems [5 core hours] CE-DBS0 History and overview [1] CE-DBS1 Database systems [2] * CE-DBS2 Data modeling [2] * CE-DBS3 Relational databases * CE-DBS4 Database query languages * CE-DBS5 Relational database design * CE-DBS6 Transaction processing * CE-DBS7 Distributed databases * CE-DBS8 Physical database design *	**CE-DIG Digital Logic** [57 core hours] CE-DIG0 History and overview [1] CE-DIG1 Switching theory [6] CE-DIG2 Combinational logic circuits [4] CE-DIG3 Modular design of combinational circuits [6] CE-DIG4 Memory elements [3] CE-DIG5 Sequential logic circuits [10] CE-DIG6 Digital systems design [12] CE-DIG7 Modeling and simulation [5] CE-DIG8 Formal verification [5] CE-DIG9 Fault models and testing [5] CE-DIG10 Design for testability
CE-DSP Digital Signal Processing [17 core hours] CE-DSP0 History and overview [1] CE-DSP1 Theories and concepts [3] CE-DSP2 Digital spectra analysis [1] CE-DSP3 Discrete Fourier transform [7] CE-DSP4 Sampling [2] CE-DSP5 Transforms [2] CE-DSP6 Digital filters [1] CE-DSP7 Discrete time signals CE-DSP8 Window functions	**CE-ELE Electronics** [40 core hours] CE-ELE0 History and overview [1] CE-ELE1 Electronic properties of materials [3] CE-ELE2 Diodes and diode circuits [5] CE-ELE3 MOS transistors and biasing [3] CE-ELE4 MOS logic families [7] CE-ELE5 Bipolar transistors and logic families [4] CE-ELE6 Design parameters and issues [4] CE-ELE7 Storage elements [3] CE-ELE8 Interfacing logic families and standard

CE-DSP9 Convolution CE-DSP10 Audio processing CE-DSP11 Image processing	buses [3] CE-ELE9 Operational amplifiers [4] CE-ELE10 Circuit modeling and simulation [3] CE-ELE11 Data conversion circuits CE-ELE12 Electronic voltage and current sources CE-ELE13 Amplifier design CE-ELE14 Integrated circuit building blocks
CE-ESY Embedded Systems [20 core hours] CE-ESY0 History and overview [1] CE-ESY1 Embedded microcontrollers [6] CE-ESY2 Embedded programs [3] CE-ESY3 Real-time operating systems [3] CE-ESY4 Low-power computing [2] CE-ESY5 Reliable system design [2] CE-ESY6 Design methodologies [3] CE-ESY7 Tool support CE-ESY8 Embedded multiprocessors CE-ESY9 Networked embedded systems CE-ESY10 Interfacing and mixed-signal systems	**CE-HCI Human-Computer Interaction** [8 core hours] CE-HCI0 History and overview [1] CE-HCI1 Foundations of human-computer interaction [2] * CE-HCI2 Graphical user interface [2] * CE-HCI3 I/O technologies [1] * CE-HCI4 Intelligent systems [2] * CE-HCI5 Human-centered software evaluation * CE-HCI6 Human-centered software development * CE-HCI7 Interactive graphical user-interface design * CE-HCI8 Graphical user-interface programming * CE-HCI9 Graphics and visualization * CE-HCI10 Multimedia systems *
CE-NWK Computer Networks [21 core hours] CE-NWK0 History and overview [1] CE-NWK1 Communications network architecture [3] CE-NWK2 Communications network protocols [4] CE-NWK3 Local and wide area networks [4] CE-NWK4 Client-server computing [3] CE-NWK5 Data security and integrity [4] CE-NWK6 Wireless and mobile computing [2] CE-NWK7 Performance evaluation CE-NWK8 Data communications CE-NWK9 Network management CE-NWK10 Compression and decompression	**CE-OPS Operating Systems** [20 core hours] CE-OPS0 History and overview [1] CE-OPS1 Design principles [5] * CE-OPS2 Concurrency [6] * CE-OPS3 Scheduling and dispatch [3] * CE-OPS4 Memory management [5] * CE-OPS5 Device management * CE-OPS6 Security and protection * CE-OPS7 File systems * CE-OPS8 System performance evaluation *
CE-PRF Programming Fundamentals [39 core hours] CE-PRF0 History and overview [1] CE-PRF1 Programming Paradigms [5] * CE-PRF2 Programming constructs [7] * CE-PRF3 Algorithms and problem-solving [8] * CE-PRF4 Data structures [13] * CE-PRF5 Recursion [5] * CE-PRF6 Object-oriented programming * CE-PRF7 Event-driven and concurrent programming * CE-PRF8 Using APIs *****	**CE-SPR Social and Professional Issues** [16 core hours] CE-SPR0 History and overview [1] CE-SPR1 Public policy [2] * CE-SPR2 Methods and tools of analysis [2] * CE-SPR3 Professional and ethical responsibilities [2] * CE-SPR4 Risks and liabilities [2] * CE-SPR5 Intellectual property [2] * CE-SPR6 Privacy and civil liberties [2] * CE-SPR7 Computer crime [1] * CE-SPR8 Economic issues in computing [2] * CE-SPR9 Philosophical frameworks *****
CE-SWE Software Engineering [13 core hours] CE-SWE0 History and overview [1] CE-SWE1 Software processes [2] * CE-SWE2 Software requirements and specifications [2] *	**CE-VLS VLSI Design and Fabrication** [10 core hours] CE-VLS0 History and overview [1] CE-VLS1 Electronic properties of materials [2] CE-VLS2 Function of the basic inverter structure [3]

CE-SWE3 Software design [2] * CE-SWE4 Software testing and validation [2] * CE-SWE5 Software evolution [2] * CE-SWE6 Software tools and environments [2] * CE-SWE7 Language translation * CE-SWE8 Software project management * CE-SWE9 Software fault tolerance *	CE-VLS3 Combinational logic structures [1] CE-VLS4 Sequential logic structures [1] CE-VLS5 Semiconductor memories and array structures [2] CE-VLS6 Chip input/output circuits CE-VLS7 Processing and layout CE-VLS8 Circuit characterization and performance CE-VLS9 Alternative circuit structures/low power design CE-VLS10 Semi-custom design technologies CE-VLS11 ASIC design methodology

Mathematics Knowledge Areas and Units

CE-DSC Discrete Structures [33 core hours] CE-DSC0 History and overview [1] CE-DSC1 Functions, relations, and sets [6] * CE-DSC2 Basic logic [10] * CE-DSC3 Proof techniques [6] * CE-DSC4 Basics of counting [4] * CE-DSC5 Graphs and trees [4] * CE-DSC6 Recursion [2] *****	**CE-PRS Probability and Statistics** [33 core hours] CE-PRS0 History and overview [1] CE-PRS1 Discrete probability [6] CE-PRS2 Continuous probability [6] CE-PRS3 Expectation [4] CE-PRS4 Stochastic Processes [6] CE-PRS5 Sampling distributions [4] CE-PRS6 Estimation [4] CE-PRS7 Hypothesis tests [2] CE-PRS8 Correlation and regression

* Similar to the 2001 BOKs

Appendix B: Catalog Descriptions of New Courses

I. Core Courses

COE 208 (3-3-4) Computer Organization and Architecture:

Computer organization, machine instructions, addressing modes, assembly language programming, integer and floating-point arithmetic, CPU performance and metrics, data-path and control unit design, single-cycle, multi-cycle, and pipelined processor design, pipeline hazards, memory system design and cache memory.

Prerequisites: COE 202, ICS 201

Note: COE 208 is equivalent to ICS 233. Students can take credit for only one of them.

COE 240 (2-3-3) Probability and Statistics for Computer Engineers:

Conditional and independence probability, Discrete and continuous probability, Moments, Introduction to Bernoulli and Poisson processes, Markov chains, Simple Queuing models, Sampling, Point estimates, Hypothesis formulation and testing, and Correlation and Regression.

Prerequisites: Math 201

COE 305 (3-3-4) Microprocessor System Design:

Embedded system characteristics, embedded system design life cycle, embedded microprocessor & microcontroller architecture and instruction set, Memory and I/O subsystems, organization, timing, interfacing and programming, Bus architectures & protocols, This course will gear to the integration of hardware modules to construct embedded systems, and the programming models and characteristics of various input/output interfaces. Either assembly language or any high-level languages will be chosen to meet computation, resource, and software development requirements.

Prerequisites: COE 203 and COE 208

COE 307 (3-0-3) Computer Systems:

Embedded system characteristics, embedded system design life cycle, embedded microprocessor & microcontroller architecture and instruction set, Memory and I/O subsystems, organization, timing, interfacing and programming, Bus architectures & protocols, This course will gear to the integration of hardware modules to construct embedded systems, and the programming models and characteristics of various input/output interfaces. Either assembly language or any high-level languages will be chosen to meet computation, resource, and software development requirements.

Prerequisites: COE 208

COE 341 (3-0-3) Information Representation and Systems:

Introduction to information representation and systems, Convolution, Fourier analysis for continuous/discrete–time signals, Spectra analysis, Introduction to sampling theorem, Introduction to transmission impairments and media, Signal encoding techniques, Audio processing, and Image processing.

Prerequisites: Math 102

COE 361 (3-0-3) Fundamentals of Computer Electronics:

The course aims to explain the purpose and role of electronics in computer engineering. It introduces students to the basic electronic materials and components of a typical computer system and the simulation tools used to model, design and verify the performance of these components. These components include diodes, transistors, simple analog electronic circuits as well as digital circuits and buses.

Prerequisites: COE 203, EE 201

COE 400 (3-3-4) Embedded Systems:

This is a project guided course where a sample project serves as example when covering the different topics of the course. Project life cycle. Embedded system design methodologies. Specifications. Hardware/software co-design. Embedded systems hardware platform. Designing robust software for embedded systems. RTOS features.

Prerequisites: COE 305

COE 485 (2-3-3) Capstone Design:

This course is designed to give students the experience of tackling a realistic engineering problem. The intent is to show how to put theoretical knowledge gained into practical use by starting from a word description of a problem and proceeding through various design phases to end up with a practical engineering solution. Project management and team work concepts are introduced and applied. Various projects are offered by COE faculty in their respective specialization areas. The project advisor guides the student in conducting feasibility study, preparation of specifications, and the methodology for the design. Detailed design and implementation of the project are carried out followed by testing, debugging, and documentation. An oral presentation and a final report are given at the end of the semester.

Prerequisites: Senior Standing

II. Elective Courses

COE 407 (3-0-3) Reconfigurable Computing:

This course aims to introduce students to the emerging non-conventional computing field of reconfigurable computing. This includes technologies, architectures, methodologies and applications. The following topics will be covered: Reconfigurable Fabrics (Logic and Interconnect), Software-Hardware partitioning, Co-Design and Co-Simulations, Dynamic Re-partitioning (i.e. Run-time Re-configuration), Platform-based designs and Instruction-set-specific-processors.

Prerequisites: COE 203, COE 307

COE 445 (3-0-3) Internet Engineering & Technologies

This course focuses on engineering technologies for the Internet: Internet and its architecture, Internet services business models, Information retrieval architecture, design, and performance evaluation, Technologies and protocols for QoS support in the Internet. Network security: technologies and protocols.

***Prerequisite*:** COE 344 or Consent of Instructor

COE 448 (3-0-3) Network Planning and Optimization

Study the principals of network planning of different types of data networks including computer networks, wireless data networks, ad-hoc networks, sensor networks, etc. Cover the fundamentals of traffic engineering and how they can be applied in data networks optimization. Consider the usage of different heuristics algorithms for certain network optimization problems related to server placement, cell placement, terminal assignment, communication links weight setting, etc.

***Prerequisite*:** COE 344 or Consent of Instructor

COE 470 (3-0-3) Information Security

Principles of information security & Authentication; Certification programs; Security polices and management; Trusted computing; Security Architectures & Models; Protection mechanisms; Business Continuity planning & Disaster Recovery; Access control systems; Intrusion detection systems; Cryptography; Application development security

***Prerequisite*:** Junior Standing

COE 471 (3-0-3) Cyber & Computer Security

Assessing systems; Securing computer systems; Crypto systems; Cyber crime and Internet fraud; Cyber terrorism & info warfare; Cyber detective; Computer security hardware & software

***Prerequisite*:** Junior Standing

COE 472 (3-0-3) Implementation of Security Protocols

Applications security; Malicious code; Viruses & worms; Defenses; Memory and file protection; User authentication; Denial of service attacks; Data confidentiality & integrity; Distributed systems security; Directory management; Reliability & fault tolerance; Concurrency and integrity; Issues in analysis of security protocols; Verification tools; Monitoring & administration

***Prerequisite*:** Junior Standing

COE 473 (3-0-3) Computer Security & Crypto Architectures

Introduction to computer security and cryptography. Cryptography Mathematical Foundation and Hardware Designing. Private and Public key Cryptosystems. Advanced Ciphers Engineering. Digital Signatures. Security and Cryptosystems Architectures.

***Prerequisite*:** COE 307

COE 474 (3-0-3) Network Security Engineering

Introduction to the fundamental theories and practices underlying the field of network security. Risk analysis, access control and security policies. Vulnerability Analysis and Auditing. Principles of secure networks design.

***Prerequisite*:** COE 344 or Consent of Instructor

COE 479 (3-0-3) Special Topics on Computer Security

Special topics in issues related to computer and network security. Topics and specifics will be announced well before the course starting date.

Prerequisite: Junior Standing

COE 481 (3-0-3) Design and Implementation of Smart Access Systems

The course is composed of two parts: smart cards and RFID. In the smart card part, the following topics are covered: an overview of different types of smart cards, smart card applications, architectures, standards, operating systems, security, management and fabrication. In the RFID part, the following will be covered: RFID concepts and fundamentals including components of RFID systems, the design and architecture, middleware, standards, RLTS (Real Time Location Systems), RFID in the context of ubiquitous computing, privacy and security techniques, engineering design tradeoffs in designing both smart card and RFID systems.

***Prerequisite*:** Senior standing or Consent of Instructor.

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

This course covers both technical and human aspects of the rapidly growing field of ubiquitous and pervasive computing. Students will learn how to design, build and evaluate various ubiquitous computing technologies in order to create novel user experiences. The course covers the following: Sensors and sensor network that can capture and disseminate context information, Sensor network coverage, localization, synchronization, sleep scheduling, connectivity, routing, energy efficient, date centric and transport protocols, and Context-aware applications that use context information to create intelligent everyday objects and applications.

***Prerequisite*:** COE 344

COE 483 (3-0-3) Data Management Systems

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

***Prerequisite*:** Senior standing or Consent of Instructor.

Appendix C:
Benchmarking Results for Determining Credit Assignment per Breadth Area

Table B.1: Detailed credit assignments for studied universities

University	Area	Cr. Hrs	Comments/Details
MINNESOTA	Dept, Semester, Quarter, Others..	126	Dept. of CS & Engineering / Semester System
	Networking/ Communications	0	Only Sig. & Systems course (3)
	Circuits/ Electronics	15	Electronics & Ckts(4) + Dig/Analog Electron (4) + Ckts& Electronics Lab (4) + Linear Sys & Ckts (3)
	Programming	8	
	Computer Science	12	OS(4)+ Algorithms &D_Struc (4)+ Discrete structures (4)
	Computer Org./ Architecture	4	
	Digital Sys. Design	6	Dig. Design (4) + (2)[2] from a split crs
	Embedded Systems	6	Intr. Microcontrollers (4) + (2)[3] from a split crs
	Professional/ Personal Skills	0	At least **4** courses that contain a "**significant writing component**", one of which must be in the major department. These courses are designated as *'writing intensive' (WI)*.
University of Texas at Austin*	Dept, Semester, Quarter, Others..	123	Dept. of E & C Engineering / Semester System
	Networking/ Communications	0	Of course a signals and systems course …
	Circuits/ Electronics	10.5	1.5Cr. From Intro. To ECE course, + 4 cr. Circuit Theory, + 4 cr. Electronic Circuits + 4 cr. Semiconductor Devices (only devices not circuits)
	Programming	3	3 Cr. Intro. To Programming
	Computer Science	3	3 Cr. Data Structures, + 3Cr. Discrete Math
	Computer Org./ Architecture	4.5	1.5 Cr. From Intro. to Computing course, + 3 Cr. µP organization and programming –No core Arch. Course!
	Digital Sys. Design	4.5	1.5 Cr. From Intro. to Computing course, + 3 cr. Logic design
	Embedded Systems	3	3 cr. Microprocessor Interfacing Laboratory

[2] Choice of one of (1. Digital Design using PLD, or 2. Micro Processor & Microcontroller System Design)
[3] Choice of one of (1. Digital Design using PLD, or 2. Micro Processor & Microcontroller System Design)

	Professional/ Personal Skills	11.5	1.5 Cr. Fro Intro. To ECE course, + 3 Cr. Rhetoric and Composition course, + 3 Cr. Eng. Communication, + 3 Cr. Eng. Economics, + 1 cr. Seminar
University of Illinois at* UC	Dept, Semester, Quarter, Others..	128	Dept. of E & C E / Semester System
	Networking/ Communications	0	
	Circuits/ Electronics	5	1 Cr from Introduction to EE and CE (ECE110) + 1 Cr from Analog Sig. Proc (ECE210) + 3 Cr. Solid State Electronic Devices (ECE440)
	Programming	3	3 Cr. From ECE 190 Introduction to Computer Systems
	Computer Science	4	**4 Cr. CS 225 Data Structure & Software Principles**
	Computer Org./ Architecture	7	3 Cr. ECE 390 Computer Engineering II + 4 Cr. ECE411 Computer Organization and Design
	Digital Sys. Design	6	**1 Cr. From ECE 190 Introduction to Computer Systems, + 3 Cr. ECE 290 - Computer Engineering I, + 2 Cr. ECE Digital Systems Lab, +**
	Embedded Systems	0	
	Professional/ Personal Skills	4	4 cr. Technical writing
University of Notre Dame	Dept, Semester, Quarter, Others..	130	Dept. of CS and E (college of engineering)/ Semester System
	Networking/ Communications	0	3 cr. Signals and system course!
	Circuits/ Electronics	9	3 Cr. Circuits + 4 Crs. Electronics (similar to our ee203) + 2 Cr. From Intro. To EE course (project based, learning to use discrete components including µps)
	Programming	8	2 4 Cr. Courses on programming (Fund. Of Comp. I and II)
	Computer Science	4	3 Cr. Discrete math, + 3 Cr. Data Structures, + 3 Cr. Operating Systems, + 4 Cr. CS 225 Data Structure & Software Principles
	Computer Org./ Architecture	8	2 4 Cr. Courses, 1st covers Org. & Assembly and second covers architecture
	Digital Sys. Design	6	1 Cr. From ECE 190 Introduction to Computer Systems, + 3 Cr. ECE 290 - Computer Engineering I, + 2 Cr. ECE Digital Systems Lab
	Embedded Systems	0	

* 3cr Electromagnetic, 21 cr. Technical Electives from the ECE dept, 18 Cr.s Humanities and social sciences, 12 Cr. Free electives and 9 cr.s advanced math

	Professional/ Personal Skills	11	2 4 cr. Introduction to Engineering courses (4 projects) + 3 Cr.s Ethics & Social issues course
Carleton University	Dept, Semester, Quarter, Others..	126	Computer Systems Engineering /Semesters – Very little humanities and electives
	Networking/ Communications	7.5	3 cr. Communications and 3 cr. Networks, + 1.5 cr. from A circuits and signals course that serves both serve electronics
	Circuits/ Electronics	10.5	3 cr. Digital Electronics and 3 cr. Electronic Materials, Devices, and Transmission Media, 3 cr. Circuits, 1.5 Cr. From A circuits and signals course that serves both serve electronics
	Programming	3	
	Computer Science	9	
	Computer Org./ Architecture	21	Real time systems, Embedded systems (mixed into architecture courses)
	Digital Sys. Design	3	
	Embedded Systems	0	
	Professional/ Personal Skills	12	
Purdue University: Computer Engineering Technology Option	Dept, Semester, Quarter, Others..	128	Dept. of Electrical & Computer Engineering / Semester System
	Networking/ Communications	3	
	Circuits/ Electronics	20	Electric Ckts (4)+ Electronics & Ckts(4) + AC Electronics & Ckts (4) + Power and RF Electronics (4) + Electronic Prototype Dev. (4)
	Programming	3	
	Computer Science	8	
	Computer Org./ Architecture	4	
	Digital Sys. Design	7	
	Embedded Systems	4	Intr. Microcontrollers
	Professional/ Personal Skills	15	Technical writing (3) + project Dev. & management (2) + Professional Issues in EET (1) + Communications (3) + Intro. to EET & projects (2)

Florida State University	Dept, Semester, Quarter, Others..	127	Dept. of Electrical & Computer Engineering / Semester System
	Networking/ Communications	3	Introduction to communication (3) + signal and linear systems (3)
	Circuits/ Electronics	8	Electric Ckts with computers (4)+ Electronics & Ckts(4)
	Programming	6	C for majors (3) + Object-Oriented programming (3)
	Computer Science	9	Data structures (3) + introduction to operating systems (3)+ discrete Math (3)
	Computer Org./ Architecture	3	
	Digital Sys. Design	7	
	Embedded Systems	4	Microprocessor based system design
	Professional/ Personal Skills	?	Students must satisfy the Florida College Level Academic Skills Test (CLAST) requirements. The CLAST measures the level of a student's achievement in communication and computational skills. In general, CLAST requirements must be satisfied before a student can be admitted to the upper division.
University of California, San Diego	Dept, Semester, Quarter, Others..	171 units	Dept. of CS & Engineering (BS Computer Engineering Program[4]) / Quarter System (3 equal quarters)[5]
	Networking/ Communications	0	
	Circuits/ Electronics	16	ECE 53A: Fundamentals of Electrical Engineering I (4), ECE 53B: Fundamentals of Electrical Engineering II (4) , ECE 102: Introduction to Active Circuit Design (4), ECE 108: Digital Circuits (4)
	Programming	4	CSE 8B: Introduction to Computer Science: Java or CSE 11: Introduction to Computer Science and Object-Oriented Programming: Java *(Accelerated Pace)*
	Computer Science	36	CSE 12: Basic Data Structures and Object-Oriented Design(4), CSE 20: Discrete Mathematics(4) , CSE 21: Mathematics for Algorithm and Systems(4), CSE 100: Advanced Data Structures(4), CSE 101: Design and Analysis of Algorithms(4), CSE 105: Theory of Computability(4), CSE 120: Principles of Computer Operating Systems(4), CSE 131A: Compiler Construction I(4), CSE 131B Compiler Construction II(4).
	Computer Org./ Architecture	10	CSE 30: Computer Organization and Systems Programming(4), CSE 141: Introduction to Computer Architecture (4), CSE 141L: Project in Computer Architecture(2)
	Digital Sys. Design	6	CSE 140: Components and Design Techniques for Digital Systems(4), CSE 140L: Digital Systems Laboratory(2).
	Embedded	0	

[4] jointly administered by the Computer Science and Engineering (CSE) and the Electrical and Computer Engineering (ECE) Departments. Students wishing to major in computer engineering must be admitted to one of the departments.

[5] Credits should be multiplied by 2/3 to make them equivalent to a regular semesters system

	Systems		
	Professional/ Personal Skills	0	
Arizona State University	Dept, Semester, Quarter, Others.	128	Department of Computer Science and Engineering 2 Semester; program: computer systems engineering
	Networking/ Communications	0	
	Circuits/ Electronics	8	Electrical Networks; Elec. Devices and Inst;
	Programming	3	Introduction to Programming
	Computer Science	21	Principles of Computing; Data Structures & Algorithms I & II; Principles of Programming Languages; Introduction to Theoretical Computer Science; Introduction to Software Engineering; Elementary Concepts of Operating Systems
	Computer Org./ Architecture	7	Assembly Language Programming; Computer Organization and Architecture
	Digital Sys. Design	3	Digital Design Fundamentals
	Embedded Systems	8	Microprocessor System Design I & II;
	Professional/ Personal Skills	3	Introduction to Engineering Design
Ohio Sate University	Dept, Semester, Quarter, Others..	196	Department of Computer Science and Engineering quarters; (with CS)
	Networking/ Communications	0	
	Circuits/ Electronics	0	
	Programming	4	Programming Languages for Programmers development of Software Components;
	Computer Science	30 + 4[6]	Software Development Using Components; D Case Studies in Component-Based Software; Systems Software Design, Development, and Documentation; Introduction to Automata and Formal Languages; Introduction to the Principles of Programming Languages; Introduction to Operating Systems; Introduction to Database Systems I; Introduction to Analysis of Algorithms and Data Structures
	Computer Org./ Architecture	7	Introduction to Computer Systems; Introduction to Computer Architecture
	Digital Sys. Design	4+ 4	Switching Circuits Laboratory; Introduction to Logic Design

[6] Capstone design course: One of the following: Computer Animation; Knowledge-Based Systems; Software Engineering Project; Advanced Operating System Laboratory; Information System Project; Computer-Aided Design; Analysis of VLSI Circuits

	Embedded Systems	2	Microprocessor/Microcontroller Laboratory
	Professional/ Personal Skills	4	Elementary Numerical Methods; Social and Ethical Issues in Computing;
	Technical Electives	27	**Software Systems:** Required: a 3 hours math + 6 hours CSE Software Engineering U G 3 ; Microcomputer Systems U G 3 or Introduction to Computer Networking U G 3, Computer Architecture U G 3 Electives (18 hours): At least 12 of these hours must be CSE The remainder may be CSE or from the following ECE 561, 761, 765, 769; ISE 573; Math 568/571, 572, 575, 647, 648. **Hardware-Software Systems**: Required (12-13 hours): 3 hours math + (CSE or ECE) Microcomputer Systems U G 3 or Microcomputer Structures U G 3; Introduction to Computer Networking U G 3; Digital Circuit Design U G 3; Electives (14-15 hours): At least 12 of these hours must be CSE The remainder may be CSE or from the following: ECE 761, 762, 765, 769; ISE 573; Math 568/571, 572, 575, 647, 648. CSE 778 is recommended as the capstone course **Information Systems**: Required Courses (19 hours): **Object-Oriented Systems Analysis U G 4**; **Introduction to Database Systems II U G 3**; Acct & MIS 211 or 310; Bus Mgmt 630; Math 568 or 571. Electives (8 hours): must be CSE plus ISE 573. **Individualized Option:** At least 15 credit hours must be CSE The remaining 12 credit hours may be CSE courses or appropriate courses from one or more other disciplines.
	Dept, Semester, Quarter, Others..	199	Department of Electrical & Computer Engineering quarters; (with EE)
	Networking/ Communications	0	
	Circuits/ Electronics	17	Circuit Analysis; Circuits and Electronics Laboratory; Analysis and Design in Circuits and Electronics; Electronic Analysis, Design and Simulation; Systems I&2
	Programming	3	Development of Software Components;
	Computer Science	17	Software Development Using Components; Case Studies in Component-Based Software; Systems Software Design, Development, and Documentation; Introduction to Operating

			Systems
	Computer Org./ Architecture	3	Theory and Design of Digital Computers;
	Digital Sys. Design	7	Switching Circuits Laboratory; Introduction to Logic Design; Digital Circuit Design
	Embedded Systems	6	Introduction to Microprocessor-Based Systems; Microprocessor/Microcontroller Laboratory
	Professional/ Personal Skills	4	Professional Aspects of Electrical and Computer Engineering; Special Group Project for Electrical and Computer Engineering Design
	Technical Electives	33	15 hours must be ECE
University of Washington (Seattle)	Dept of CS&E Hardware option	180[7]	**Quarter** System (Hardware option)
	Networking/ Communications	4	For both options (Hardware & Software)
	Circuits/ Electronics	10	Intro to EE (4) + Ckt Theory (5) + Adv Digital Design*(1)
	Programming	8	2 Comp Programming Courses (2*4 cr hrs)
	Computer Science	15	OS(4) + D_Struc (4) + Formal Models (3) + Discrete Structures(4)
	Computer Org./ Architecture	4	Machine org & Assembly Lang (4) For both options (Hardware & Software)
	Digital Sys. Design	12	Dig. Design (4) + (3) from CSE 467* + Hardware design capstone (5)
	Embedded Systems	4	Software for embedded systems(4)
	Professional/ Personal Skills	7	Technical writing (7 cr hrs) + (5cr hrs) of English composition

[7] Most students attend 3 equal quarters each is 10 weeks. Thus, all Cr. Jrs reported here must be multiplied by(2/3) when comparing with KFUPM hours.

Appendix D: Syllabi of the New COE Core Course

1. **COE 208 (3-3-4) Computer Organization and Architecture**

Catalog Description

Computer organization, machine instructions, addressing modes, assembly language programming, integer and floating-point arithmetic, CPU performance and metrics, datapath and control unit design, single-cycle, multi-cycle, and pipelined processor design, pipeline hazards, memory system design and cache memory.

Prerequisite: COE 202, ICS 201

Note: COE 208 is equivalent to ICS 233.
Students can take credit for only one of them.

Potential Text Books

- *Computer Organization & Design: The Hardware/Software Interface*, 3rd edition, David A. Patterson and John L. Hennessy, Morgan Kaufmann, 2005, ISBN: 1-55860-604-1 (lecture)
- *See MIPS Run*, 2nd edition, Dominic Sweetman, Morgan Kaufmann, 2006, 0-12-088421-6 (lab)

Lecture Topics

a. Computer Organization (3 lectures)

Processor, memory, I/O devices, buses, reading and writing memory
Memory hierarchy: registers, caches, main memory, and disk storage
Instruction execution cycle
Technology trends

b. MIPS Assembly Language Programming (10 lectures)

High-level, assembly-, and machine-languages, instructions, instruction formats, syntax of assembly language programs, directives, defining data of various sizes, arrays and strings, symbolic constants, MIPS instruction set, integer arithmetic and logical instructions, load and store instructions, addressing modes, jump and conditional branch instructions, procedures and the stack, stack frames, system calls and I/O, exceptions and interrupts.

c. Computer Arithmetic (8 lectures)

Binary, decimal, and hexadecimal number, base conversions, unsigned and signed integers of various sizes, characters, binary addition and subtraction, hexadecimal addition and subtraction, carry and overflow. Integer multiplication, integer division, floating point representation, IEEE 754 standard, normalized and de-normalized numbers, zero, infinity, NaN, FP comparison, FP addition, FP multiplication, rounding and accurate arithmetic.

d. Performance (3 lectures)

CPU performance and metrics, CPI, performance equation, MIPS as a metric, Amdahl's law, benchmarks and performance of recent processors.

e. Data-path and Control (6 lectures)

Designing a processor, register transfer logic, data-path components, clocking methodology, single-cycle data-path, main control signals, ALU control, single-cycle delay, multi-cycle instruction execution, multi-cycle implementation, microprogramming.

f. Instruction pipelining (9 lectures)

Pipelining versus serial execution, MIPS 5-stage pipeline, pipelined data-path, pipelined control, pipeline performance. Pipeline hazards, structural hazards, data hazards, stalling pipeline, forwarding, load delay, compiler scheduling, hazard detection, stall and forwarding unit, control hazards, branch delay, dynamic branch prediction, branch target and prediction buffer.

g. Memory System Design (6 lectures)

Cache memory design, locality of reference, memory hierarchy, DRAM and SRAM, direct-mapped, fully-associative, and set-associative caches, handling cache miss, write policy, write buffer, replacement policy, cache performance, CPI with memory stall cycles, AMAT, two-level caches and their performance, main memory organization and performance.

Lab Topics

First Part on MIPS Assembly Language Programming

1. Introduction and orientation, individual and group work, grading, introduction to the MIPS assembly programming environment (we can use MARS: MIPS Assembler and Runtime Simulator, or something else)
2. Syntax of assembly language programs, defining data and symbolic constants, viewing memory data segment, byte ordering.
3. Instruction formats, integer arithmetic and logic instructions, system calls and I/O, writing simple programs in assembly language.
   - Programming assignment 1 (small, graded, done individually)
4. Jumps and conditional branch instructions, translating if statements, switch statements, and loops.
   - Programming assignment 2 (small, graded, done individually)
5. Procedures, call and return, parameters, results, local variables, stack frame.
   - Programming assignment 3 (medium, graded, done individually)
6. Floating-point instructions and applications.
7. Interrupts and exceptions, writing interrupt service routines.

Programming Project (large, graded, group work). It can start immediately after programming assignment 3, and can span at most three weeks. It is completed outside the lab, and should not interfere with the registered lab hours. It should address some ABET requirements, such as group work, developing alternative solutions, thorough testing, documentation, and technical report writing.

Second Part on Data-path and Control Design

8. Introduction to LogiSim (a simple graphical tool that can be used to design and simulate a simple CPU), designing components of the data-path, such as an ALU and a multi-ported register file (project oriented and group work)
9. Designing a single-cycle data-path and its control for a small subset of MIPS-like instructions (group work)

10. Completing the single-cycle processor design, designing test cases, and writing a report document (group work)
11. Designing a pipelined data-path and its control (project oriented, group work)
12. Completing the pipelined processor design, handling pipeline hazards, designing test cases, and writing a report document (group work)
13. Experiment on cache memory and its performance.

To summarize, there are two design projects that will span at most 6 weeks of the semester. The first project is the design of the single-cycle CPU (3 weeks) and the second one is the design of the pipelined CPU and the handling of pipeline hazards (3 weeks). The lab will introduce the tools, and the approach that will be used in the design, and will instruct the students to begin working on their projects. However, the projects should be completed after the lab hours. The design projects should also address ABET requirements, such as group work, testing, documentation, and report writing.

Course Learning Outcomes Table

Course Learning Outcomes	Outcome Indicators and Details	Assessment Methods and Metrics	Min. Weight	ABET 2000 Criteria
O1. Ability to apply knowledge of mathematics, probability, and statistics in computer analysis and design.	• Integer representation, addition, and multiplication • Floating-point representation, rounding, normalization, addition, and multiplication. • Program and instruction execution times and stall cycles. • Speedup computation • Evaluation of the average performance of I-pipelining and memory system	• Assignments • Quizzes • Exams	40%	A(H)
O2. Ability to design the data-path and control of a processor.	• Design generic data-path based on Instruction Set requirements. • Identify data-path components and clocking methodology. • Design a detailed single-cycle integer data-path, Muxes, and PC updating. • Identify control signals and design control logic • Design inter-stage buffers and clocking for multi-	• Assignments • Quizzes • Exams • Project	20%	C (H)

	cycle data-path. • Design multi-cycle control states and logic. • Design pipelined data-path and control • Detect and eliminate structural hazards • Detect data hazards and implement forwarding • Handle control hazards and predict branches			
O3. Ability to identify, formulate, and solve computer architecture problems.	• Assess design methodologies in single-cycle, multi-cycle, and multiple-issue data-paths. • Assess tradeoffs in cache design, page size, bus width, degree of associativity, cache capacity, and main memory access time. • Assess tradeoffs in address translation, virtual page size, TLB size, sequential versus concurrent TLB and cache access. • Assess scalability issues in shared-memory and distributed-memory systems.	• Assignments • Quizzes • Exams	5%	E (L)
O4. Ability to use simulator tools.	• Ability to set up a simulator. • Set up simulation runs based on some design specifications. • Run simulations and collect results and statistics • Ability to analyze simulation results and modify design specifications to improve performance.	• Assignments • Mini-group Projects	2%	K(L)

O5. Ability to engage in self-learning.	• Demonstrates reading, writing, listening and speaking skills • Identifying, retrieving, and organizing information • Following a learning plan • Demonstrate critical thinking skills such as applying the facts, formulas, theories, etc. to everyday situations.	• Mini-group Projects • Assignments • Quizzes • Exams	2%	I(L)

2. **COE 240 (2-3-3) Probability and statistic for Computer engineers**

Catalog Description:

Conditional probability, independence, Discrete probability, Continuous probability, Moments, Introduction to Bernoulli and Poisson processes, Discrete parameter Markov chains, Simple Queuing models, Sampling, Point estimates, Hypothesis formulation and testing, and Correlation and Regression.

Potential Textbooks:

1. Probability & Statistics for Engineers & Scientists by Walpole et. al. (STAT 319)
Percentage coverage: 65% (at best)
Remarks:

- Textbook may not contain necessary material on transforms and moments
- Textbook definitely has no content with regard to learning outcome number 2, i.e. in the area of stochastic and queuing models.

2. Applied Statistics and Probability for Engineers by D. C. Montgomery and G. C. Runger (SE 205)
Percentage coverage: 65% (at best)
Remarks:

- It includes a CD, has a lot of exercises (more than 50 per chapter, and in some cases more than 100), and got a rating of 3.5/5 in Amazon (the best I found among the others)
- Textbook may not contain necessary material on moments, transform methods, and conditional expectation (corresponding to CE-PRS3 – 4 hours in CE2004).
- Textbook definitely has no content with regard to learning outcome number 2, i.e. in the area of stochastic and queuing models (corresponding to CE-PRS4 – 6 hours in CE2004).

Lecture breakdown (weekly):

Learning Outcome	Week #	Topic	Remarks
1	1	Overview of Probability and Statistics, Conditional probability, independence, and Bayes' theorem	
	2	Discrete probability: binomial, Poisson, and geometric distributions; mean and variance	
	3	Continuous probability: Continuous random variables, probability density functions	
	4	Continuous probability: exponential and normal distributions; mean and variance	
	5	Moments, transform methods, and conditional expectation	
2^+	6	Introduction: Bernoulli and Poisson processes, renewal process, etc	
	7	Discrete parameter Markov chains: transition probabilities, limiting distributions	
	8	Simple M/M/1 queuing model, its	

		variants, and applications	
	9	Simple M/G/1 queuing model and applications	
3	10	Random Sampling Sampling Distributions	
	11	Sampling Distribution of Means Sampling Distribution of Sample Variance	
4	12	Point estimates and interval estimates, confidence intervals	
	13	Hypothesis formulation, testing hypothesis, criteria for acceptance of hypothesis	
	14		
5	15	Correlation and Regression Conditioning Random Variables Properties of the Least Squares Estimators, Inferences Concerning the Regression Coefficients	

+ - the topics for this learning outcome are copied from the Computing Curricula - Computer Engineering (CE2004) - Appendix A - body of knowledge.

Course Learning Outcomes Table:

Course Learning Outcomes	Outcome Indicators and Details	Assessment Methods and Metrics	ABET 2002 Criteria
1. The ability to calculate probability of events, moments, and transforms of discrete and continuous random variables. (14 hrs)	• Ability to calculate mean, moments, transforms of discrete (Binomial, Poisson, etc.) distributions • Ability to calculate mean, moments, transforms for continues (exponential, normal, etc.) distributions. • Application of conditional probabilities and Bays theorem. • Differentiate between dependant and independent events	• Assignments • Quizzes • Exams	L(H)
2. Ability to apply the concepts and tools of stochastic processes to analyze the performance of simple computer and networking systems. (12 hrs)	• Apply and analyze simple M/M/1 and M/M/c models and their variations. • Apply and analyze simple M/G/1 queueing models • The student shall be able to identify the merits and limitations of Markov chain modeling and analysis.	• Assignments • Quizzes • Exams	L(H)

	• Characterize the Bernoulli and Poisson processes. • Apply Markov chain analysis to evaluate performance of simple systems		
3. Ability to apply appropriate sampling methods in a range of situations. (4 hrs)	• .Apply random sampling methods in range of situations • Calculate numerical summaries and represent distributions graphically. • Calculate sample distribution of the sample mean and sample variance.	• Assignments • Quizzes • Exams	B(M)
4. The ability to apply basic principles to derive estimates for a given distribution, and to formulate hypothesis and test their credibility. (6 hrs)	• Derive estimators • Describe the main steps of hypothesis testing • Formulate a hypothesis and test its acceptability	• Assignments • Quizzes • Exams	A(M)
5. Ability to apply correlation and regression techniques with a view to establishing relationships between variables. (2 hrs)	• The student shall be able to define correlation and regression • The student shall be able to calculate the correlation coefficient. • The ability to calculate the least squares fitting for a set of points.	• Assignments • Quizzes • Exams • Demo (e.g. Matlab)	K(L)

3. **COE 305 (3-3-4) Microprocessor System Design**

Catalog Description

Embedded system characteristics, embedded system design life cycle, embedded microprocessor & microcontroller architecture and instruction set, Memory and I/O subsystems, organization, timing, interfacing and programming, Bus architectures & protocols, This course will gear to the integration of hardware modules to construct embedded systems, and the programming models and characteristics of various input/output interfaces. Either assembly language or any high-level languages will be chosen to meet computation, resource, and software development requirements.

Prerequisite: COE 203 and COE 208

Text Book

- "Computers as Components : Principles of Embedded Computer Systems Design", Wayne Wolf , Morgan Kaufmann Publisher, 2005
- Reference "Embedded Microprocessor Systems: Real World Design" by Stuart R. Ball. Publisher: Butterworth-Heinemann. Third edition ISBN 0-7506-7534-9. Copyright 2002.
- Additional material will be provided by the instructor on WebCT

Course Topics

1. **Introduction to Embedded Systems (6 lectures)**

Embedded Systems overview, Characteristics of Embedded computing applications, Challenges in Embedded microprocessor system design, Embedded System Design Life cycle - Requirements, Specifications, architecture design, Hardware/Software partitioning, designing hardware and software components, system integration, formalisms for system design - Structural design, Behavioral design, Design example

2. **Embedded Microprocessor & Microcontroller architecture and Instruction set (15 lectures)**

Embedded microcontroller overview, ARM & SHARC Processor architecture, CPU interface: clock, control, data and address buses, Instruction Sets - Introduction and review of instruction set and assembly language programming, instruction execution cycle and timing. (Introduction to the ARM architecture and instruction set, Use of ARM Software Development Toolkit (ARM SDT 2.02u) to develop and debug assembly/C programs in an ARM instruction set simulator called an ARMULATOR)

3. **Memory devices & Interfacing (8 lectures)**

Memory devices – EPROM, EEPROM, flash memory, SRAM, DRAM, RDRAM, SDRAM(SDR, DDR, DDR2) and SDRAM controller, Address decoding & Memory interfacing

4. **I/O devices, Interfacing & Programming (16 lectures)**

Parallel I/O interface and signal handshaking, Serial communication: UART, SPI, and I^2C, I/O programming, Interrupts and DMA, disk operation, Interfacing Keyboards and LCD, Touch panel, A/D-D/A converters, Timers and counters, Bus architecture and protocols, access arbitration and timing.

Lab Topics

Hardware platform for lab assignments & projects will be SoC based Drangonball MX1 development boards with ARM920T processor core (MX1ADS) accompanied with a peripheral board on which various devices are installed. Embedded Linux (MontaVista Linux development tools) is chosen as the software platform on the MX1ADS board. Lab assignments will consist of the following: assignments on understanding the programming environment on ARM simulator and target development board, Lab assignments on Memory interfacing, programming and interfacing with various peripheral units, programming device drivers for various peripheral units in embedded Linux environment followed by Mini-projects to build applications integrating multiple devices.

Course Learning Outcomes Table

Course Learning Outcomes	Outcome Indicators and Details	Assessment Methods and Metrics	Min. Weight	ABET 2000 Criteria
O1. Ability to apply knowledge of mathematics, probability and engineering in microprocessor based system design	➢ Analysis of bus Fan-in and Fan-out requirements, ➢ analysis of bus and processor timing, performance evaluation, ➢ CPU execution time ➢ memory access time and bandwidth ➢ wait state computation ➢ computation of timing delays ➢ I/O performance such as interrupt latency and DMA speed	• Quizzes • Assignme nts • Exams	10%	A(M)
O2. Ability to design, debug and test a small scale microprocessor system	➢ Design of Clock generation, Reset generation & synchronization, Wait state computation & generation, Ready synchronization, ➢ Address bus latching, data bus buffering, ➢ Design of Memory Map, Memory Address decoder, Memory Read and write logic ➢ Interfacing of RAM and EPROM memories. to processor(appropriate selection and connection of address bus, data bus, read/write control and chip select) ➢ Modes of I/O data transfer –	• Quizzes • Assignme nts • Exams • Lab work	35%	C(H)

	Programmed or Polled I/O, Interrupt driven I/O, DMA ➢ Design of I/O Map, I/O address decoder and I/O Read and Write logic ➢ Interfacing of Parallel & Serial I/O devices to processor using peripheral chips 8255 PPI, 8254 PIT, 8259PIC, 8237DMAC, 16650UART - appropriate selection and connection of address bus, data bus, read/write control, chip select between processor and peripheral chips - data, control and status signal interconnections between peripheral chips and I/O devices - Programming of Peripheral interfacing chips ➢ debug and test the design as well as to develop small test program to test the design correctness and timing versus some requirements. ➢ Revise the design appropriately ➢ Report and document the design.			
3. Ability to identify, formulate, and solve engineering problems in microprocessor based system design	➢ Identify, formulate and solve engineering problems in the microprocessor based system design considering the following : - Enhancements in the processor internal architecture, processor address & data bus width - Latest trends and developments in Memory Technology (SRAM, DRAM, SDRAM, RDRAM, DDR/DDR2) - Recent developments	• Quizzes • Assignments • Exams • Lab work	25%	E(H)

	in I/O interfacing standards and I/O devices			
4. Ability to use design tools for microprocessor system design, test and evaluation.	➢ Use of tools for debugging, develop techniques for testing, and use of trace analysis and timing for evaluation ➢ Use of Logic analyzers, oscilloscopes, logic probes, multimeters ➢ Use of 8086 Flight Electronics kits to conduct I/O interfacing experiments.	• Lab work	8%	K(L)
5. Ability to engage in self-learning	➢ Demonstrates reading and writing skills ➢ Identifying, retrieving, and organizing information ➢ Following a learning plan ➢ Demonstrate critical thinking skills such as applying the facts, formulae, theories, etc. to everyday situations.	• Assignments • Quizzes • Exams	2%	I(L)
6. Ability to function as an effective team member.		• Lab work	5%	D(L)
7. Ability to design and conduct experiments as well as to analyze and interpret data.		• Lab work	5%	B(L)

4. **COE 307 (3-0-3) Computer Systems**

Catalog Description

Introduction to computer systems from a programmer's perspective, processes, threads, system kernel, system calls, exceptional control flow, concurrent programming, virtual memory, input/output subsystem, parallel processor systems , optimizing and measuring program performance.

Prerequisite: COE 208 (Computer Organization and Architecture)

Potential Textbooks

- Randal Bryant and David O'Hallaron, Computer Systems, a Programmer's Perspective, Prentice Hall, 2003, ISBN: 0-13-178456-0.

  Useful chapters:

  1) A Tour of Computer Systems, 5) Optimizing Program Performance,
  8) Exceptional Control Flow, 9) Measuring Program Execution Time,
  10) Virtual Memory, 11) System-Level I/O, 13) Concurrent Programming.

- Andrew Tanenbaum, Modern Operating Systems, 3/E, Prentice Hall, 2008, ISBN: 0-13-600663-9.

  Useful chapters:

  1) Introduction, 2) Processes and Threads, 3) Memory Management, 4) File Systems,
  5) Input/Output, 8) Multiple Processor Systems, 10) Case Study 1: Linux. 20 %

Course Topics

1. **Introduction to Computer Systems (3 lectures)**

   Hardware organization, memory hierarchy, caches, storage devices, operating system, processes, threads, virtual memory, and files.

2. **C Primer (3 lectures)**

   Overview of the C programming language for Java programmers.

3. **Processes and Exceptional Control Flow (6 lectures)**

   Processes, private address space, system kernel, context switches, creating and terminating processes, system calls and error handling, implementing processes in the kernel, classes of exceptions, exception handling, signals and signal handling issues.

4. **Concurrent Programming (6 lectures)**

   Concurrent programming with processes and threads, thread execution model, Posix threads, shared variables, synchronizing threads with semaphores, using existing library functions in threaded programs.

5. **Virtual Memory (6 lectures)**

   Physical and virtual addressing, address spaces, paging, page tables, page faults, memory allocation and management, simplifying linking, loading, and sharing of pages, memory protection, integrating caches and virtual memory, translation lookaside buffer, multi-level page tables, case study: the Linux memory system.

6. **I/O Subsystem (6 lectures)**

I/O devices and controllers, memory-mapped I/O, interrupt-driven I/O, using DMA, interrupt handlers, device drivers, I/O software, clocks and timers, disk hardware, file concepts, directory structure, file system implementation.

7. **Parallel Processor Systems (9 lectures)**

   Shared-memory multiprocessors, multiprocessor operating system, synchronization, scheduling, and programming. Distributed-memory multi-computers, process and user-level communication software, distributed-shared memory, scheduling, and load balancing. Virtualization, memory and I/O virtualization, examples of parallel virtual machines. Distributed systems, network service and protocols, middlewares.

8. **Optimizing and Measuring Program Performance (6 lectures)**

   Compiler optimization techniques, data-dependence analysis, loop recurrences, and parallelization techniques, reducing loop overhead, reducing procedure calls, converting to pointer code, impact of caches, writing cache friendly code, measuring time by interval counting, measuring time with IA-32 cycle counters, time-of-day measurements.

Course Learning Outcomes Table

Course Learning Outcomes	Outcome Indicators and Details	Assessment Methods and Metrics	Min. Weight	ABET 2000 Criteria
O1. Ability to apply knowledge of mathematics, probability, and statistics in computer system.	Analysis and Performance of: • concurrent programs • Optimizing and Measuring Program Performance • Speedup computation.	• Assignments • Quizzes • Exams	30%	A(M)
O2. Ability to design concurrent programs and optimizing and measuring program performance.	• Concurrent programming with processes and threads, • Programming with Posix threads, shared variables, synchronizing threads with semaphores. • Apply compiler optimization techniques, data-dependence analysis, loop recurrences, and parallelization techniques, reducing loop overhead, reducing procedure calls, impact of caches, • Measuring time by interval counting,	• Assignments • Quizzes • Exams • Project	50%	C (H)

O3. Ability to identify, formulate, and solve computer architecture problems.	• Tradeoffs in implementing processes in the kernel, • Assess tradeoffs in concurrent programming, I/O systems and Parallel Processor systems. • Assess tradeoffs in virtual memory, address translation, virtual page size, TLB size, sequential versus concurrent TLB and cache access. • Assess scalability issues in optimizing and measuring program performance	• Assignments • Quizzes • Exams	10%	E (L)
O4. Ability to use computer system tools.	• Ability to use compiler, debugger, and exception handling programming tools. • Run sequential and concurrent programs and collect results and statistics • Ability to use compiler optimization tools and asses performance.	• Assignments • Mini-group Projects	5%	K(L)
O5. Ability to engage in self-learning.	• Demonstrates reading, writing, listening and speaking skills • Identifying, retrieving, and organizing information • Following a learning plan • Demonstrate critical thinking skills such as applying the facts, formulas, theories, etc. to everyday situations.	• Mini-group Projects • Assignments • Quizzes • Exams	5%	I(L)

5. **COE 341 (3-0-3) Information Representation and Systems**

Catalogue Description:

Introduction to information representation and systems, Convolution, Fourier analysis for continuous/discrete–time signals, Spectra analysis, Introduction to sampling theorem, Introduction to transmission impairments and media, Signal encoding techniques, Audio processing, and Image processing.

Course Learning Outcomes:

- Knowledge of information representation using Fourier series, Fourier transform, and Laplace transform.
- Ability to apply knowledge of mathematics to understand basic concepts in communication engineering.
- Ability to analyze and/or design basic systems.
- Ability to use programming tools and skills for the simulation, analysis, and design of basic systems.

Suggested Textbook:

Fundamentals of Signals and Systems Using the Web and MATLAB (2nd Edition) by Ed Kamen and Bonnie Heck, Publisher: Prentice-Hall, ISBN: 0130172936. Online material: http://users.ece.gatech.edu/~bonnie/book/

References:

- Fundamentals of Signals and Systems by Benoit Boulet, Publisher: CHARLES RIVER MEDIA, ISBN: 1584503815
- Signals and Systems: Continuous and Discrete 4th edition, Publisher: Prentice-Hall ISBN: 013496456X
- Signals and Systems (2nd Edition) by Alan V. Oppenheim, Alan S. Willsky, with S. Hamid, S. Hamid Nawab, Publisher: Prentice-Hall, ISBN: 0138147574
- Data and Computer Communications (7th Edition) by William Stallings, Publisher: Prentice-Hall, ISBN: 0131833111.

- **Tentative Weekly course schedule**

Week	Topics	Textbook Sections
1	***INTRODUCTION TO INFORMATION REPRESENTATION*** Introduction to signals & systems Continuous-Time Signals Discrete-Time Signals Systems Examples of Systems Basic System Properties	Chapter 1
2	***TIME-DOMAIN MODELS OF SYSTEMS*** Input/Output Representation of Discrete-Time Systems Convolution of Discrete-Time Signals Difference Equation Models	Chapter 2
3	Differential Equation Models Solution of Differential Equations Convolution Representation of Continuous-Time Systems	Cont.
4	***THE FOURIER SERIES AND FOURIER TRANSFORM*** Representation of Signals in Terms of Frequency Components Trigonometric Fourier Series Fourier Transform	Chapter 3
5	Spectral Content of Common Signals Properties of the Fourier Transform Channel Capacity & Effective Bandwidth (handout)	Cont.
6	***FOURIER ANALYSIS OF DISCRETE-TIME SIGNALS*** Discrete-Time Fourier Transform Discrete Fourier Transform DFT of Truncated Signals FFT Algorithm Application to Data Analysis	Chapter 4
7	***FOURIER ANALYSIS OF SYSTEMS*** Fourier Analysis of Continuous-Time Systems Response to Periodic and Nonperiodic Inputs Analysis of Ideal Filters	Chapter 5
8	Sampling Fourier Analysis of Discrete-Time Systems Application to Lowpass Digital Filtering	Cont.
9	***THE LAPLACE TRANSFORM AND THE TRANSFER FUNCTION REPRESENTATION*** Laplace Transform of a Signal Properties of the Laplace Transform Computation of the Inverse Laplace Transform	Chapter 6
10	***INTRODUCTION TO TRANSMISSION IMPAIRMENTS & MEDIA*** Transmission impairments and error Guided transmission media Wireless transmission	Handout
11	***SIGNAL ENCODING TECHNIQUES*** Digital signal encoding Modulation and shift keying	Handout
12	Modulation and shift keying (cont.) PCM and Delta modulation systems	Handout
13	Application of Fourier Transform to Signal Modulation and Demodulation	Section 3.8

14	***AUDIO PROCESSING*** Speech coding Audio coding and MPEG algorithms	Handout
15	***IMAGE PROCESSING*** Analog to digital transformations Sampling and image integrity Image coding and algorithms	Handout

Course Learning Outcomes Table

Course Learning Outcomes	Outcome Indicators and Details	Assessment Methods and Metrics	ABET 2000 Criteria
1. Knowledge of information representation using Fourier series, Fourier transform, and Laplace transform	Fourier analysis for continuous/discrete–time signals Spectra analysis Laplace Transform	• Assignments • Quizzes • Exams • Matlab assignment	J(H)
2. Ability to apply knowledge of mathematics to understand basic concepts in communication engineering	Application of: • Fourier series and transforms • Spectral power density to understand the following concepts: Absolute and effective bandwidth of signals Filtering and band limiting Modulation and bandwidth requirements	• Assignments • Quizzes • Exams • Matlab assignment	A(M)
3. Ability to analyze and/or design basic circuits and systems	The student shall be able to analyze and/or design: Simple filters PCM and Delta modulation systems	• Assignments • Quizzes • Exams	C(M)
4. Ability to use programming tools and skills for the simulation, analysis, and design of basic systems and circuits	Matlab or LabVIEW-based programming assignments covering one of the following areas: FFT Filters Generation of digital codes Modulation and shift keying PCM and Delta modulation systems Calculation of bit error rate vs signal to noise ratio curves Audio and image processing	• Programming Assignments • Demos	K(M)

6. **COE 361 (3-0-3) Fundamentals of Computer Electronics:**

Catalog Description:

The course aims to explain the purpose and role of electronics in computer engineering. It introduces students to the basic electronic materials and components of a typical computer system and the simulation tools used to model, design and verify the performance of these components. These components include diodes, transistors, simple analog electronic circuits as well as digital circuits and buses.

Prerequisites: COE 203, EE 201

Potential Textbook:

Microelectronic Circuits Revised Edition (5^{th} edition), by Adel S. Sedra and Kenneth C. Smith. Oxford Press, 2007.

Course Topics:

Topic	**Lecture topics**	**Lab**	**Lab Week #**
Course overview	1hr	Lab policies/equipments	1
Electronic properties of materials	3hrs – Solid-state semi-conducting materials – Electrons and holes – Doping, acceptors and donors – p- and n-type material – mobility, Conductivity and resistivity – P-N junction structure and built-in voltage	Introduction to Circuit modeling and simulation with SPICE (circuit description, analysis types, and output) (apply transient analysis on simple RC, RL circuits)	2
Diodes and diode circuits	4 hrs – Diode operation and i-v characteristics – Regions of operation, models, and limitations – Schottky, Zener, variable capacitance diodes – Single diode circuits, the load line – Multi-diode circuits – Rectifiers	Diode operation, simple diode circuits (half wave rectifiers) (include SPICE simulations from this lab onwards)	3
Operational Amplifiers	4hrs – Ideal op-amps and circuit analysis – Ideal op-amp circuits: Inverting and non-inverting amplifiers, summing amplifier, difference amplifier, integrator, low pass filter – Non-ideal op-amps: dc errors, CMRR, input and output resistances, frequency response, output voltage and current limitations – Circuits with non-ideal amplifiers Multi-stage op-amp circuits	Multi-diode circuits	4
Bipolar transistors	4hrs	Operational Amplifiers	5

and amplifiers	– npn and pnp transistor structure and operation – i-v characteristics, Regions of operation, models, and limitation – Current buffering (Darlington pair) – BJT as an amplifier, Biasing for amplifier applications → single BJT, CE amplifier → Transfer characteristic of BJT with load resistor		
MOS transistors and biasing	3hrs: – MOS field-effect transistor structure and operation, threshold voltage, short channel effects – i-v characteristics, Regions of operation, models (capacitance, SPICE, equivalent resistance), and limitations – Enhancement and depletion-mode devices	npn and pnp transistor operation i-v characteristics BJT as a switch BJT as a current amplifier	6
Logic families	6 hrs: Introduction to Digital Logic Families: – Logic level definitions, Noise Margins Definitions Bipolar Logic families: – The BJT as a switch – Transistor-transistor logic – inverters, NAND, other functions, STTL, Open collector (logic levels, Noise margins, Currents, power dissipation) – The differential pair as a current switch – Emitter-coupled logic – OR/NOR gate, other functions (logic levels, Noise margins, Currents, power dissipation) MOS Logic Families: – Static NMOS logic design: Inverter, complex gates (logic levels, Noise margins, Currents, power dissipation) – Static CMOS logic: Inverter, complex gates (logic levels, Noise margins, Currents, power dissipation)	BJT biasing and amplifiers (CE)	7
Principles of VLSI Design	6 hrs CMOS inverter: 1. Connectivity, layout, and basic functionality of a CMOS	MOS operation, i-v characteristics, regions of operation MOSFET as a switch	8

	inverter 2. The CMOS inverter voltage transfer characteristic (VTC) 3. Analysis of the CMOS VTC for switching threshold, , , VIH, VIL, and noise margins <u>CMOS Combinational logic structures :</u> 1. Basic CMOS gate design 2. Layout techniques for combinational logic structures 3. Transistor sizing for complex CMOS logic devices 4. Transmission gates <u>Sequential logic structures:</u> 1. Storage mechanisms in CMOS logic 2. Static latch and flip-flop circuits 3. Sequential circuit design (setup, hold, delay times)		
Design parameters and issues	3hrs <u>Design strategies dealing with:</u> – Switching energy, power-delay product comparison, – Propagation delay, rise time, fall time – Fan-in and fan-out – Power dissipation, noise margin – Power supply distribution – Sources of signal coupling and degradation – Transmission line effects; passive, active, dc and ac termination – Element tolerances – Worst-case analysis of circuits – Monte Carlo analysis – Monte Carlo analysis in SPICE – Six-sigma design	<u>Logic Families:</u> Transistor-transistor logic – inverters, NAND, other functions, STTL, Open collector CMOS Logic levels … noise margins .. IOL IOH IIL IIH	9
Interfacing logic families and standard buses	3hrs: – Terminal characteristics of various logic families – Standard interface characteristics – Level translations: TTL/CMOS, TTL/ECL, CMOS/ECL – Single-ended to differential and differential to single-ended conversion – Transmission line characteristics, reflections – Bus termination: Passive, active, dc, ac – 4-20 mA current interfaces – RS-XXX buses – IEEE-XXXX buses	Interfacing logic families and standard buses	10

	– Low-level differential signaling – RAMBUS – DDR		
Electronic voltage and current sources	2 hrs: – Electronic voltage sources: ideal voltage source characteristics; voltage sources utilizing operational amplifiers – Electronic current sources: ideal current source characteristics; current sources utilizing operational amplifiers	VLSI Design using SPICE	11
Data conversion circuits	2 hrs: – D/A Converters: Definitions such as for codes, LSB, and MSB; linearity, differential linearity, offset and gain errors – A/D Converters: Definitions such as for codes, LSB, MSB, and missing codes, quantization error; linearity, differential linearity, offset and gain errors, missing codes; Sample-and-hold	VLSI Design using SPICE	12
Total of 41 hours of lecture and 14 experiments		VLSI Layout techniques	13
		VLSI Layout techniques	14
		Lab evaluation	15

Course Learning Outcomes Table

Course Learning Outcomes	**Outcome Indicators and Details**	**Assessment Methods and Metrics**	**ABET 2000 Criteria**
1. An ability to apply knowledge of mathematics, science, and engineering in the design, analysis and modeling of electronic circuits	• Design of diode circuits, Op-Amp circuits, BJT and MOS circuits	• Assignments • Quizzes • Exams	A(L)
2. An ability to design and conduct experiments using SPICE to characterize and optimize electronic circuits	• Noise Margins adjustments • Rise and Fall times adjustments • Delay adjustments • Driving capabilities of I/O buffers	• Assignments • Lab • Project	B(H)
3. Ability to Design, Verify, Analyze and Evaluate the performance (speed, Power, Area, Noise margins) of different	• Design of MOS circuits	• Assignments • Quizzes • Lab • Project • Exams	C(H)

	electronic circuits for different design specifications			
4.	An ability to use various CAD tools in the design and verification of Electronic circuits	• LogicWorks/ModelSim/Xilinx for logic design/verification • SPICE for circuit design/analysis/verification	• Assignments • Lab • Project	K(M)
5.	An ability to function as an effective team member	• Project task assignment and integration	• Project	D(L)
6.	An ability to communicate effectively	• Project report(s)	• Project	G(L)

7. **COE (3-3-4) 400: Embedded Systems**

Catalog Description

This is a project guided course where a sample project serves as example when covering the different topics of the course. Project life cycle. Embedded system design methodologies. Specifications. Hardware/software co-design. Embedded systems hardware platform. Designing robust software for embedded systems. RTOS features.

Prerequisite: COE – 305

Textbook

1. Frank Vahid & Tony D. Givargis, *Embedded Systems Design: A Unified Hardware/Software Introduction,* Wiley, John & Sons, Inc., October 2001, ISBN: 0471386782

Course Topics

1. **Introduction to Embedded Systems:** Definitions of an Embedded System; Requirements Analysis; Design methodologies overview; Project life cycle ***(1 week)***
2. **Specifications Representation:** Specification description ; System modeling and representation techniques; Hardware/software partitioning; Constraints ***(2 weeks)***
3. **Hardware Platform:** Hardware platform requirements; Processor selection; Memory Architecture; IO capabilities; Communication ***(2 weeks)***
4. **Software Design and Development:** Software development methodologies; Integrated Development Environment (IDE); Coding techniques; Concurrent design methods (cross-compilers); Software design flows and tools; Device drivers; OS services; Real Time issues; Scheduling; Concurrent programming using threads; Middleware development and usage ***(4 weeks)***
5. **Hardware/Software Integration:** Integration as a phase in the project; Requirements for integration; Releases; The hardware/software concurrent design process requirements; Continuous documentation; Interfacing issues; Performance issues; How to reduce number of re-spins; Incremental integration ***(2 weeks)***
6. **Verification, Debugging and Testing:** Verification plan development; Execution of verification plan; Embedded verification structures; The test plan: a subset of the verification plan; Testing/debugging tools: JTAG, ICE, Logic Analyzers; Software tools ***(3 weeks)***

Board

Based on any ARM processor, should have the following features:

- Memory: SRAM, SDRAM, Flash, EEPROM
- Interfaces: Serial, USB, SPI, I2C, IIS, Analog, Timer, PWM
- LAN: Ethernet
- Display: Standard IC interface available on header pins
- Test: ICE, JTAG support

Lab Topics

- ARM Embedded Systems
- The Integrated Development Environment
- Efficient C Programming
  - Overview of C Compilers and Optimization
  - Basic C Data Types
  - C Looping Structures

    - Register Allocation
    - Function Calls
    - Pointer Aliasing
    - Structure Arrangement
    - Bit-fields
    - Unaligned Data and Endianness
    - Division
    - Floating Point
    - Inline Functions and Inline Assembly
    - Portability Issues
- Exception and Interruput Handling
    - Exception Handling
    - Interrupts
    - Interrupt Handling Schemes
- uC Linux/ RTOS Programming

The Lab of The Embedded Systems will have several mature projects following a different model than the current COE-400 where not all the students are involved in the same project. The project focus will be on the following:

- Specification description (and possibly modeling)
- Hardware/Software partitioning (using tools or methods)
- Software design and quick development
- Hardware/Software integration
- Verification
- Testing and Debugging
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Course Learning Outcomes Table

Course Learning Outcomes	Outcome Indicators and Details	Assessment Methods and Metrics	Min. Weight	ABET 2000 Criteria
1. Ability to apply knowledge of mathematics, science and Engineering in design and analysis of different alternative implementations of a system's specification.	• Ability to estimate the computational complexity of a particular algorithm for solving an engineering problem starting from a problem statement • Ability to use knowledge of physics and math to perform power conversions • Ability to use knowledge of physics and engineering to design the proper interface when applying embedded systems to solve practical problems like in motor control for example • Ability to use knowledge of science and engineering	• Project	10%	A(M)

	to be able to read, understand and analyze data sheets of required products to solve engineering problems			
2. Ability to design and implement an embedded system starting from given specifications.	• Ability to understand and use Engineering Design trade-offs: - software/hardware trade-off - cost/performance trade-off • Ability to interface sensors/actuators to a microcontroller • Ability to perform low power design • Ability to understand and utilize hard and soft real-time issues	• Assignments • Quizzes • Project	40%	N (H)
3. Ability to identify, formulate, and solve engineering problems such as the selection of most appropriate solutions for solution criteria.	• Ability to assess various microcontrollers' specifications. • Assess tradeoffs between various communications standards used in microcontroller based systems. • Assess tradeoffs between centralized and distributed microcontroller based designs.	• Assignments • Quizzes • Exams	10%	E (L)
4. Ability to use tools to achieve design objectives.	• Ability to effectively use the software IDE • Ability to learn how to use the computing debugging hardware and software tools.	• Assignments • Project	5%	K(L)

5. Ability to function as an effective team member.	• Ability to establish task priorities and clearly state expectations • Ability to keep the team focused • Ability to be flexible and adapt to demands of situations and constraints • Ability to maintain an appropriate balance between listening and speaking	• Project	5%	D(M)
6. Ability to engage in self-learning.	• Ability to demonstrate reading, writing, and speaking skills • Ability to Identify, retrieve, and organize information from the web • Ability to follow a learning plan • Ability to demonstrate critical thinking skills.	• Project	5%	I(L)
7. Ability to communicate effectively.	• Ability to submit progress reports on milestones of the project • Ability to deliver a number of presentations to the class	• Project	10%	G(M)

8. **COE 485 (2-3-3) Capstone Design:**

Catalog Description:

This course is designed to give students the experience of tackling a realistic engineering problem. The intent is to show how to put theoretical knowledge gained into practical use by starting from a word description of a problem and proceeding through various design phases to end up with a practical engineering solution. Project management and team work concepts are introduced and applied. Various projects are offered by COE faculty in their respective specialization areas. The project advisor guides the student in conducting feasibility study, preparation of specifications, and the methodology for the design. Detailed design and implementation of the project are carried out followed by testing, debugging, and documentation. An oral presentation and a final report are given at the end of the semester.

Prerequisites: Senior Standing

Project Guidelines:

Faculty members are required to propose senior projects with the following criteria:

1. The project should be a **design** or **design analysis** type. No term-paper-like or research project should be given. If a faculty member wants to utilize the student(s) as a research assistant, he should formulate the problem to the student as a design problem; **clear specifications and measurable (known apriori) outcomes.**

2. The project should represent a complete design cycle (i.e. product oriented), with cost-performance issues.

3. Teamwork is a must? Projects should require at least 2 students to work on and a maximum of 5. This also necessitates project management (work division and allocation).

4. Projects should deal with contemporary issues and expose the students to socio-economical issues of the new technologies.

5. Faculty members should submit their project proposals two weeks before the end of the term that precedes the intended term. This will allow the students sufficient time to select the projects they want and start working on them early on.

Course Objectives

After successfully completing the course, students will be able to:

- Define formal specifications from the problem statement.
- Examine different approaches.
- Develop new solutions that utilize fundamental scientific concepts.
- Describe a system design from high level specifications.
- Describe a detailed design of the required components.
- Implement a prototype, design and conduct experiments
- Document clearly the work by presenting original work.
- Communicate effectively the project details orally.
- Demonstrate team work skills, meet deadlines, and plan properly.
- Understand the impact of a solution on the society.
- Understand the impact of contemporary issues on a design.

Topics Discussed

- *Project management*
- *Engineering approach to design*
- *Design verification and testing*
- *Work habits*
- *Project Documentation*
- *Oral Presentation*

Course Contribution to Meet the Professional Component

The course allows the students to learn more about the methodology and phases of conducting a design project. Students examine different approaches, conduct a feasibility study, and prepare specifications. They also carry out a detailed design and implementation of the project, followed by testing, debugging, and documentation, and oral presentation.

Relationship to Program Outcomes

Outcome 1: Ability to apply knowledge of mathematics, science, and engineering. **[ABET Criterion 3a]**
Outcome 2: Ability to design and conduct experiments, as well as to analyze and interpret data. **[ABET Criterion 3b]**
Outcome 3: Ability to design a system, component, or process to meet desired needs. [**ABET Criterion 3c**]
Outcome 4: Ability to identify, formulate, and solve engineering problems. [**ABET Criterion 3e**]
Outcome 5: Understanding of professional and ethical responsibility. [**ABET Criterion 3f**]
Outcome 6: Ability to communicate effectively. [**ABET Criterion 3g**]
Outcome 7: The broad education necessary to understand the impact of engineering solutions in a global and societal context. [**ABET Criterion 3h**]
Outcome 8: Recognition of the need for, and an ability to engage in life-long learning. [**ABET Criterion 3i**]
Outcome 9: Knowledge of contemporary issues. [**ABET Criterion 3j**]
Outcome 10: Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. [**ABET Criterion 3k**]
Outcome 11: Ability to function as an effective team member [**ABET Criterion 3d**]