COMPUTER ENGINEERING DEGREE

FOCUS AREAS GUIDE

2006 - 2007

UNIVERSITY OF MINNESOTA, MINNEAPOLIS

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1. INTRODUCTION

The computer revolution has created vast industries and countless jobs that employ professionals trained in computer engineering, computer science, and information technology –all closely related disciplines involving the understanding and design of computers and computational processes. Computer profession specialties constitute a continuum. At one pole is computer science, primarily concerned with theory, design, and implementation of software. It is a true engineering discipline, even though the product is an intangible—a computer program. At the other pole is computer engineering, primarily concerned with firmware (the microcode that controls processors) and hardware (the processors themselves, as well as entire computers). It is not possible, however, to draw a clear line between the two disciplines; many practitioners function, to at least some extent, as both computer engineers and computer scientists.

This Guide includes a list of focus areas and the corresponding electives within each focus area that are offered through the Department of Electrical and Computer Engineering for computer engineering majors. The electives described in this Guide provide a good background relating to a particular specialty and also serve as an introduction to specializations in graduate study. Since these courses are designed to compliment the undergraduate curriculum, they will not give highly specialized knowledge in any particular focus area.

Please note that the courses listed in this Guide are not required for graduation. The courses listed under a particular focus area are simply suggested electives that will provide some concentration in a selected focus area. Consult the CompE Curriculum Guide for the CompE degree requirements.

Selection of elective courses permits some specialization in the following areas:

- Computer Architecture
- Computer and Embedded System Design
- VLSI and Computer-Aided Design
- Networks and Communication

Guidance in selecting elective courses can be obtained from a member of the Central ECE Advising Committee or any faculty member in your area of interest. A list of faculty with interests in the various focus areas is given in Section 2.

2. FACULTY AREAS OF INTEREST/ADDRESSES

Computer Architecture

Hsu, Wei Cheng	612-625-2013	EE/CS 4192	hsuxx012@umn.edu
Kim, Chris	612-625-2346	EE/CS 4161	kimxx624@umn.edu
Kinney, Larry	612-625-4359	EE/CS 6121	kinney@umn.edu
Kumar, Vipin	612-624-8023	EE/CS 4192	kumar@cs.umn.edu
Lilja, David	612-625-5007	EE/CS 6109	lilja@ece.umn.edu
Tripathi, Anand	612-625-9515	EE/CS 5205	tripathi@cs.umn.edu
Yew, Pen-Chung	612-625-7387	EE/CS 4192	yew@cs.umn.edu

Computer and Embedded System Design

Kinney, Larry	612-624-9803	EE/CS 4178C	kinney@ece.umn.edu
Tripathi, Anand	612-625-9515	EE/CS 5205	tripathi@cs.umn.edu
Voyles, Richard	612-624-8306	EE/CS 4192	voyle002@umn.edu

VLSI and Computer-Aided Design (CAD)

Bazargan, Kiaresh	612-625-4588	EE/CS 4159	kia@ece.umn.edu
Harjani, Ramesh	612-625-4032	EE/CS 4165	harjani@ece.umn.edu
Parhi, Keshab	612-624-4116	EE/CS 6181	parhi@ece.umn.edu
Riedel, Marc	612-625-6086	EE/CS 4167	mriedel@umn.edu
Roychowdhury, Jaijeet	612-626-7203	EE/CS 4155	jaijeet@ece.umn.edu
Sobelman, Gerald	612-625-8041	EE/CS 4157	sobelman@ece.umn.edu
Sapatnehar, Sachin	612-625-0025	EE/CS 4153	sachin@ece.umn.edu
Shragowitz, Eugene	612-625-3368	EE/CS 4192	shragowit@cs.umn.edu

Networks and Communication

Cherkassky, Vladimir	612-625-9597	EE/CS 6111	cherkass@ece.umn.edu
Du, David	612-625-2560	EE/CS 4225B	du@cs.umn.edu
Zhang, Zhi-Li	612-625-8568	EE/CS 4192	zhang089@umn.edu

3. COMPUTER ENG DEGREE FOCUS AREA DESCRIPTION

The Computer Engineering Degree Curriculum is a combination of the core courses from electrical engineering and computer science most closely related to the design of computers or to the design of systems containing computing devices. This curriculum encompasses nearly all areas of electrical engineering: e.g. 1) the design of workstation, mainframe, and supercomputers; 2) the design of communication control and signal processing systems with their special purpose processors; and 3) the design of instruments, appliances, toys, etc., that use microprocessors or microcontrollers. The four suggested Computer Engineering Focus Areas reflect different levels of design.

3.1. Computer Architecture

The pervasiveness and impact of computers are driven by their ever increasing speed and decreasing cost. Major reasons for the decreasing cost are advancements in the fabrication and design of VLSI circuits. Similarly, increasing speed results from improvements in the materials, devices, and fabrication of integrated circuits. But increasing speed also results from innovations in the organization and the functionality of the computer. Computer architects analyze the behavioral of computers with different functionality and organizations, and they develop new approaches to improve the computer's speed. A computer architect would work for a company that designs computers, either general purpose computers or computers intended for particular applications.

3.2. Computer and Embedded System Design

Nearly all devices and instruments contain computers, usually in the form of a microcontroller in a so-called embedded system. While these computers are not as powerful as many personal computers and most workstations, they are far more ubiquitous. They are used for sensing and control in automobiles, aircraft, industrial assembly lines, appliances, instruments, etc. An engineer designing an embedded system needs a background in computer hardware, software, and electronics used in sensors and controllers. This background is exactly what is provided with the computer engineering degree.

3.3. VLSI and Computer-Aided Design (CAD)

The design of a Very Large Scale Integrated (VLSI) Circuit requires many steps. Some steps include the development and processing of semiconductor materials and the implementation of electronic devices and circuits from these materials. Other steps are the implementation of system components from the circuits, implementation of the system from its components, and the placement and interconnection of the components. Courses within the computer engineering program can be chosen to provide the background needed to perform any of the latter steps. Some VLSI systems are implementations of general purpose computers, i.e. microprocessors or microcontrollers. Yet many more implement special purpose systems used in communication, control, signal processing, and other application areas. A computer engineer who designs a special purpose system needs a background in the application area as well.

Computer Aided Design (CAD) tools, sometimes called electronic design automation (EDA), are software programs that aid engineers in the design and analysis of devices, circuits, and systems. In the computer engineering area, CAD tools aid in the design integrated circuits (e.g. VLSI circuits), computers, and software systems. Engineers involved in CAD development need a background in the type of system for which the CAD tools are intended, i.e. devices, circuits or systems, and in the design and implementation of software systems.

Students with a VLSI circuits background could work for any company that designs or manufacturers integrated circuits. Larger companies include Medtronic, Intel, Motorola, Texas Instruments and Hewlett Packard. Many of these companies also develop CAD tools to aid in their designs and, hence, employ students with a CAD background. Other companies such as Mentor Graphics, Synopsys, and Cadence develop CAD tools for sale to other companies.

3.4. Networks and Communication

The rapid growth of the Internet, distributed and parallel computing, and both wired and wireless communication has made networks and communication a part of many electronic systems. The networks and communication engineer must understand both the hardware and software required to provide information transfer between systems. Such an engineer may be involved in implementing network technologies, implementing a network system, managing a network installation, or interfacing a network via hardware and software to other devices. Such an engineer may work for a company that manufacturers network equipment or for a company that utilizes a network or distributed data processing and communication in its manufacturing and engineering operations.

4. CompE DEGREE FOCUS AREA COURSE SUGGESTIONS

4.0. Course Suggestions

Listed below are suggested courses to take if you are primarily interested in a particular focus area. Note that it is **not** necessary to follow any one of these to obtain the BCompE degree; the degree requirements are as specified in the CompE Curriculum Guide. The course lists are simply suggestions from faculty of courses relevant to a particular focus area.

A given student may not be able to take all the courses in the student's focus area of interest. The student may need to take other courses to satisfy some requirement or the student may not be qualified to take some of the courses. The latter situation may occur if the student does not have the prerequisites for the course or, in the case of 5000 level courses, the requisite gpa to take the course. 5000 level courses are intended primarily for graduate students and, in general, an undergraduate can take a 5000 level course only if their gpa is 3.2 or larger. See the EE Curriculum Guide for the procedure required to register for a 5000 level course.

Also, students should consider that, during their career, they are likely to have many different jobs and work in many different areas of CompE. In order to prepare for this diversity of work, it may be best to select courses from several different areas rather than trying to specialize in the undergraduate program. Specialization can be obtained after graduation through graduate work, company courses, etc.

Note that the credit requirements listed are for students who entered the University of Minnesota **Fall 2006 or later**.

4. CompE DEGREE FOCUS AREA COURSE SUGGESTIONS

4.1. Computer Architecture (at least 28 credits)[*]

Suggested EE & CSci Electives....................(22-28 credits)

One of the following is required:

EE 4951W - Senior Design Project (4 credits)
<u>OR</u> EE 4981H-4982V - Senior Honors Project I-II (2 credits each)

At least one of the following courses:

EE 4301 - Digital Design W/Programmable Logic (4 credits)
EE 4341 - Microprocessor & Microcontroller System Design (4 credits)

Highly Recommended Electives:

EE 4301 - Digital Design W/Programmable Logic (4 credits)
EE 5364 – Advanced Computer Architecture (3 credits)
EE 5371 - Computer Systems Perf Measurement & Evaluation (3 credits)
CSci 4011 - Formal Languages & Automata Theory (4 credits) (1902 or 2011 or #; no cr for grads in CSci)
CSci 5103 - Operating Systems (3 credits) (4061 or #)
CSci 5106 - Programming Languages (3 credits) (4011 or #)
CSci 5161 - Introduction to Compilers (3 credits) (4011 or #)
CSci 5451 - Intro to Parallel Computing: Arch, Algor & Prog (3 credits) (4041 or #)

Suggested Non-EE/CSci Electives (0-6 credits)

Math 5651 - Basic Theory of Probability & Statistics (4 credits)
Math 5705-5707 – Enumerative Combinatorics A & B (4 credits each)
Math 5711 - Linear Programming & Combinatorial Optimization (4 credits)

[*] This guide gives suggestions for selecting elective courses to provide some specialization in the CompE Degree Program. It does <u>not</u> list requirements for the degree; please see the CompE Curriculum Guide for the degree requirements.

4. CompE DEGREE FOCUS AREA COURSE SUGGESTIONS

4.2. Computer and Embedded System Design (At least 28 credits)[*]

Suggested EE & CSci Electives....................(22-28 credits)

One of the following is required:

EE 4951W - Senior Design Project (4 credits)
<u>OR</u> EE 4981H-4982V - Senior Honors Project I-II (2 credits each)

At least one of the following courses:

EE 4301 - Digital Design W/Programmable Logic (4 credits)
EE 4341 - Microprocessor & Microcontroller System Design (4 credits)

Highly Recommended Electives:

EE 4111 - Analog Electronics Design W/ Operational Amplifiers (4 credits)
EE 4231 - Linear Control Systems (3 credits)
EE 4235 - Linear Control Systems Laboratory (1 credit)
EE 4501 - Communications Systems (3 credits)
EE 4505 - Communications Systems Laboratory (3 credits)
EE 4541 - Digital Signal Processing (3 credits)
EE 5141 - Integrated Sensors & Transducers (4 credits)
EE 5364 - Advanced Computer Architecture (3 credits)

CSci 5511 - Artificial Intelligence I (3 credits) (2011 or #)
CSci 5551 - Intro to Intelligent Robotic Systems (3 credits) (5511 or #)
CSci 5561 - Computer Vision (3 credits) (5511 or #)

Suggested Non-EE/CSci Electives (0-6 credits)

ME 3321 - Thermodynamics (4 credits) (Chem 1021, math 2243, Phys 1301, IT student
[wood & paper sicence eng'g major]

[*] This guide gives suggestions for selecting elective courses to provide some specialization in the CompE Degree Program. It does <u>not</u> list requirements for the degree; please see the CompE Curriculum Guide for the degree requirements.

4. CompE DEGREE FOCUS AREA COURSE SUGGESTIONS

4.3. VLSI and Computer Aided Design (CAD) (at least 28 credits)*

Suggested EE & CSci Electives.....................(22-28 credits)

One of the following is required:

EE 4951W - Senior Design Project (4 credits)
OR EE 4981H-4982V - Senior Honors Project I - II (2 credits each)

At least one of the following courses:

EE 4301 - Digital Design W/Programmable Logic (4 credits)
EE 4341 - Microprocessor & Microcontroller System Design (4 credits)

Highly Recommended Electives:

EE 5301-5302 - VLSI Design Automation I-II (3 credits each)
EE 5323 - 5324 - VLSI Design I-II (3 credits each)
EE 5327 - VLSI Design Laboratory (3 credits)
EE 5333 – Analog Integrated Circuit Design (3 credits)

CSci 5283 - Computer-Aided Design I (3 credits) (prereq CSci 2021 or #)
CSci 5285 - Computer-Aided Design of VLSI (3 credits) (prereq CSci 2021 or #)

Suggested Non-EE/CSci Electives (0-6 credits)

Math 5165-5166 - Mathematical Logic I-II (4 credits each)
Math 5705-5707 - Combinatorics A-B (4 credits each)
Math 5711 - Linear Programming & Combinatorial Optimization (4 credits)

* This guide gives suggestions for selecting elective courses to provide some specialization in the CompE Degree Program. It does not list requirements for the degree; please see the CompE Curriculum Guide for the degree requirements.

4. CompE DEGREE FOCUS AREA COURSE SUGGESTIONS

4.4. Networks and Communication (At least 28 credits)*

Suggested EE & CSci Electives.....................(22-28 credits)

One of the following is required:

EE 4951W - Senior Design Project (4 credits)
OR EE 4981H-4982V - Senior Honors Project I-II (2 credits each)

At least one of the following courses:

EE 4301 - Digital Design W/Programmable Logic (4 credits)
EE 4341 - Microprocessor & Microcontroller System Design (4 credits)

Highly Recommended Electives:

EE 4501 - Communications Systems (3 credits)
EE 4505 - Communications Systems Laboratory (3 credits)
EE 5501 - Digital Communication (3 credits)
EE 5505 - Wireless Communication (3 credits)
EE 5581 – Information Theory & Coding (3 credits)

CSci 5131 – Advanced Internet Programming (3 credits) (= 4341; 5106 or 5211 or #; (4081 or 5801), 5707 recommended)
CSci 5211 - Data Communications & Computer Networks (3 credits) (=4211; [4601 or #], basic knowledge of Computer Architecture, operating systems, probability)

Suggested Non-EE/CSci Electives (0-6 credits)

Math 5251 - Error-Correcting Codes, Finite Fields, Algebraic Curves (4 credits)
Math 5651 - Basic Theory of Probability & Statistics (4 credits)
Math 5652 - Introduction to Stochastic processes (4 credits)
Math 5711 - Linear Programming & Combinatorial Optimization (4 credits)

* This guide gives suggestions for selecting elective courses to provide some specialization in the CompE Degree Program. It does not list requirements for the degree; please see the CompE Curriculum Guide for the degree requirements.