COMPUTER ENGINEERING UNDERGRADUATE HANDBOOK

FOR THE COMPUTER ENGINEERING MAJOR IN THE

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

COLLEGE OF ENGINEERING

AT THE

PENNSYLVANIA STATE UNIVERSITY

Effective Summer, 2008

Department of Computer Science and Engineering:
342G Information Sciences and Technology Building
Phone: 865-9505
Hours: Monday - Friday; 8:00 a.m. - 5:00 p.m.

(Some) University Park Offices and Phone Numbers

College of Engineering:	
Dean's Office, 101 Hammond Building	865-7537
Associate Dean of Undergraduate Studies, 101 Hammond Building	863-3750
International Engineering Programs, 205 Hammond Building	863-1032
Office of Student Services, 208 Hammond Building	863-1033
Engineering Advising Center, 208 Hammond Building	863-1033
Assistant Dean for Student Services, 208G Hammond Building	865-7539
Minority Engineering Program, 208 Hammond Building	865-7138
Women in Engineering Program, 208 Hammond Building	863-1080
Cooperative Education Program, 205 Hammond Building	863-1032
Center for Adult Learner Services (Outreach), 128 Outreach Building	863-3887
Career Services, 101 MBNA Career Services Center	865-2377
Information Technology Services (ITS) Help Desk, 215 Computer Building	863-2494
Counseling and Psychological Services (CAPS), 501 Student Health Center	863-0395
Disability Services, 116 Boucke Building	863-1807
Penn State World Campus (correspondence courses), 128 Outreach Bldg.	865-5403
Division of Undergraduate Studies (DUS), 118 (lobby) Grange	865-7576
University Learning Resource Center, 220 Boucke Building	865-1841
Office of Student Aid (financial), 314 Shields Building	865-6301
Residence Life, 135 Boucke Building	863-1710
Undergraduate Admissions (for transferring credits), 201 Shields Bldg.	865-5471
Schreyer Honors College, 10 Schreyer Honors College (Atherton Hall)	863-2635
Veterans Programs, 325 Boucke Building	863-0465
General Information, HUB Desk, First Floor Lobby	865-2000

Sources of Information

This *Handbook* provides program information specifically for the undergraduate Computer Engineering major. It should be used as a supplement to the *College of Engineering Undergraduate Programs Guide 2008 – 2009*. The information in this *Handbook* pertains to students starting at the University Summer 2008, Fall 2008, or Spring 2009. Students who enrolled at the University in an earlier year should refer to the appropriate earlier version of the *Computer Engineering Undergraduate Handbook*. For information about the Computer Science degree, refer to the *Computer Science Undergraduate Handbook*. All of these documents are available in the department office, 342G Information Sciences and Technology Building. (If you are at a campus other than University Park, you should contact the College of Engineering representative at your location).

Although this *Handbook* lists all requirements for the Computer Engineering major, only those specific to Computer Engineering are described in detail. Other requirements are discussed only briefly with references to more comprehensive supporting documents. Hard copies of these documents can be obtained from a Dean's office or local bookstore. Many are available on-line through the World Wide Web. A list of useful web resources is provided below. For easy reference, resource names are printed in bold throughout the *Handbook*.

- **Semester Course Schedules**
- **DUS Advising Resource**
- **Department of Computer Science & Engineering**
- **Penn State University**
- **Engineering Advising Center**
- **Bulletin of Baccalaureate Degree Programs**
- **University Faculty Senate Policies for Students**
- **Student Guide to General University Policies and Rules**
- **Registrar's Schedule of Courses**
- **General Education & Cultural Diversity in the Curriculum**
- **eLion**

For additional information, you can contact the **Engineering Advising Center** (208 Hammond, 863-1033), the Assistant Dean for Student Services (208G Hammond, 865-7539), or the **Department of Computer Science and Engineering** (342G Information Sciences and Technology Building, 865-9505). The structure in the Department of Computer Science and Engineering includes a Director of Academic Affairs and an Undergraduate Secretary, both of whom can provide information and guidance during your academic career.

The Computer Engineering Major*

The Department of Computer Science and Engineering was created in 1993 with the merger of the Computer Engineering Program and the Computer Science Department. The department offers B.S. degrees in both Computer Engineering (CMPEN) and Computer Science (CMPSC) through the College of Engineering.

The mission of the faculty of the undergraduate computer engineering program at Penn State is to provide students with the knowledge and experience needed to pursue a productive lifelong career in industry or to engage in further study at the graduate level. Students participate in a balanced program of instruction covering the basic principles of the design and application of computer systems. The program includes coverage in breadth and depth of basic science, engineering, and abstract concepts of information handling. Students specialize in and are prepared for careers in the design, analysis and use of hardware, software and systems. The program is structured to ensure that graduates have a clear understanding of the design and the applications of computers, as well as the ability to apply this knowledge throughout their professional careers. In particular, within a few years after graduation, graduates in computer engineering should be able to:

1. Successfully enter a technical graduate degree program.
2. Complete an assigned portion of a significant hardware/software project that meets the specifications and complies with time and budget constraints.
3. Lead a design team in a significant hardware and/or software project.
4. Function as an engineer or graduate student in an ethical manner.
5. Engage in lifelong learning, keeping up to date with current engineering practice, tools, and technologies.
6. Effectively collaborate with co-workers, customers, and partners in diverse environments.
7. Effectively articulate and defend a technical position.

During the first two years, students in Computer Engineering take many courses in common with other engineering majors, including courses in mathematics, physics, and chemistry. In addition, students take several specialized courses in the major, such as algorithms and programming, electrical engineering, digital systems and logic, and computational theory. From these courses, students gain experience using sophisticated software tools, working in a hardware laboratory, and completing individual and group projects. During the second two years, students complete a series of courses in both hardware and software systems. Students also select from numerous electives. Throughout the four years, students develop communication skills, including a senior year course in which students examine the complete design process and participate in a series of oral and written experiences similar to those that would be seen in industry.

The following Program Outcomes summarize the skills acquired through the Computer Engineering program:

Program Outcomes

Fundamental Skills (hardware):

1. Demonstrate basic laboratory skills, including the use of standard laboratory equipment.
2. Analyze and design circuits, devices, and systems using differential and integral calculus and principles of electricity, magnetism, and modern physics.
3. Analyze linear systems using continuous and discrete-time techniques.
4. Design the electronic/logic circuits that form the basic building blocks of a computer system.
5. Design the architecture and organization of the basic components of a computer system.

Fundamental Skills (software):

6. Demonstrate an ability to analyze the space/time complexity of algorithms using discrete mathematics, including the appropriate use of O-notation and recurrence relations.
7. Analyze algorithms or computer code for correctness and efficiency.
8. Develop a modest (on the order of a thousand lines of code) software application, using appropriate data structures and algorithms.

Integrative Skills:

9. Analyze the performance of software and/or hardware systems using probabilistic, statistical, and simulation methods.
10. Design and implement computer operating system components for managing various systems resources.
11. Given specifications, design and implement a computer system (defined as any digital device used for computation or control) under time and budget constraints.

Professional Skills:

12. Write clear and effective technical prose.
13. Speak clearly and persuasively about technical subjects in large and/or small group settings, and use supporting materials effectively.
14. Demonstrate independent learning by using unfamiliar computer systems, test equipment, and software tools to solve technical problems.
15. Be able to discuss major trends in industry and current research activities within the discipline.
16. Demonstrate an ability to work effectively in multi-disciplinary teams. The term multi-disciplinary is used here in the broader sense to include teams of computer professionals having different skills; e.g., one team member might be familiar with web development, whereas another might have experience with microprocessor systems.
17. Be able to state a code of professional ethics and to identify ethical issues in engineering case studies.

Students who are interested in math and science and enjoy solving problems are excellent candidates for the Computer Engineering major. CMPEN 270 or 271 and CMPSC 121 are excellent introductions to this major. Job opportunities are virtually limitless; graduates are employed by all sectors of industry, government, and academic institutions. Because of the close relation to computer science, simultaneous degrees and dual majors in Computer Engineering and Computer Science are not permitted.

*Computer Engineering is accredited by the Engineering Accreditation Commission of ABET, Inc., 111 Market Place, Suite 1050, Baltimore, MD 21202-4012, telephone: 410-347-7700 or **http://www.abet.org**.

Advising and Procedures for Major

If you are a first- or second-year student at University Park who is intending to major in Computer Engineering, you will see an adviser at the **Engineering Advising Center** (EAC), 208 Hammond Building, 863-1033. This office is open Monday through Friday, 8:00 a.m. to 5:00 p.m. (Walk-in advising is available but appointments are encouraged).

If you are a junior or senior who has been admitted into the computer engineering major or a University Scholar, you will be assigned a faculty adviser in the Computer Science and Engineering Department. If you do not know your assigned adviser's name or office address, ask in the department office in 342G Information Sciences and Technology Building. This information is also available from **eLion**.

Required courses for the Computer Engineering major and a suggested schedule are given on the following pages. Information about all majors at Penn State are listed in the **Bulletin of Baccalaureate Degree Programs**. The *Bulletin* is updated yearly and should be used along with this *Handbook*. Exceptions to the *Bulletin* are noted here.

The final responsibility for selecting courses and meeting degree requirements is yours. The role of your adviser is to suggest, recommend, and remind you of the requirements of the major and rules of the University. (Two helpful references for University procedures on-line are: **University Faculty Senate Policies for Students**, and the **Student Guide to General University Policies and Rules**). When meeting with your adviser, always take a copy of your recent audits, grade reports, transcript, your present schedule, and your plan for at least the next semester's courses.

Because computer engineering is such a rapidly changing field, adjustments in course content and/or course offerings should be expected. It will be to your advantage to keep abreast of new course offerings, current course enhancements, and allowable course substitutions through regular contact with your adviser and the department office.

Entrance to the major -- To qualify for the Computer Engineering major:

(1) You must complete MATH 140, MATH 141, CHEM 110, and PHYS 211 with a grade of C or better in each by the end of Spring semester, 2010.
(2) You must be enrolled in the College of Engineering (ENGR major) or DUS (declared as heading toward an engineering major).
(3) You should complete at least two full semesters of coursework appropriate to the major. You should be taking CMPEN 270 or (CMPEN 271 and CMPEN 275), and E E 210 during your second year in order to make normal progress. Be sure you're accumulating credits at a minimum rate of 30 credits per calendar year. Be aware that a deferred grade or withdrawal should be discussed with an adviser so that your schedule is not judged "inappropriate."
(4) Early in Spring semester, 2010, you must complete a Sophomore Application to Major form and submit it by the published deadline. (See *College of Engineering Undergraduate Programs Guide 2008 – 2009* for more details).

In summary, during your first two years, you must complete MATH 140, MATH 141, CHEM 110, and PHYS 211 with a grade of C or better in each. You must declare your intended major as Computer Engineering, schedule your courses wisely, and maintain a high grade point average.

Change of Major – If you discover an interest in other areas of study or you are not admitted into Computer Engineering, you should explore other possible majors and alternatives at the **Engineering Advising Center** or the**DUS Advising Resource**.

Concurrent Major – Concurrent majors will not be allowed in Computer Science and Computer Engineering.

Registration – Each semester, you register for classes by planning what you need to take (referring to this *Handbook* and the *College of Engineering Undergraduate Programs Guide 2008 – 2009*), by checking with your adviser, and then by following the instructions in the *Schedule of Courses* that is published each semester. (You can also find out what courses are still open, what courses have had sections added, etc., on-line at the **Registrar's Schedule of Courses** website.

Re-ordering your course schedule will not necessarily delay graduation. The key to completing 129 credits over 4 years is to average approximately 16-17 credits per semester. Though many students do maintain this pace, it is not unusual for students to take lighter loads some semesters and to delay graduation. Experience has shown that the 5th semester has been difficult for many students; if you have doubts, it is a good place for a light load. Needed credits are often taken during the summer (not necessarily at University Park) or by independent learning. Some students will elect to attend for a 9th semester. Some electives are not offered every semester, so please be careful in your scheduling. This is especially true for co-op students.

Schedule Changes – Schedule adjustments (course adds/drops) may be made on line through **eLion** during the first 10 calendar days of each semester. Detailed instructions, costs, and deadlines are provided in the *Schedule of Courses*. After this time, you may still adjust your schedule, but any change is considered a late add or a late drop and requires an adviser's signature. *You have a limit of 16 late-drop credits, so consultation with your adviser is important.* (REMEMBER: A student who has not yet been admitted to the major should seek advice at the **Engineering Advising Center**; a student who has been admitted should see the assigned faculty adviser in Computer Science and Engineering).

General Education – All students at the University are required to complete 46 credits of General Education. A General Education course can be identified by its course suffix. You will partially meet these requirements by taking specific courses required for the Computer Engineering major, and by following the general guidelines below.

General Education consists of the following categories:

- first year seminar - at least 1 credit - courses with the designation PSU will fulfill this requirement, as will courses with the suffix FYS
- writing/speaking - 9 credits - course suffix of GWS
- quantification - 6 credits - suffix of GQ
- health and physical activity - 3 credits - suffix GHS
- natural sciences - 9 credits - suffix GN
- arts - 6 credits - suffix GA
- humanities - 6 credits - suffix GH
- social and behavioral sciences - 6 credits - suffix GS

College of Engineering students follow the University's General Education guidelines; refer to the *College of Engineering Undergraduate Programs Guide 2008 – 2009* and to the University's **Baccalaureate Degree Programs Bulletin** for a complete list of available courses.

Check with your adviser if you would prefer to develop a sequence of 9 credits in arts, humanities, or social and behavioral sciences by substituting 3 credits from one of the other 2 areas. Please note: students may take a level III language course and use it as one of the AHS courses, but it cannot be the only course in an area; thus, it can only be the second or third course of the 9-6-[not the 3] sequence in any of the AHS areas. It should also be noted that Engineering students must take ECON 2, 4, or 14 or ENNEC 100 as one of the courses in the social and behavioral sciences sequence. Petitions to use the 9-6-3-sequence option for meeting AHS requirements will be approved as long as the above requirements are met.

Writing Requirement – All Penn State students have a Writing Across the Curriculum graduation requirement. You must complete at least 3 credits of writing-intensive courses selected from "W" courses offered within the major or college of enrollment. The course in the Computer Engineering major that fulfills this requirement is CMPEN 482W (Computer Engineering Project Design).

Diversity Requirement – Beginning summer 2005, the Intercultural and International Competence (GI) requirement has been replaced by a requirement in United States Cultures (US) and International Cultures (IL). Courses approved to fulfill this requirement will be designated as US, IL, or both US and IL. The degree audit will monitor the completion of the requirement for each student based on his/her program year.

Students admitted to baccalaureate degree status after spring 2005 must complete 3 credits in US and 3 credits in IL. If a student takes a 3-credit course that is both US and IL, to complete the requirement, he/she must take another 3-credit course that is US, IL, or both US and IL. Education abroad courses and other credit-bearing experiences such as internships that meet this requirement will be designated as US, IL, or both US and IL.

A good reference, updated yearly, is the small blue booklet *General Education and Cultural Diversity in the Curriculum*. Education Abroad is another option for fulfilling the diversity requirement.

Sixth Semester Audit – During your sixth semester, the Department will send you a copy of your transcript or a computer audit and a requirement checklist for the major. A copy of this checklist appears on the last page of this handbook. You must fill out the requirement checklist and return it so that your progress can be checked and any problems resolved before graduation. **If you have questions on your audit, it is your responsibility to talk to your adviser and/or to the undergraduate secretary (in 342H Information Sciences and Technology Building).**

Graduation Requirements – To graduate from the University, every student must:

(1) Complete the course requirements for his or her major;
(2) Earn at least a 2.0 cumulative grade-point average for all courses taken at the University; and
(3) Earn at least a C in each of these courses: CMPSC 121, CMPSC 122, CMPSC 221, CMPSC 360, CMPEN 270 or CMPEN 271 and CMPEN 275, CMPSC 311, CMPEN 331, CMPEN 431, CMPSC 465, CHEM 110, E E 210, E E 310, E E 353, MATH 140, MATH 141, PHYS 211.

Credit Acquisition – In addition to taking courses at any Penn State campus, you can earn credit through Independent Learning (correspondence) or by transferring credits from another school. Before taking a course at another university, check with the Admissions office and your adviser to be sure the course will transfer usefully.

Cooperative Education Program – The cooperative education program provides work experience by alternating periods of academic study and full-time employment in industry or government. The program typically starts at the beginning of the junior year and consists of three rotations, providing a cumulative work experience of one year.

If you have interest in the co-op program, you should obtain advising no later than your fourth semester from the designated co-op adviser, who will help you plan work and study schedules. You may earn up to 3 credits toward graduation in the Department List requirements.

If you prefer less of a time commitment, you can pursue one or more summer internships. You earn 1 credit per internship (maximum of 2 credits total) toward graduation in the Department List requirements.

If you are not a formal co-op or internship student, you may still take related summer jobs; however, you may not claim credits for jobs you arrange outside of the formal programs.

Honors Program – Students in the Schreyer Honors College (Atherton Hall, 863-2635) have the option of pursuing an honors degree in Computer Engineering by participating in the Computer Engineering Honors Program. See an honors adviser if you are interested in finding out more about this program. (The department office, 342G Information Sciences and Technology Building, can identify the honors advisers for you).

Minors – A minor is a specialization of at least 18 credits that supplements a major. Some courses may concurrently meet the requirements of our major. Popular minors for students in our department include:

1) Engineering Leadership Development
2) Engineering Entrepreneurship
3) Mathematics
4) Business/Liberal Arts

Other Issues – For additional information on minors, withdrawal, leaves of absence, concurrent majors, change of major, satisfactory/unsatisfactory credits, and other academic issues, refer to **University Faculty Senate Policies for Students**. For information on campus and community resources (parking, libraries, museums, etc.; referrals for returning adult students, minority students, veterans, women), refer to *Easy Access,* available during orientation and published by Student Life.

Any exceptions made in the degree requirements must be approved and documented, usually using a college petition form. Inquiries about exceptions and general degree requirements should be taken to the Computer Science and Engineering Department Office (342G Information Sciences and Technology Building), to your adviser, or to the **Engineering Advising Center**. (Note that such petitions will NOT be accepted during the semester that you plan to graduate).

Academic Integrity – Recognizing not only the value of integrity in the academic environment, but also its value for the practicing engineer and for society at large, we in the department urge you to act as a responsible professional while you are a student. Academic integrity is defined as follows in Faculty Senate rule 49-20:

> "Academic integrity is the pursuit of scholarly activity free from fraud and deception and is an educational objective of this institution. Academic dishonesty includes, but is not limited to, cheating, plagiarizing, fabricating of information or citations, facilitating acts of academic dishonesty by others, having unauthorized possession of examinations, submitting work of another person or work previously used without informing the instructor, or tampering with the academic work of other students."

It is commonly accepted that people learn better if they can interact, discuss, and assist each other in solving problems and understanding concepts. Yet persons submitting identical homework papers overstep the bounds of beneficial interaction. You are encouraged to discuss homework assignments. You may discuss what you are supposed to do, the general algorithm and data structures that might be used. The furthest that cooperation is allowed is to assist another student in debugging their code. Do not, for any reason, show another student sections of your code or write sections of code for another student. Any collaboration that exceeds these guidelines will be considered cheating. Clearly, professionals share ideas but they should not use another's work without clear acknowledgement of who did the work. Academic dishonesty in any form is not condoned or tolerated.

Engineering Design Experience – Design is incorporated into a majority of courses taught in the Computer Engineering Program. Many of the courses are split between engineering science and engineering design, so that the design experience is spread throughout the program.

At the sophomore level, in CMPEN 270 or CMPEN 271 and CMPEN 275, students design and build digital circuits consisting of combinational and sequential components. Students begin with analysis type projects, learning basic laboratory skills, problem specification, and project planning. Projects become increasingly more design oriented and open ended, culminating in a significant two- or three-week design effort, allowing the student to make choices and trade-offs between multiple design criteria.

During the junior year, students learn about computer organization in CMPEN 331 and CMPEN 431. Trade-offs in the design of a computer are examined.

The design experience culminates in the senior year, where students choose from a variety of system-level design courses in both hardware and software areas. Choices include laboratory design courses in microcomputer systems, VLSI, FPGA, software engineering, compilers, databases, and concurrent computing. Each of these courses involves the student in a significant design problem by the end of the course.

The final design course for most students is CMPEN 482W. Students experience the entire design process, starting from problem definition and requirements analysis to proposal preparation, to steps in the design review process, and finally, to design specification and implementation. Projects require students to consider a number of design factors including cost, size, human factors, reliability, power consumption, manufacturability, etc. The course is considered writing intensive and involves students in a number of technical writing experiences, as well as oral presentations.

Engineering Topics – Students achieve breadth in computer engineering through a series of required courses. Background in software related areas is gained through CMPSC 121, CMPSC 122, CMPSC 221, CMPSC 311, CMPSC 465, and CMPSC 473. Background in hardware areas is gained through CMPEN 270 or CMPEN 271 and CMPEN 275, CMPEN 331, CMPEN 362, and CMPEN 431.

Specialization is provided through the students' selection of senior year electives. Students must select 12 credits of technical electives (Select 6 credits from CMPEN 471, CMPEN 472, CMPEN 473, CMPEN 411, CMPEN 417, CMPEN 416, CMPEN 455, CMPEN 454, and EE 453, 456 and select 6 credits from any 400-level CMPSC/CMPEN course).

Issues related to the integration of hardware and software, and hardware-software tradeoffs are discussed in the required courses CMPSC 311, CMPEN 331, CMPSC 473, CMPEN 482W, and CMPEN 431, as well as some elective courses such as CMPEN 472 (Microprocessors and Embedded Systems) and CMPEN 473 (Microcomputer Laboratory).

Students receive appropriate introduction to various specialized mathematics topics in a sequence of required courses that include: CMPSC 360 (Discrete Mathematics for Computer Scientists), STAT 418 (Probability), and MATH 220 (Matrices). A variety of methods for modeling computer processes and systems are introduced in the required courses CMPSC 465, CMPEN 331, CMPSC 473, and CMPEN 431.

Students learn to use a number of computer-aided design tools through the laboratory courses and in regular lecture courses. These include a digital schematic capture and simulation tool in CMPEN 270 or CMPEN 271 and CMPEN 275; an analog simulation tool in EE 210; a hardware design language and a microprocessor emulation system in CMPEN 473; a hardware description language simulator in CMPEN 431; logic design CAD tools in CMPEN 431 and CMPEN 471; VLSI CAD tools in CMPEN 411; and various digital image processing and computer vision software tools in CMPEN/EE 455 and CMPEN/EE 454.

All students learn at least three programming languages, JAVA, C, and C++. Assembly language is studied in CMPEN 331 and CMPEN 472. Students make extensive use of both Microsoft and UNIX operating systems.

Program Requirement Summary Chart – On the next pages, you will find a semester-by-semester chart of what courses to take with notes describing any choices to be made or restrictions to be followed. Please realize that although all the courses listed are required for the degree, they need not be taken during the semesters shown in the charts; however, you should be sure to check course prerequisites before you deviate from the suggested schedule. **Care should be exercised to be sure core courses are taken in the proper sequence and in a time frame allowing you to meet entrance to major requirements.** A total of 129 credits are required for graduation.

Suggested Schedule of Courses by Semester

SEMESTER 1 16 credits		**SEMESTER 2** 17 credits	
MATH 140 GQ or MATH 140E (Calculus I)*	4	MATH 141 GQ or MATH 141E (Calculus II)*	4
PHYS 211 GN (Mechanics)*	4	PHYS 212 GN (Electricity & Magnetism)	4
CHEM 110 GN (Chemical Principles)*	3	CMPSC 121 GQ (Intro. To Prog. Techniques)*	3
CHEM 111 GN (Experimental Chemistry)	1	GA, GH, or GS course (or ENGL 15 or 30)	3
ENGL 15 or 30 GWS (Rhetoric & Composition) (or GA/GH/GS)	3	GA, GH, or GS course	3
First Year Seminar[xi]	1		
SEMESTER 3 17 credits		**SEMESTER 4** 15 credits	
MATH 250 (Differential Equations)	3	MATH 231 (Calculus of Several Variables)	2
MATH 220 GQ (Matrices)	2	CMPSC 221 (OOP with Web Applications)*	3
CMPSC 122 (Intermediate Programming)*	3	E E 210 (Circuits and Devices)*	4
CMPEN 270 (Intro to Digital Systems)◊*	4	ECON 2, 4, or 14 or ENNEC 100 (GS)[ix]	3
PHYS 214 GN (Wave Motion & Quantum Physics)	2	CMPEN 331 (Computer Organization & Design)*	3
GA, GH, or GS course	3		
SEMESTER 5 16 credits		**SEMESTER 6** 15 credits	
CMPEN 431 (Intro to Computer Architecture)*	3	CMPEN 362 (Communication Networks)	3
E E 310 (Electronic Circuit Design)*	4	CMPSC 360 (Discrete Math for Comp. Science)*	3
CMPSC 311 (Systems Programming)*	3	CMPSC 473 (Operating Systems)	3
STAT 418 (Probability)	3	ENGL 202C (Technical Writing)	3
CAS 100 A/B (Effective Speech)	3	E E 353 (Signals & Systems)*	3
SEMESTER 7 16.5 credits		**SEMESTER 8** 16.5 credits	
GA, GH, or GS course	3	CMPEN Computer Engineering Elective[ii]	3
CMPEN 482W (Comp. Eng. Project Design)	3	CMPSC/CMPEN 400-level~	3
CMPSC 465 (Data Structures & Algorithms)*	3	CMPSC/CMPEN 400-level~	3
CMPEN Computer Engineering Elective[ii]	3	Department List (General Elective) [x]	3
Department List (General Elective) [x]	3	GA, GH, or GS course	3
Health & Physical Activity (GHA)[vii]	1.5	Health & Physical Activity (GHA)[vii]	1.5

Superscripts in Roman numerals refer to the Graduation Requirements Notes on the following pages.

* A grade of C or better in these courses is required for graduation. (MATH 140, MATH 141, CHEM 110, and PHYS 211 require a C or better for entrance to the major). If a course requires a "C" or better and the course is a prerequisite for another course, a "C" is required to meet the prerequisite.

~ Select from any 400-level CMPSC/CMPEN course.

◊ This course is the equivalent of the combination of CMPEN 271 and CMPEN 275. At the time of publication, the approval for the course was pending.

GRADUATION REQUIREMENTS NOTES

Many of the courses below have prerequisites; some prerequisites are shown in parentheses; others are given in the Bulletin.

I. Computer Science and Engineering (34 credits):

CMPSC 121 GQ (3) – Introduction to Programming Techniques
(prerequisite: 2 entrance units in MATH)
CMPSC 122 (3) – Intermediate Programming
(prerequisite: CMPSC 121)
CMPSC 221 (3) – Object Oriented Programming with Web-Based Applications
(prerequisite: CMPSC 122)
CMPSC 360 (3) – Discrete Mathematics for Computer Science
(co-requisite: CMPSC 122)
CMPEN 270 (4) – Introduction to Digital Systems
(prerequisite: PHYS 212)
CMPSC 311 (3) – Systems Programming
(prerequisite: CMPSC 221)
CMPEN 331 (3) – Computer Organization and Design
(prerequisite: CMPEN 271; CMPSC 121 or CMPSC 201)
CMPSC 473 (3) – Operating Systems
(prerequisite: CMPSC 311; CMPEN 331)
CMPEN 431 (3) – Introduction to Computer Architecture
(prerequisite: CMPEN 331 or CMPEN 371)
CMPSC 465 (3) – Data Structures and Algorithms
(prerequisite: CMPSC 360 or MATH 311W)
CMPEN 362 (3) – Communication Networks
(prerequisite: CMPEN 271; Concurrent: STAT 301 or STAT 318 or STAT 401 or STAT 414 or STAT 418)

II. Computer Engineering Electives (6 credits):

Select 6 credits from:

CMPEN 411 (3) – VLSI Digital Circuits
(prerequisite: CMPEN 371 or CMPEN 471; E E 310)
CMPEN 416 (3) – Digital Integrated Circuits
(prerequisite: E E 310)
CMPEN 417 (3) – Digital Design using Field Programmable Devices
(prerequisite: CMPEN 331)
CMPEN 454 (3) – Fundamentals of Computer Vision
(prerequisite: MATH 230 or MATH 231; CMPSC 121 or CMPSC 201)
CMPEN 455 (3) – Digital Image Processing
(prerequisite: E E 353 or E E 350; CMPSC 121 or CMPSC 201)
CMPEN 471 (3) – Logical Design of Digital Systems
(prerequisite: CMPEN 331)
CMPEN 472 (3) – Microprocessors and Embedded Systems
(prerequisite: CMPEN 331)
CMPEN 473 (3) – Microcomputer Laboratory
(prerequisite: CMPEN 472)
CMPEN 475 (3) – Functional Verification
(prerequisite: CMPEN 331)
EE 453 (3) – Fundamentals of Digital Signal Processing
(prerequisite: E E 351 or E E 351 or E E 353)
EE 456 (3) – Introduction to Neural Networks
(prerequisite: CMPSC 201 or CMPSC 202; MATH 220)

Some courses are NOT offered every semester or even every year.

III. Writing Intensive Course (3 credits):

CMPEN 482W (3) – Computer Engineering Project Design
(prerequisite: EE 310, EE 353, CMPSC 473, ENGL 202C)

IV. Electrical Engineering (11 credits):

EE 210 (4) – Circuits and Devices
(prerequisite: PHYS 212; concurrent: MATH 250)
EE 310 (4) – Introduction to Electron Devices and Circuits
(prerequisite: EE 210)
EE 353 (3) – Signals and Systems: Continuous and Discrete-Time
(prerequisite: CMPSC 201 or CMPSC 202, EE 210, MATH 250)

V. Communications (9 credits):

ENGL 15 GWS (3) – Rhetoric and Composition
(ENGL 30 GWS may be substituted)
ENGL 202C GWS (3) – Technical Writing
CAS 100 A/B (3) – Effective Speech

VI. Quantification and Statistics (18 credits):

MATH 140 GQ (4) – Calculus with Analytic Geometry I
MATH 141 GQ (4) – Calculus with Analytic Geometry II
MATH 220 GQ (2) – Matrices
MATH 231 (2) – Calculus of Several Variables
MATH 250 (3) – Ordinary Differential Equations
STAT (MATH) 418 (3) – Probability

VII. Health Sciences and Physical Education (3 credits):

The Health Science/Physical Activity (ESACT) requirement can be met by taking one 3-credit course or various credit combinations (which can be taken in different semesters)

VIII. Natural Sciences (14 credits):

PHYS 211* GN (4) – General Physics (mechanics)
PHYS 212* GN (4) – General Physics (electricity, magnetism)
PHYS 214* GN (2) – General Physics (wav e motion and quantum physics)
CHEM 110 GN (3) – Chemical Principles
CHEM 111 GN (1) – Experimental Chemistry
*Preferred sequence is PHYS 211, 212, and 214, but may not be available at all campuses.

IX. Arts, Humanities, Social and Behavioral Sciences, Diversity (18 credits):

Six credits are required in each of the 3 categories: Arts (A), Humanities (H), and Social and Behavioral Sciences (S), as listed under the University's General Education Guidelines [see the University's **Baccalaureate Degree Programs Bulletin**]. See page 6 [this *Handbook*], **General education**, for an explanation of the 9-6-3 sequence as it pertains to AHS courses. You may use one of your Arts, Humanities, or Social or Behavioral Sciences selections to fulfill the University's Diversity requirement (see page 7 [this *Handbook*], **Diversity requirement****). A work chart follows.

Arts	
Humanities	
Social Sci.	**ECON 2*, ECON 4*, or ECON 14* or ENNEC 100***
Diversity Focused Course	

**Either ECON 2, 4, or 14 or ENNEC 100 is required for College of Engineering majors.*
***For diversity-focused courses, see* **General Education and Cultural Diversity in the Curriculum** on-line and the **Semester Courses Schedules.**

X. Department List (General Elective) Guidelines (6 credits):

These 6 credits are sometimes called approved free electives or general electives, but restrictions apply as described below. These credits provide some flexibility and also allow inclusion of up to 6 credits of ROTC or up to 3 Cooperative Education credits. If your Diversity course was not an Arts, Humanities, Social or Behavioral Sciences course, it may be counted in this list. (For diversity focused courses, see the *General Education and Cultural Diversity in the Curriculum* booklet and the *Schedule of Courses*). We encourage, but do not require, the taking of technical electives in Computer Science, Engineering, Math or Physics in this category.

The following restrictions apply:

- no courses not satisfying minimum requirements for a baccalaureate degree program (see course descriptions in University *Bulletin*)
- no courses described as intended for non-science or non-technical majors in course descriptions in the University *Bulletin* (**You may take non-technical courses**, but look at the *Bulletin* to be sure the description doesn't say "for non-science majors only").
- no courses similar or remedial to a required course or course already taken (when in doubt, check with your advisor before scheduling the course). For example, you may not include 2 credits of MATH 140A or 2 credits of CHEM 106.
- none of the following:

  Astronomy (ASTRO) 1, 10, 11, 120, 140
  Biological Science (BI SC) 1, 2, 3, 4
  Chemistry (CHEM) 1, 3, 108, 101
  Computer Science (CMPSC) 100, 203
  Earth and Mineral Sciences (EM SC) 150
  English as a Second Language (ESL) 004
  Language and Literacy Education (LL ED) 5, 10
  Mathematics (MATH) 200, MATH below 140
  Philosophy (PHIL) 12
  Physical Science (PH SC) 7
  Physics (PHYS) 250, 251, PHYS below 211
  Science, Technology, and Society (S T S) 150
  Speech Communication (CAS) 126, 283
  Statistics (STAT/MATH) below 319
  Statistics (STAT/MATH) 401

- no more than 6 credits of ROTC
- no more than 3 additional credits of physical education
- no more than 3 credits of Cooperative Education
- no more than 2 credits of Engineering Internship
- ***IST courses are accepted with the following exceptions:***

  IST 210 – (if the student has completed CMPSC 441W)
  IST 220 – (if the student has completed CMPEN 362)

XI. First Year Seminar (1 credit):

Small interactive classes that allow first-year students to meet faculty and alumni, explore different majors and career opportunities, or focus on hands-on projects and skill development.

Changes in Course Abbreviations Effective Spring 2008		
New Course	**Old Course**	**Official Course Title**
CMPEN 271	CSE 271	INTRODUCTION TO DIGITAL SYSTEMS
CMPEN 275	CSE 275	DIGITAL DESIGN LABORATORY
CMPEN 331	CSE 331	COMPUTER ORGANIZATION AND DESIGN
CMPEN 362	CSE 458	COMMUNICATION NETWORKS
CMPEN 411	CSE 477	VLSI DIGITAL CIRCUITS
CMPEN 416	CSE 447	DIGITAL INTEGRATED CIRCUITS
CMPEN 417	CSE 478	DIGITAL DESIGN USING FIELD PROGRAMMABLE DEVICES
CMPEN 428W	CSE 430W	COMPUTER ENGINEERING PROJECT DESIGN
CMPEN 431	CSE 431	INTRODUCTION TO COMPUTER ARCHITECTURE
CMPEN 454	CSE 486	FUNDAMENTALS OF COMPUTER VISION
CMPEN 455	CSE 485	DIGITAL IMAGE PROCESSING
CMPEN 471	CSE 471	LOGICAL DESIGN OF DIGITAL SYSTEMS
CMPEN 472	CSE 472	MICROPROCESSORS AND EMBEDDED SYSTEMS
CMPEN 473	CSE 473	MICROCOMPUTER LABORATORY
CMPEN 482W	CSE 430W	COMPUTER ENGINEERING PROJECT DESIGN
CMPSC 97	CSE 97	SPECIAL TOPICS
CMPSC 101	CMPSC 101	INTRODUCTION TO C++ PROGRAMMING
CMPSC 102	CMPSC 101B	INTRODUCTION TO VB PROGRAMMING
CMPSC 109	CMPSC 140	INTRODUCTION TO DATA PROCESSING WITH COBOL
CMPSC 121	CSE 121	INTRODUCTION TO PROGRAMMING TECHNIQUES
CMPSC 122	CSE 122	INTERMEDIATE PROGRAMMING
CMPSC 200	CMPSC 201A	PROGRAMMING FOR ENGINEERS WITH MATLAB
CMPSC 201	CMPSC 201C	PROGRAMMING FOR ENGINEERS WITH C++
CMPSC 202	CMPSC 201F	PROGRAMMING FOR ENGINEERS WITH FORTRAN
CMPSC 203	CMPSC 203	INTRODUCTION TO SPREADSHEETS AND DATABASES
CMPSC 221	CSE 221	OBJECT ORIENTED PROGRAMMING WITH WEB-BASED APPLICATIONS
CMPSC 295	CSE 295	INTERNSHIP
CMPSC 296	CSE 296	INDEPENDENT STUDIES
CMPSC 297	CSE 297	SPECIAL TOPICS
CMPSC 311	CSE 311	INTRODUCTION TO SYSTEMS PROGRAMMING
CMPSC 360	CSE 260	DISCRETE MATHEMATICS FOR COMPUTER SCIENCE
CMPSC 431W	CSE 441W	DATABASE MANAGEMENT SYSTEMS
CMPSC 442	CSE 481	ARTIFICIAL INTELLIGENCE
CMPSC 443	CSE 443	INTRODUCTION TO COMPUTER SECURITY
CMPSC 450	CSE 457	CONCURRENT SCIENTIFIC COMPUTING
CMPSC 451	CSE 451	NUMERICAL COMPUTATIONS
CMPSC 455	CSE 455	INTRODUCTION TO NUMERICAL ANALYSIS I
CMPSC 456	CSE 456	INTRODUCTION TO NUMERICAL ANALYSIS II
CMPSC 458	CSE 418	FUNDAMENTALS OF COMPUTER GRAPHICS
CMPSC 461	CSE 428	PROGRAMMING LANGUAGE CONCEPTS
CMPSC 465	CSE 465	DATA STRUCTURES AND ALGORITHMS
CMPSC 466	CSE 460	COMBINATORICS AND GRAPH THEORY
CMPSC 467	CSE 467	FACTORIZATION AND PRIMALITY TESTING
CMPSC 468	CSE 468	THEORY OF AUTOMATA, LANGUAGES, AND COMPUTABILITY
CMPSC 471	CSE 421	INTRODUCTION TO COMPILER CONSTRUCTION
CMPSC 473	CSE 411	OPERATING SYSTEMS DESIGN & CONSTRUCTION
CMPSC 483W	CSE 420W	SOFTWARE DESIGN METHODS
CMPSC 494H	CSE 494H	SENIOR HONORS THESIS
CMPSC 496	CSE 496	INDPENDENT STUDIES
CMPSC 497	CSE 497	SPECIAL TOPICS
CMPSC 498	CSE 498	SPECIAL TOPICS

Graduation Requirements Checklist for B.S. Degree in Computer Engineering

[format is COURSE (grade, credits, semester): e.g., CMPEN 270 (A,4,FA09)]

Computer Science and Engineering: _____ **(34)**
CMPSC 121/ GQ (,3,), CMPSC 122 (,3,), CMPSC 221 (,3,),
CMPSC 360 (,3,), CMPEN 270 (,4,),
CMPSC 311 (,3,), CMPEN 331 (,3,), CMPEN 362 (,3,),
CMPEN 431 (,3,), CMPSC 465 (,3,), CMPSC 473 (,3,)

Computer Engineering Electives: _____ **(12)**
CMPEN _____ (,3,), CMPEN _____ (,3,)
CMPEN/CMPSC _____ (,3,), CMPEN/CMPSC _____ (,3,)

Writing Intensive Course: _____ **(3)**
CMPEN 482W (,3,)

Electrical Engineering: _____ **(11)**
E E 210 (,4,), E E 310 (,4,), E E 353 (,3,)

Communications: _____ **(9)**
ENGL 15 GWS (,3,), ENGL 202C GWS (,3,),
CAS 100 A/B (,3,)

Quantification, Statistics: _____ **(18)**
MATH 140 GQ (,4,), MATH 141 GQ (,4,),
MATH 231 (,2,), MATH 220 GQ (,2,), MATH 250 (,3,),
STAT 418 (,3,)

Health Sciences and Physical Activities: _____ **(3)**
_____ (, ,) _____ (, ,) _____ (, ,)

Natural Sciences: _____ **(14)**
PHYS 211 DN (,4,), PHYS 212 DN (,4,),
PHYS 214 DN (,2,)
CHEM 110 DN (,3,), CHEM 111 DN (,1,)

Arts, Humanities, Social & Behavioral Sciences, Diversity (indicate GA, GH, GS, & DF): _____ **(18)**
ECON 2, 4 or 14 or ENNEC 100 (, 3 ,) _____ (, ,)
_____ (, ,) _____ (, ,)
_____ (, ,) _____ (, ,)

Department List (General Electives): _____ **(6)**
_____ (, ,) _____ (, ,)

First Year Seminar: _____ **(1)**
_____ (,1,)

TOTAL CREDITS _____ **(129+)**

_____ (student name) is planning to graduate at the end of

_____ Semester, 20___.

Advisor's signature _____