UNIVERSITY OF WISCONSIN MADISON

ADVISING INFORMATION FOR ECE UNDERGRADUATES

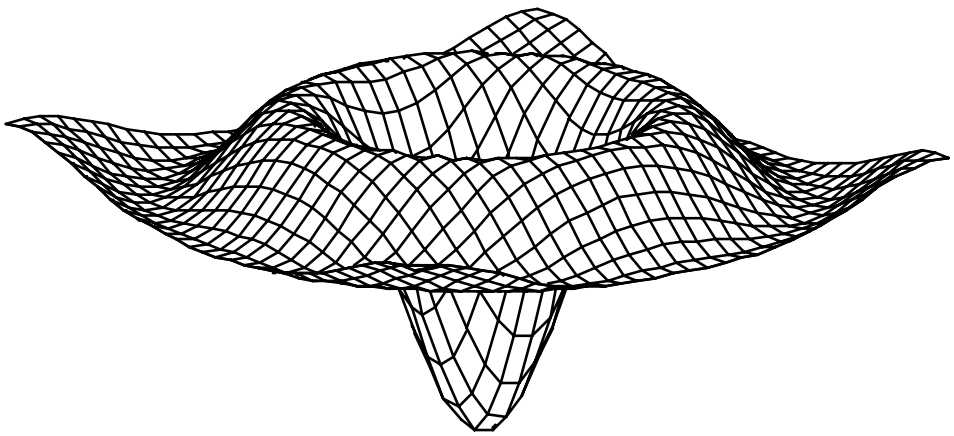
in the

BS Computer Engineering Program

Admitted for

Fall 2005

or Thereafter



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This booklet is published by the Department of Electrical and Computer Engineering (ECE) to provide guidance to undergraduates in managing their programs and in selecting courses toward the **BS Computer Engineering (BSCMPE)** degree. This booklet supplements information in the UW *Undergraduate Catalog.* (See **http://www.wisc.edu/pubs/ug/**). A separate advising booklet is available for the **BS Electrical Engineering (BSEE)** degree program. The Associate Chair for Undergraduate Activities welcomes suggestions for improving the presentation of this material.

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1. IMPORTANT REQUIREMENTS AND PROCEDURES

1.1 ADMISSION

Under current admission procedures, incoming freshmen are admitted to the College of Engineering with the pre-engineering classification EGR. (See the *Undergraduate Catalog*.) A pre-engineering student may not have a year classification higher than EGR 2.

To be considered for admission to the Computer Engineering (CMPE) program, a student must have

1) satisfied the Communications Part A requirement (see the *Undergraduate Catalog*)
2) a minimum of 24 credits
3) a minimum of 17 credits from the chemistry, computer science, statics, statistics, physics, and calculus courses (**including Math 222**) required for an engineering degree
4) a grade-point average of at least 2.5 for all chemistry, computer science, statics, statistics, physics, and calculus courses
5) a grade-point average at least 2.0 for all courses not included in 4)

When the number of applicants to the BSCMPE degree program meeting 1)-5) exceeds the capacity of the program, admission will be limited to that capacity. It is the student's responsibility to submit a timely application to the Dean's office for admission to the BSCMPE degree-granting classification. Application periods are as follows:

For Fall Semester:	**January 15 to March 1**
For Spring Semester:	**September 15 to November 1**
For Summer Session:	**January 15 to March 1**

A student, whose admission to a degree program is declined, may file an appeal with the appropriate dean. The ECE department may specify that certain courses are not open to pre-engineering or non-ECE students.

Students transferring to UW-Madison from another institution must meet the same requirements as pre-engineering students. Note that late transfers into the program are discouraged by the following graduation requirements:

1) You must have completed at least 30 credits in residence in the College of Engineering, including 15 credits of study in your degree-granting department.
2) You must have completed your last two semesters in residence in the College of Engineering as a full-time student.

1.2 YOUR CURRICULUM

Unless the ECE Department provides information to the contrary, **the curriculum you are to follow is the one in effect during your first semester in the ECE Department.** Exceptions to this rule may occur in the case of students who are readmitted. The program you follow must be based on the *Advising Information* booklet for **your curriculum**, which may not be the most recent edition of the booklet.

1.3 CURRICULUM AND ADVISING INFORMATION

Additional advising information is available on the shelves outside Room 2413 EH and on the bulletin boards outside Rooms 2415 and 2421 EH. For example, notices concerning registration and course cancellations are posted regularly. It is your responsibility to stay informed by occasionally scanning the bulletin boards. Information is also available on the Web at (**http://www.engr.wisc.edu/ece/current/**) and may be sent to students via email. **Please check this booklet and the other sources of information before contacting ECE Student Services personnel or your advisor with questions.**

1.4 ADVISING

Students entering the CMPE program are assigned to faculty advisors on an alphabetical basis. The Advisor Assignment List is posted outside Room 2413 EH. As you progress through your undergraduate education, you are encouraged to choose an area of specialization within CMPE. A brief description of each area is included in Section 4 of this booklet. When you choose an area, you should change your advisor to a faculty member in that area. This can be done by simply asking that person to be your advisor. No formal departmental approval is required to change your advisor. If you wish to have your advisor's name appear on your registration materials, make this request in Room 2413 EH.

You are expected to maintain a record of your progress in your program and to bring the record with you whenever seeking advice. You are encouraged to use your **DARS** (**Degree Auditing and Reporting System**) report as your develop this record. Your DARS report can be requested through the My-UW, which is accessible as a link from the university home page (**http://www.wisc.edu**)**.** An easy way to record your progress is to use the CMPE Curriculum Checklist in Section 2.6 of this booklet. Simply fill in your courses on the checklist as you complete them.

You are not required to obtain an advisor's approval for registration; however, you are encouraged to consult with your advisor each semester for general advice and program planning. Before you see your advisor, you should try to pre-plan your curriculum one or two semesters ahead. Your advisor's time is much more efficiently used in answering questions such as, “Out of these courses that relate to my interests, which ones do you recommend?”, rather than questions like “What should I take next semester?” Advisors have specific office hours, but they are also available by appointment, if necessary.

1.5 WORKLOAD

While the curriculum requirements for the degree can be satisfied in four years of study by completing 14-16 credits of work each semester, many students choose to take longer. A nine-semester or ten-semester program may be selected in order to achieve broader coverage of an area of specialization, penetrate an area more deeply, or pursue a second major. In addition, many students participate in the engineering cooperative education (co-op) program; this requires one or two additional semesters.

1.6 PART-TIME STUDY

Normally, engineering students are expected to study full-time. This means that they must enroll for at least 12 credits each semester. There is no minimum credit load in the Summer session. Students who wish to carry fewer than 12 credits in a semester must request written permission from the appropriate dean. Part-time permission is granted only for specific reasons such as a verifiable disability, necessity of employment exceeding 15 hours per week, or the need for fewer than 12 credits for graduation. Part-time
request forms are available in the **Academic Affairs** Office, 2630 Engineering Hall; the form **must** be signed by your advisor. For the semester in which part-time status is granted and the one

following it, the academic standing of the student is the responsibility of the dean. Part-time permission should be requested within the first two weeks of the semester and applies only to that semester.

1.7 INTERNATIONAL STUDENTS

International students are usually required by their visas to study full-time. If an international student changes to part-time status for any reason, the student must inform the **International Student Services (ISS)** office, 716 Langdon St. (**http://www.intstudents.wisc.edu**) and take the necessary actions to preserve visa status.

An international student who wishes to leave the U.S. temporarily (e.g. for a holiday recess) must have his or her current academic status verified prior to leaving, in order to regain an I-20 upon return. This is accomplished by obtaining the INS Form D-2 from the ISS office, completing the name and personal information section of the form, and then taking the form to Ann Morris in Room 2630 EH for verification of academic status.

1.8 TRANSFER STUDENTS

Transfer students sometimes find themselves short of credits in mathematics, physics, or computer science. If you find yourself in that situation, seek advice from the ECE Student Services office (Room 2413 EH), or the Associate Chair for Undergraduate Activities, regarding appropriate substitutions.

1.9 PASS-FAIL COURSES

You may take up to **two** courses pass/fail and count them toward your degree. These courses **must** qualify as Liberal Studies courses and **must** be applied to the Liberal Studies requirement. Other courses taken pass/fail will not count toward your degree. You must submit an application for pass-fail permission before the end of the fourth week of the semester in which the course is taken. The appropriate form can be obtained at (**http://registrar.wisc.edu/forms/student/**) or in the Academic Affairs Office, 2630 Engineering Hall and should be submitted there. A student must be in good standing (i.e. not on probation) to take a course pass-fail. In a pass-fail course, a D becomes an F.

1.10 ECE SCHOLARSHIPS

Scholarships (ranging in amounts from $400 to $2000) are available to ECE undergraduates and to EGR students expecting to be admitted to the ECE Department for the term of the scholarship. Awards are based on academic merit and not financial need. Application forms are available at (**http://www.engr.wisc.edu/ece/current/undergrad/scholarship.pdf**) or on the shelves outside Room 2413 EH at the start of the Spring semester and are normally due in early April. All applicants receive notification in late summer.

1.11 GRADUATE STUDIES

Students qualified for admission to graduate study are encouraged to discuss this option with their advisors. Students may request UW graduate studies information in Room 2413 EH. For more information on UW graduate studies and graduate financial support (including fellowships), check the following websites:

http://www.wisc.edu/grad/

http://www.wisc.edu/grad/catalog/

1.12 SENIOR/GRADUATE STATUS

UW-Madison undergraduate seniors who are **within six credits** of satisfying graduation requirements, and who otherwise meet the requirements for graduate admission with full standing, may apply for one semester's concurrent enrollment in the Graduate School and as an undergraduate in the College of Engineering. The six credits must include those remaining for the BSCMPE degree as well as those remaining for all additional majors. Courses with a grade of Incomplete must be counted in the total. All grade points earned as a senior/graduate student are counted toward the student's cumulative undergraduate Grade Point Average. A senior/graduate student's program is subject to the regulations and requirements of the Graduate School. Graduate credit will be awarded only if all requirements for the Bachelor's degree are completed by the end of the semester of senior/graduate enrollment.

1.13 GRADUATION REQUIREMENTS

For graduation with a BS degree from any curriculum in the College of Engineering, you **must**

1) have fulfilled the published graduation requirements of that curriculum, with all substitutions formally approved
2) have a PCR* of at least 2.0 for those semesters and sessions containing the last 60 credits taken at UW-Madison or for all credits taken at UW-Madison, if fewer than 60
3) have a departmental PCR of at least 2.0 for courses taken in the degree-granting department
4) have completed at least 30 credits in residence in the College of Engineering, including 15 credits of work in the degree-granting department
5) have completed the last two semesters in residence in the College of Engineering as a full-time student
6) have a GPA of at least 2.0 both for the last semester and also for the combined last two semesters
7) have filed a Personal Record form with Engineering Career Services (**http://ecs.engr.wisc.edu**).

In order to earn the BSCMPE degree, you must satisfy the following additional conditions:

8) You **must** take ECE 350 and at least 15 credits of CMPE Advanced Electives in residence**.**
9) You **must** submit an Application to Graduate and a CMPE Advanced Elective Approval form, signed by your advisor, to the Student Status Examiner in Room 2413 EH. May and August graduates must submit the forms by October 1. December graduates must submit them by March 1. **You will not be permitted to register for your final semester of coursework until you have submitted these forms.**
10) If you are clearing an Incomplete grade during your semester of graduation in a course applied toward your degree, the final grade for that course **must be dated** on or before the last day of final exams. An Incomplete cleared later will prevent you from graduating.
11) If a UW Extension course is taken during your semester of graduation, and the course is required for graduation, the Dean's office **must** receive a transcript dated on or before the last day of final exams. The Dean suggests that you take the final exam in your Extension course on the first day of the final exam period to allow enough time for paperwork to be processed.

* PCR is the Point-Credit Ratio, which differs from GPA. PCR involves only those credits and grade points that count toward graduation. When a course is repeated, only those credits and grade points earned in the final attempt are included in the PCR.

12) If a problem is encountered when your file is checked for graduation (e.g. a missing requirement or no approval for a course substitution), and you cannot be reached for consideration of corrective actions, you will not graduate. **It is your responsibility to make sure that you meet all graduation requirements.**

2. THE COMPUTER ENGINEERING UNDERGRADUATE CURRICULUM

The Computer Engineering undergraduate curriculum provides broad elective freedom, while maintaining some requirements common to all CMPE students. The program ensures sufficient breadth and depth in CMPE as well as science, mathematics, and non-technical subjects.

Course requirements within the CMPE program can be divided into two levels. The first level consists of courses that every CMPE student must complete. These courses form the **CMPE Core**, consisting of ten classroom courses and three labs. They form a common basis upon which successive courses are built.

The second level is comprised of **CMPE Advanced Electives**. At this level, there are some general choices to be made corresponding to your interests, but within certain constraints. You are required to take at least one course from each of four groups, consisting of classroom courses and labs.

To aid you in making these decisions, descriptions of five areas of specialization within Computer Engineering are included in this booklet in Section 4. Area recommendations on course selection appear throughout this section.

Few students know exactly which areas they wish to emphasize when they begin the CMPE curriculum. It is important that you begin thinking about your choice early so that you can take full advantage of your electives in developing a coherent program. Through exposure to the required courses and consultation with your advisor, you should choose one or two areas by your senior year.

In addition to ECE courses, the student must take courses in Mathematics, Science, Communication Skills, and Liberal Studies. Guidelines for the choice of these courses can also be found in this section. In the CMPE curriculum, credit requirements are distributed as follows:

Requirement	**Credits**
Math/Science	41
Liberal Studies	15
CMPE Core	34
CMPE Advanced Electives	25
Communication Skills	5
	120

Sometimes a student may wish to make a course substitution in order to enhance a specific aspect of his or her program. If the student can demonstrate that such a request is well-founded, a substitution can often be made, but it must be approved by the Associate Chair for Undergraduate Activities. Such a request is also subject to review by a series of three departmental and college committees.

Sections 2.1-2.5 list all requirements for the BSCMPE degree. Sections 2.6 and 2.7 provide material to help the student plan a program of study. These sections expand on the description of the CMPE curriculum presented in the College of Engineering pages of the ***Undergraduate Catalog*** (**http://www.wisc.edu/pubs/ug/**). Our goal is to provide answers to questions that arise frequently in student advising.

2.1 MATH/SCIENCE REQUIREMENT

Calculus: There are two calculus sequences you may follow:

Standard Sequence	**Honors Sequence**
Math 221 (5 cr.)	Math 275 (5 cr.)
Math 222 (5 cr.)	Math 276 (5 cr.)
Math 234 (3 cr.)	Math 375 (5 cr.)[†]

Discrete Mathematics: Choose either Math 240 or Math 475.

General Physics: Physics 201 and Physics 202

Probability/Statistics: Choose either ECE 331, Math 431, or Stat 311.

Algebraic Language Programming: CS 302

Data Structures: CS 367

General Science: Students must choose at least 6 credits from any of the following categories.

1) Courses having Timetable designation B, N, or P (Biological, Natural, or Physical Science) and **not** offered by or cross listed with ECE. CS courses are also inadmissible, except CS 425, 475, 513, 514, 515, and 525. Math courses must be numbered 300-699.
2) College of Engineering courses 200-699 **not** offered by or cross listed with ECE, CS, or EPD.
3) INTEREGR 160 (Introduction to Engineering)

Required courses in Math/Science (e.g. Physics 201) may **not** be applied toward General Science, since credits can never be double-counted.

[†] If you take Math 375, 2 credits will be applied to General Science.

Area Math/Science Recommendations: The following table lists Math/Science course recommendations by area of specialization. Courses should be selected carefully, since some are prerequisite for advanced electives. Entries are ranked as either (1) strongly recommended, (2) recommended, or (3) useful. Additional information is available from advisors in each area.

Area	Probability/Statistics	General Science
Electrical Engineering Applications	(1) Stat 311	(1) Math 319, 340‡
Electronic Design Automation	(1) Stat 311	(1) Math 319, 340[1]
Embedded Systems Design	(1) ECE 331 (2) Math 431	(1) Math 320[1] (3) INTEREGR 160
Networking and Communications	(1) ECE 331	(1) Math 319, 340[1]
VLSI Systems Design	(1) Stat 311	(1) Math 320[1] (2) Physics 244 (3) INTEREGR 160

2.2 LIBERAL STUDIES REQUIREMENT

Choose Liberal Studies courses to bring the total number of credits in this category to at least 15. To be admissible, a course **must** be classified as either Humanities, Social Science, Literature (i.e. identified by the letters **H**, **L**, **S**, or **Z** in the "**B**" column of the ***Timetable***), or Foreign Language. The courses **must** also satisfy the following conditions:

1) At least two courses must be from the same department or program.
2) At least one course in 1) must be above the elementary level (i.e. identified by the letters **I**, **A**, or **D** in the "**L**" column of the *Timetable*).
3) At least six credits must be classified as Humanities (**H**, **L**, or **Z**) or Foreign Language.
4) At least three credits must be classified as Social Science (**S** or **Z**).
5) At least three credits must be classified as Ethnic Studies (i.e. identified by the letter **e** in the "**e**" column of the *Timetable*).
6) At **most** three credits from courses cross listed with the School of Business may be applied to Liberal Studies.

Foreign language departments sometimes award "retro credits" for successful completion of a higher-level course. Retro credits do not count toward 3), nor do they count toward the total of 16 required Liberal Studies credits. However, they do count toward 1).

2.3 CMPE CORE REQUIREMENT

All CMPE students **must** take each of the following courses:

Classroom Course	Credits
ECE 220 (Electrodynamics I)	3
ECE 230 (Circuit Analysis)	4
ECE 321 (Transmission Lines for Digital Applications)[§]	1
ECE 330 (Signals and Systems)	3
ECE 340 (Electronic Circuits I)	3
ECE/CS 352 (Digital System Fundamentals)	4
ECE 353 (Introduction to Microprocessor Systems)	3
ECE/CS 354 (Machine Organization and Programming)	4
ECE 551 (Digital System Design and Synthesis)	3
ECE/CS 552 (Introduction to Computer Architecture)	3
Total	**31**

Laboratory	Credits
ECE 170 (Introductory Laboratory)	1
ECE 270 (Circuits Laboratory I)	1
ECE 351 (Digital Logic Laboratory)	1
Total	**3**

2.4 CMPE ADVANCED ELECTIVE REQUIREMENT

Select courses from the following categories, for a total of at least **25** credits. At least **15** credits **must** be taken in residence at UW-Madison.

Electronic Circuits Elective: Choose either ECE 342 or ECE 555.

Design Laboratory Elective: Choose either ECE 453, ECE 468, or ECE 554.

Mini-Laboratory Elective: Choose either ECE 271, ECE 438, or one course from ECE 301-317.

System Software Elective: Choose either CS 536, CS 537, or CS 564.

Additional Advanced Electives: Choose courses to bring the total number of Advanced Elective credits to 25. These **must** be either ECE courses numbered 320-699 or CS courses numbered 400-640 or 699. The courses you choose **must satisfy** the following conditions:

1) At least 6 credits **must** be in ECE courses numbered 400 and above.
2) ECE 376 and ECE 377 may **not** be used.

[§] ECE 320 may be taken in place of ECE 321; the excess 2 credits of ECE 320 are then used toward Additional Advanced Electives. (See Section 2.4.) If both ECE 320 and ECE 321 are taken, only 2 credits in ECE 320 may be applied toward your degree.

3) If both ECE 320 and ECE 321 are taken, only 2 credits of ECE 320 may be applied toward your degree.
4) If your cumulative GPA is at least 2.5, you may register for ECE 399 (**Independent Study**), ECE 699 (**Advanced Independent Study**), or CS 699 (**Directed Study**) and apply up to 3 credits toward the requirement. (You must submit an Application for Independent Study Credit, available on the shelves outside Room 2413 EH, **prior to the semester in which the course is taken**.)
5) If your cumulative GPA is at least 3.5, you may register for ECE 489 (**Honors in Research**) and apply up to 6 credits toward the requirement. (You must submit an Application for Independent Study Credit, available on the shelves outside Room 2413 EH, **prior to the semester in which the course is taken**.)
6) If your cumulative GPA is at least 2.5, you may register for ECE 491 and apply 3 credits toward the requirement. (You must submit an Application for Independent Study Credit, available on the shelves outside Room 2413 EH, **prior to the semester in which the course is taken**.)
7) You may use one degree credit of ECE 001 (**Cooperative Education Program**).
8) You may apply other courses to this category only with the approval of your advisor. These courses must have a clear pertinence to your selection of advanced courses in ECE.

Selection of **CMPE Advanced Electives** is a matter of major importance; it should be done in consultation with your advisor. Since not all advanced courses are offered every semester, you are advised to plan ahead and to begin taking some of these courses prior to your final year. For a schedule of advanced courses, see the handout "**ECE Department *Tentative* Course Offerings**", available on the shelves outside Room 2413 EH.

By the deadline corresponding to your graduation date, you must submit a **CMPE Advanced Elective Approval form**, signed by your advisor, to the Student Status Examiner in Room 2413 EH. (See rule 9 in Section 1.13 of this booklet.) **You will not be permitted to register for your final semester of coursework until you have submitted this form.**

Area Advanced Elective Recommendations: The following table lists CMPE Advanced Elective course recommendations by area of specialization. Courses should be selected carefully, since some are prerequisite for other advanced electives. Entries are ranked as either (1) strongly recommended, (2) recommended, or (3) useful. Additional information is available from advisors in each area.

Area	Electronic Circuits	System Software	Design Lab	Mini-Lab	Additional
Electrical Engineering Applications	No recommendation	(1) CS 536	(1) ECE 453	(1) ECE 315	(1) CS 412, 577
			(2) ECE 468		(2) ECE 420, 431, 438, 447, 533, 543 CS 559
					(3) ECE 447
Electronic Design Automation	(1) ECE 555	(1) CS 536	(1) ECE 554	(1) ECE 315	(1) ECE 553, 556 CS 412, 577
					(2) CS 525
					(3) CS 425
Embedded Systems Design	(1) ECE 342	(1) CS 537	(1) ECE 453	(1) ECE 315	(1) ECE 332, 334, 409, 431
			(2) ECE 468		(2) ECE 417, 438
					(3) ECE 463, 553
Networking and Communications	(1) ECE 555	(1) CS 537	(1) ECE 453	(1) ECE 315	(1) ECE 437, 438, 537
			(2) ECE 554		(2) ECE 431 CS 640
					(3) ECE 436, 447
VLSI Systems Design	(1) ECE 555	(1) CS 537	(1) ECE 554	(1) ECE 315	(1) ECE 431, 553
					(2) ECE 335, 541, 556
					(3) ECE 437

2.5 COMMUNICATION SKILLS REQUIREMENT

Professional Expression: ECE 350 (Professional Expression)

Communication Part A: Choose one course from the following list:

1) COM ARTS 100 Introduction to Speech Composition (3 cr.)
2) ENGLISH 100 Freshman Composition (3 cr.)
3) ENGLISH 118 English as a Second Language: Academic Writing II (3 cr.)
4) EPD 155 Basic Communication (2 cr.)
5) L SC COM 100 Introduction to Communication: Inquiry and Exposition (3 cr.)

Students are expected to satisfy the Communications Part A requirement by the end of their first year. The excess credit in courses 1), 2), 3), and 5) may be applied toward the Liberal Studies requirement. (See Section 2.2.)

Exemption: Students may be exempted from the Communications Part A requirement by approved college coursework while in high school, AP test scores, or placement testing. Exempted students may take two credits of free electives any time prior to graduation and substitute them for the Communications Part A requirement. Exemption **does not** reduce the total 120-credit requirement for the BSCMPE degree.

2.6 CURRICULUM CHECKLIST

Course requirements for the BSCMPE degree are summarized in the following table. Note that this information complements both the flow chart on page 1 and your DARS report. You should fill in the table at the end of each semester or session and bring it with you whenever you see your advisor.

Math/Science	Credits	Grade
Math 221	5	
Math 222	5	
Math 234	3	
Math 240/475	3	
CS 302	3	
CS 367	3	
Physics 201	5	
Physics 202	5	
Probability/Statistics	3	
General Science		
Subtotal	41	

Liberal Studies	Credits	Grade
Ethnic Studies		
Subtotal	15	

Communication Skills	Credits	Grade
ECE 350	3	
	2	
Subtotal	5	

Total Credits: 120

CMPE Core	Credits	Grade
ECE 170	1	
ECE 220	3	
ECE 230	4	
ECE 270	1	
ECE 321	1	
ECE 330	3	
ECE 340	3	
ECE 351	1	
ECE/CS 352	4	
ECE 353	3	
ECE/CS 354	4	
ECE 551	3	
ECE/CS 552	3	
Subtotal	34	

CMPE Advanced Electives	Credits	Grade
ECE 342/555	3	
ECE 453/468/554	4	
ECE 271/438/301-317	1	
CS 536/537/564	3-4	
Subtotal	25	

2.7 AN EIGHT-SEMESTER PLAN[**]

The following table describes one possible plan for graduation with a BSCMPE degree in eight semesters.

FRESHMAN I	Credits	**FRESHMAN II**	Credits
Math 221	5	Math 222	5
CS 302	3	Math 240	3
General Science	3	Physics 201	5
Comm. Skills	2	Liberal Studies	3
Liberal Studies	3		16
	16		

SOPHOMORE I	Credits	**SOPHOMORE II**	
Math 234	3	ECE 220	3
Physics 202	5	ECE 230	4
ECE 170	1	ECE 351	1
ECE/CS 352	4	ECE/CS 354	4
CS 367	3	Liberal Studies	3
	16		15

JUNIOR I		**JUNIOR II**	
ECE 270	1	ECE 551	3
ECE 321	1	ECE 552	3
ECE 330	3	CMPE Advanced Elect.	3
ECE 340	3	CMPE Advanced Elect.	3
ECE 353	3	Probability/Statistics	3
Liberal Studies	3		15
	14		

SENIOR I		**SENIOR II**	
Electronic Circuits Elect.	3	System Software Elect.	4
Design Laboratory Elect.	4	CMPE Advanced Elect.	3
Mini-Laboratory Elect.	1	CMPE Advanced Elect.	4
General Science	3	ECE 350	3
Liberal Studies	3		14
	14		

[**] Some CMPE Advanced Electives are not offered every semester; therefore, this plan may require modification in the last three semesters. See the handout "ECE Department *Tentative* Course Offerings", available on the information shelves outside Room 2413 EH.

3. AVENUES FOR FEEDBACK ON THE CURRICULUM

The ECE faculty governs the undergraduate curriculum. Authority to approve substitutions within the guidelines of this booklet is granted to those faculty designated as advisors. More general substitution authority is given to the Associate Chair for Undergraduate Activities. In addition, the ECE Undergraduate Curriculum and Planning Committee is charged with advising the faculty on curriculum matters and recommending possible changes to the faculty. Students' comments on the undergraduate curriculum, including the manner in which courses are taught, are welcome and should be submitted either by a visit or by letter to the Associate Chair. Feedback from groups of students can be particularly valuable to the committee. The Associate Chair may periodically ask various student organizations (e.g. IEEE and Eta Kappa Nu) for comments, suggestions, and criticisms on the undergraduate curriculum.

4. AREAS OF SPECIALIZATION IN COMPUTER ENGINEERING

The CMPE curriculum provides broad elective opportunities for students to specialize in one or more areas of particular interest. Students should begin to plan the area or areas they would like to pursue at least two years prior to graduation.

Brief descriptions of the general areas within CMPE are given below. Faculty in each area and references for introductory reading are also included.

Electrical Engineering Applications

Faculty: Hagness, Hitchon

Electrical Engineering Applications deals with the design of software used by electrical engineers to perform analysis and design, particularly software for modeling physical devices and processes and visualizing the modeling results. In addition, it may include software design for other areas that are computationally intensive. This specialization is particularly useful for students interested in a graduate degree in Computational Sciences.

Electronic Design Automation

Faculty: Chen, Hu, Saluja

Electronic Design Automation (EDA) deals with the design of software used by computer and electrical engineers to perform hardware and software design and associated analysis. Examples of EDA tools you might have used are Mentor Graphics Design Architect and Quicksim and PSpice. To work in EDA, the student needs to know the underlying hardware as well as the techniques required to design the EDA software. Students in this area typically go to work for companies such at Mentor Graphics, Synopsys, or Cadence as well as many computer and semiconductor companies that have their own internal EDA departments.

Embedded Systems Design

Faculty: Ramanathan

Computers are becoming ubiquitous in society today. Everyone is familiar with the concept of the personal computer, and engineering students are likely to have encountered powerful workstations as well. These obvious "computers," however, are far outweighed by the billions of computer per year that are part of other systems ranging from TV remote controls to automobiles and large passenger aircraft and industrial assembly lines. The embedded systems area deals with the design of systems that contain computer hardware and software as a part of the system. Instead of designing computer chips and computers, graduates in this area use computer chips and other hardware and write software to implement the applications for the system being designed. Graduates in this area have a wide-range of opportunities across the spectrum from very large to very small companies.

Networks and Communications

Faculty: Ramanathan, Sayeed

Because of the explosive growth of the Internet and the transition from analog to digital electronic technologies, we are experiencing an information revolution. In dealing with both hardware and software, the networks and communications engineer has a central role in this exciting revolution with its broad impact on how we do things. The roles of the network and communications engineer include the design of networking hardware and software, setting up and managing major networking installations, and interfacing networking hardware and software to other products. Graduates in this area may work for companies manufacturing network gear or establishing large networking operations including those involving wireless communication.

VLSI Systems Design

Faculty: Chen, Hu, Lipasti, Ramanathan, Saluja, Smith

Due to the growth of the computer and communication industries, there is a significant demand for digital designers. VLSI (Very Large-Scale Integrated) Systems design deals with this design of integrated circuit chips, boards that include these chips and systems that use the boards. In addition, as the complexity of integrated circuit chips increases, analog hardware often accompanies the digital hardware on a chip. As a consequence, analog design and mixed signal design are also potential components of this area. A graduate in this area will typically work for a semiconductor company, a computer company, or any company that designs and/or manufactures chips and systems.

5. HONORS PROGRAMS IN COMPUTER ENGINEERING

There are two undergraduate honors programs available to CMPE students, Engineering Honors in the Liberals Arts (**EHLA**) and Honors in Research. A student who completes either program receives an Honors designation on his or her transcript and diploma.

In the EHLA program, undergraduates take honors courses in the College of Letters and Science. Such courses count towards the Liberal Studies requirement for the BSCMPE. Further information on the EHLA program is available at (**http://studentservices.engr.wisc.edu/classes/ehla.html**) or in Room 2640 Engineering Hall.

Honors in Research

Objectives and Goals of the Program: The Honors in Research program gives an undergraduate the opportunity to participate in a research project under the direction of a faculty member. It is expected that the student will be actively involved in research that could lead to new knowledge. The project can be independent or a component of a larger team effort. The research culminates in a senior thesis that the student presents in an Honors Seminar.

Admission Requirements: In order to be admitted to the **Honors in Research** program, a student **must**

1) complete at least one semester on the UW-Madison campus
2) have a cumulative GPA of at least 3.5
3) major in Computer Engineering
4) identify an ECE faculty advisor who is willing to supervise the research project

Admission Process: The student should submit a letter to the ECE Department in Room 2413 EH requesting admission to the Honors in Research program. The letter should identify the faculty advisor for the project and the topic under investigation. A one-page summary of the research project should be attached. The student should also submit a supporting letter from the faculty advisor. The ECE Curriculum Committee will review applications and make admission recommendations.

Academic Credit: Students admitted to the program should register for one to three credits of ECE 489 (**Honors in Research**) and submit a completed Application for Independent Study Credit to the Student Status Examiner in Room 3539. A letter grade will be assigned each semester. If the project will extend into the next semester, a grade of P (Progress) is given. A final letter grade (A-F) is assigned after the senior thesis is submitted and reviewed by the faculty advisor, or if the student formally withdraws from the program. Previous grades of P are eventually replaced by the final grade. Up to six credits of ECE 489 may count as CMPE Advanced Electives.

Senior Thesis: A senior thesis worth three credits of ECE 489 **is required**. The thesis is a written document that details the objectives of the project, the methods used to carry out the research, and the results of the research activity. The thesis must be approved by the faculty advisor and presented at an Honors Seminar.

Honors Designation: The designation "**Honors in Research**" will be awarded to Computer Engineering graduates who:

1) satisfactorily complete the requirements of a BSCMPE degree
2) have a cumulative GPA of at least 3.3 upon graduation
3) complete a total of at least eight credits of ECE 489
4) receive a final grade of at least B in ECE 489

6. INTRODUCTION TO ENGINEERING

The College of Engineering puts considerable resources into first-year opportunities for students to explore engineering to ensure that it is a good fit for them. Research has shown that new students who take part in an "introduction to engineering" experience are more likely to graduate with an engineering degree than those that do not. Several such opportunities exist. In each case, credits earned can be applied to the BSCMPE degree. Although participation in these courses is not mandatory, it is strongly encouraged.

EPD 101: This 1-credit class may be applied to the Liberal Studies requirement. It helps incoming students learn about the breadth of engineering opportunities and the differences between the disciplines at the undergraduate level. The class features lectures by practicing engineers and opportunities for developing team skills.

EPD 160: This 3-credit class (with lab) may be applied to the General Science requirement. It gives new students a chance to learn about engineering through a hands-on design experience. Freshmen work in teams to create designs to solve real problems for which Madison-area clients are seeking a solution.

EPICS: EPICS stands for **Engineering Projects in Community Service**. It is an innovative program based in the College of Engineering that places teams of undergraduate and graduate engineering students, as well as students from other disciplines, into a partnership with local community service agencies. Each team works to design and develop long-term engineering projects that meet identified agency needs. ECE students may take EPICS for Advanced Elective credit as ECE 399. More information is available at (**http://epics.engr.wisc.edu/**)**.**

Research Seminars: To take advantage of UW-Madison's research reputation, new students can sign up for a one-credit freshman seminar led by an engineering professor. Topics vary by semester and are chosen to help new students understand engineering opportunities by focusing on a particular research area. More information is available (**http://studentservices.engr.wisc.edu/research/research.html**) or in Room 2640 EH.

7. CERTIFICATE PROGRAMS

7.1 The Technical Communication Certificate

The Department of Engineering Professional Development in the College of Engineering offers a program of study culminating in the **Technical Communication Certificate** (**TCC**). The program was formed to help meet the need for skilled technical communicators in engineering and other technical fields. The TCC program requires completion of 24 credits of electives that complement the BSCMPE

degree and its requirements. Students who complete the program receive a certificate and the notation "Technical Communication Certificate" on their transcripts. For specific requirements, see the TCC website at (**http://tc.engr.wisc.edu/tcweb/certificate/**). Students who wish to pursue the TCC should consult with an EPD advisor early in their college careers.

Courses may be chosen which meet the requirements of the TCC program and which can simultaneously be applied to the Math/Science, Liberal Studies, and Communication Skills requirements for the BSCMPE degree. Furthermore, if you are pursuing the TCC, you may substitute EPD 397 for ECE 350.

7.2 The Certificate in Japanese Studies for Engineering Majors

The Certificate in Japanese Studies for Engineering Majors is a 27-credit program designed to help undergraduate engineering students gain conversational and written skills in colloquial Japanese, reading and translation skills in technical Japanese, and an understanding of Japanese culture.

Japanese has become an important language in engineering and business. Increasing numbers of American companies are doing business in Japan, and many Japanese companies are expanding their activities in the United States. These companies need engineers who can read and communicate in both English and Japanese. The Certificate in Japanese Studies addresses this need.

The certificate requires two semesters of introductory Japanese, two semesters of intermediate-level technical Japanese, and three additional courses related to Japanese language or culture. Interested students should begin taking Japanese courses in their first year. For more information, contact Professor James L. Davis, Room M1056D Engineering Centers Building (262-4810), or visit the website (**http://www.engr.wisc.edu/epd/tjc/undergrad.html**).

7.3 Other Certificates

Engineering undergraduate students may enroll in certificates offered outside the College of Engineering. The many certificates available at UW-Madison include those in:

Business (**http://www.bus.wisc.edu/undergrad/certificate**)

Criminal Justice (**http://www.wisc.edu/pubs/ug/10lettsci/depts/crimjust.html**)

Environmental Studies (**http://www.ies.wisc.edu/cert/**).

8. ADDITIONAL LETTERS AND SCIENCE MAJOR

The **College of Letters and Science** (**L&S**) offers the possibility of earning a second major in L&S while studying for the BSCMPE degree. Requirements for an L&S major are described in the *Undergraduate Catalog* for most departments in L&S. Upon graduation, the additional major is noted on the student's transcript. For further information visit (**http://www.ls.wisc.edu/**).

The Office of Academic Student Affairs and the Registrar's Office have agreed upon the following rules:

1) The student **must** obtain advance approval from both the major L&S department and the College of Engineering. This is accomplished by requesting a Declaration of Major form from the L&S department and submitting it to the College of Engineering.

2) The student **must** satisfy all requirements of the L&S major, including those established by the department (e.g. required course work) and those established by the College of Letters and Science (e.g. 15 credits minimum of advanced work in the major while in residence at UW-Madison).
3) The appropriate L&S dean **must** approve all course substitutions and other modifications of L&S major requirements.
4) Students **must complete the L&S major no later than the semester of graduation with the BSCMPE degree**. Students who have finished all BSCMPE requirements may delay graduation by one semester in order to finish the L&S degree. In this case, the student **must petition the ECE Department** to delay graduation. If no petition is received, the student will graduate with a BSCMPE and will **not** be permitted to finish the L&S major. During the student's final semester, all College of Engineering regulations continue to apply.

9. PREPARATION FOR A GRADUATE DEGREE IN BUSINESS

Students sometimes wish to pursue graduate degrees in Business after completing the BSCMPE degree. If you think that you may eventually be interested in pursuing this goal, you should seek advice now on how to design your CMPE curriculum in preparation for graduate study. Advisors in the UW School of Business can help you choose courses for that purpose. As a starting point, see the UW School of Business website at (**http://www.bus.wisc.edu/graduateprograms**)**.**

10. PROFESSIONAL ENGINEER REGISTRATION

States require licensing of those engineers who engage in professional activities that may affect public health and safety. To be licensed, an engineer must earn the designation **Professional Engineer (PE**). While an "industrial exemption" covers those who are employed by industry, many engineers working for companies that deal with health and safety issues (e.g. utilities companies) find it advantageous to be registered as PE's. The PE designation is particularly important for those engineers serving as consultants or technical witnesses in court, where matters of public safety are an issue. Information concerning the advantages of registration can be obtained from the **National Society of Professional Engineers (NSPE).** (See **http://www.nspe.org**).

Registration standards are set and governed by each state individually. In Wisconsin, this is handled by the **Bureau of Business and Design Professions**. (See **http://drl.wi.gov/boards/eng/index.htm**). The Examining Board in Wisconsin uses exams from the **National Council of Engineering Examiners (NCEE)**. (See **http://www.ncees.org/**). Almost all states accept registrants from other states in recognition of the standardized national exams.

The first step toward registration is to apply to take the **Fundamentals of Engineering (FE) exam**. The Engineering Career Services office, 1150 EH; (See **http://ecs.engr.wisc.edu/student/home.html**) can supply you with application and information request forms. The exam should be taken in your senior year or as soon after graduation as possible. A candidate failing the exam may re-apply.

Satisfactory completion of the Fundamentals of Engineering exam and graduation with a BS is Engineering (or equivalent) earns the applicant the **Engineer-in-Training (EIT) certification**. After four years of training and practical experience, the Engineer-in-Training is eligible to take the **Principles and Practice of Engineering exam** (and a short exam on Barrier Free Design). Passing these exams then qualifies the applicant for registration as a PE.

The NCEE Fundamentals of Engineering exam consists of multiple-choice questions in Mathematics, Computer Programming, Modern Physics, Chemistry, Statics, Dynamics, Mechanics of Materials, Fluid Mechanics, Thermodynamics, Electrical Theory, Materials Science, and Economic Analysis. It is not expected that every applicant will be knowledgeable in all areas; however, an adequate breadth and mastery of the material is needed in order to pass the exam.

The NCEE Principles and Practice of Engineering exam consists of problem-solving questions in the appropriate disciplines (e.g. civil, mechanical, and electrical engineering and economics). Information booklets and sample exam questions can be ordered from the NCEE.

PE registration is not mandatory for every engineering position. In fact, most electrical and computer engineering graduates go to work for private industry, government, or other employers without taking any of the steps toward registration. However**, if registration is important in the type of engineering work in which you wish to be engaged, it is wise to carefully choose the engineering electives in your program so that you will not have difficulty passing the exams**. If you are not certain whether you will need registration later, you may wish to take the appropriate steps now rather than studying for the exams 10 years from now!

11. USEFUL WEB SITES AND EMAIL ADDRESSES

College of Engineering UW Madison: **http://www.engr.wisc.edu/**

Computer-Aided Engineering Center: **http://www.cae.wisc.edu/**

Engineering Co-op and Intern Program: **http://www.engr.wisc.edu/services/ecs/**

Kurt F. Wendt Library: **http://www.wisc.edu/wendt/**

Polygon (a student organization): **http://www.cae.wisc.edu/~polygon/**

Schoofs Prize for Creativity: **http://www.engr.wisc.edu/students/brainstorm/**

Steuber Prize for Excellence in Writing: **http://tc.engr.wisc.edu/steuber/**

UW-Madison Undergraduate Catalog: **http://www.wisc.edu/pubs/ug/**

UW Student Job Center, **http://financial-aid.acadsvcs.wisc.edu/finaid/cat.html**

UW Undergraduate Guidebook: **http://www.wisc.edu/pubs/ug/**

COE Information Place (lost and found, hourly jobs, etc.): **infplace@coeadm.engr.wisc.edu**

Engineering Expo: **expo@cae.wisc.edu**

Engineering Student Services Office, Room 2640 EH: **egradvisor@engr.wisc.edu**

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http://www.engr.wisc.edu/ece/
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12. ECE PAGES FROM THE UNDERGRADUATE CATALOG

This section is excerpted from the University of Wisconsin — Madison ***Undergraduate Catalog*** (**http://www.wisc.edu/pubs/ug**).published by the Office of University Publications (University Communications), 528 WARF Building, 610 Walnut Street, Madison, WI 53705-2397, April 2001.

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Professors Ramanathan (chair), Anderson, Bach (see also Computer Sciences), Barmish, Booske, Botez, Bucklew, Cerrina, DeMarco, Dobson, Goodman (also Computer Sciences), Hill (also Computer Sciences), Hitchon, Hu, Jahns, Lipo, Lorenz (also Mechanical Engineering), McCaughan, Saluja, Scharer, Sethares, Shohet, Smith, Sohi (also Computer Sciences), Tompkins (also Biomedical Engineering), van der Weide, Van Veen, Wendt, Wiley (Chancellor), Wood (also Computer Sciences); Associate Professors Blick, Cobb, Gubner, Hagness, Mawst, Milenkovic, Nowack, Sayeed, Venkataramanan; Assistant Professors Banerjee, Chen, Compton, Jiang, Knezevic, Kursun, Lipasti, Ma, Megerian, Muetze, Schulte, and Shkel.

The Department of Electrical and Computer Engineering offers the B.S., M.S. and Ph.D. degrees in **Electrical Engineering** and the B.S. degree in **Computer Engineering**.

Electrical engineers design, develop, analyze, research and manufacture electrical and electronic systems and their component parts. Examples of such systems include those for power generation and power distribution, communication, control and instrumentation. Computers and digital circuits are important integral parts of such systems today, and are widely used by the electrical engineers as parts of the systems they design. With our continuing dependence on the evolution of electrical power and on the revolutionary advancement of wired and wireless communication and computation, the electrical engineer has a vital role in shaping our lives.

The electrical engineer is also concerned with the devices that make up these systems, such as transistors, integrated circuits, rotating machines, antennas and fusion plasma confinement devices. Of most significance today are solid-state devices, whether in the form of compact, low-power, reliable integrated circuits or high-power transistors for switching large currents in power systems. Dramatic improvements in integrated circuits have driven the revolution in communications and computation, and high-power transistors in combination with electronic controls are serving as the foundation for new ways of efficiently utilizing electrical power. Electrical engineers are heavily involved in the design and development of integrated circuits and power electronic devices, as well as their application to solving present and future problems.

Computer engineers design, develop, analyze, research and manufacture hardware, software and systems that process, store and convey digital information. These systems include personal computers, workstations, mainframe computers and embedded digital systems. Embedded systems consist of one to many computers within other products such as aircraft, automobiles, communication switching systems and networking components, biomedical instrumentation and industrial automation systems. These systems are characterized by the use of digital electronic hardware and of software in performing useful tasks. Computer software in combination with digital integrated circuits provides the foundation for the

current revolution in computers and communications. This focus on software and digital hardware distinguishes the computer engineer from the electrical engineer.

The curricula in the Department of Electrical and Computer Engineering require a strong background in mathematics, physics and computer sciences. In addition to basic course requirements in these areas, elective credits in the curriculum permit the student to pursue more advanced courses in these areas or in other fields, such as chemistry, biology and mechanics. Additional electives in liberal studies broaden the programs to include such areas as economics, sociology, psychology and history.

The electrical engineering and computer engineering programs share many courses in the sophomore year including digital systems, electrical circuits and electromagnetic fields. Computer engineering students take additional courses in computer sciences to provide the software part of their background. In the subsequent semesters, the electrical engineering and computer engineering programs share the study of solid state devices, signals and systems. In the junior year, the electrical engineering program focuses on areas such as electromagnetic fields and analog electronics whereas computer engineering deals with computer hardware design and combined hardware/software design concepts. Technical elective freedom in both curricula makes it possible for the student to choose from approximately 50 more specialized courses at the junior and senior levels in electrical and computer engineering, as well as courses from other departments. In both curricula, a student can choose a broad program covering an introductory treatment of a variety of areas or focus in one or two specialized areas. In electrical engineering, nine specialized areas are available for in-depth study. In computer engineering, five specialized areas are provided. An advising program, beginning in the freshman year, helps students plan their program.

To provide students with hands-on experience in electrical and computer engineering, specialized lab courses are offered at the senior level. For example, one involves the design and fabrication of integrated circuits and another the design and prototyping of a computer. Both classroom instruction and lab work are offered in the analysis and design of control systems and also in embedded systems, with microprocessors and personal computers incorporated into larger systems. Independent study and design projects are encouraged at the senior level and an honors research program is available which spans multiple years of the undergraduate program.

Although the B.S. in Electrical Engineering and B.S. in Computer Engineering programs are intended to prepare students for immediate entry into the profession of engineering, increasingly, students find an additional year or more of study leading to the M.S. degree very desirable. The Ph.D. degree is the most advanced degree and emphasizes training in research.

Additional Departmental Regulations

Graduation review. All seniors are required to report to the department office one semester prior to the one in which they expect to graduate for a review of remaining graduation requirements.

Pass/fail. Only **two** courses taken on a pass/fail basis may be counted toward a degree in the ECE Department. These **must** be in liberal studies.

Liberal studies. Students may **not** count courses that are cross-listed with Business, Education, or the College of Agricultural and Life Sciences. Retro credits for foreign language courses do not count toward the 16-credit liberal studies requirement, but they may be used to help satisfy the 6-credit depth requirement if one course is taken at university level.

Honors programs. There are **two** undergraduate honors programs in ECE: Honors in **Research** and Honors in **Liberals Studies**. Students who complete either program receive an Honors designation on the transcript and diploma. In the Honors in Research program, undergraduates participate in research projects under the direction of faculty members. The research activities culminate in a senior thesis. In the Honors in Liberal Studies, undergraduates take honors courses in the College of Letters and Science. The honors courses may count towards the required credits in the Liberal Studies requirement. Admission requirements can be obtained from the ECE Department Office, Room 2420 EH.

Facilities

Facilities available for instruction and research include:

Automatic Control Laboratory
CAE (Computer-Aided Engineering) and ECE Laboratory
Computers
Center for Plasma Theory and Computation
Core ECE Labs
Digital Engineering Lab
Electromagnetic Materials Processing Laboratory
Electronics Lab
Embedded Systems Lab
Excimer Laser and Radiofrequency Source Laboratory
Fiber Optics and Opto-electronics Lab
Grainger Electric Machines and Power Lab
High-Frequency Engineering Lab
High-Power Microwave Mode Conversion and Transmission Lab
HSX Plasma Laboratory
Medical Instrumentation Lab
Microwave Scanner Laboratory
Photonics Lab
Plasma Processing & Technology Laboratory
Power Electronics Lab
Radiofrequency Plasma Source Laboratory
Signal Processing Lab
Vacuum Electronic Devices Lab

Courses

001 Cooperative Education Program. I, II, SS; 1 cr. Work experience which combines classroom theory with practical knowledge of operations to provide students with a background upon which to base a professional career. P: So st.

170 Introductory Laboratory. I, II, SS; 1 cr (P-E). This lab provides students with hands-on experiences in using laboratory instrumentation such as oscilloscopes and various meters. It also provides basic safety information on using various electrical equipment. P: Con reg in Physics 202.

220 Electrodynamics I. I, II; 3 cr (P-E). Vector analysis; potential theory; static and dynamic electric and magnetic fields; macroscopic theory of dielectric and magnetic materials; Maxwell's equations; boundary conditions. P: Physics 202, Math 234; ECE 230 or con reg.

230 Circuit Analysis. I, II; 4 cr (P-E). Kirchhoff's laws, resistive circuits, equivalent circuits using Thevenin-Norton theories, small signal analysis, dc operating point, first-order circuits, second-order circuits, Spice and circuit simulation methods, sinusoidal steady state, phasors, poles and zeros of network functions, ideal transformed linear and non-linear two-port networks. P: Math 222, Physics 202.

270 Circuits Laboratory I. I, II, SS; 1 cr. Experiments cover Kirchhoff's laws, inductors, basic operational amplifier circuits, and frequency response. P: ECE 170; ECE 230 or con reg.

271 Circuits Laboratory II. I, II, SS; 1 cr. Experiments cover electronic device characteristics, limitations and applications of operational amplifiers, and feedback circuits. P: ECE 270; ECE 340 or con reg.

301 Transmission Lines and Networks Laboratory. I, II; 1 cr. Experiments demonstrating the principles of lumped and distributed transmission lines for transient and sinusoidal excitation. Standing wave patterns, impedance matching, and characteristics of microwave devices. P: ECE 271; ECE 420 or con reg.

304 Electric Machines Laboratory. II; 1 cr. Terminal characteristics of electric machines, elements of speed control, voltage regulation, and applications in systems. Emphasis on the experimental approach to the solution of complex physical problems. P: ECE 271; ECE 355 or con reg.

305 Semiconductor Properties Laboratory. I, II; 1 cr. Introduction to some fundamental properties of semiconductor materials and devices through the use of characterization techniques common in modern electronic industry. These concepts include: charge carriers; energy bands; space charge regions; carrier drift, diffusion and recombination; light emission; and lattice vibrations. P: ECE 271; ECE 335 or con reg.

306 Linear Active Circuits Laboratory. I, II; 1 cr. Direct coupled and operational amplifier characteristics; applications of feedback; practical aspects. P: ECE 271; ECE 342 or con reg.

308 Nonlinear Electronic Circuits Laboratory. I, II; 1 cr. An experimental study of selected nonlinear electronic circuits and devices using diodes, transistors, op-amps, timers, data converters, and logic components. P: ECE 271; ECE 342 or con reg.

310 Plasma Laboratory. Irr.; 1 cr. Vacuum systems, thermocouple and ionization gauges, plasma production by AC, DC and rf. Measurement of plasma density and temperature. Introduction to engineering problems of controlled fusion. Demonstrations and field trips to plasma experiments on the Madison campus. P: ECE 271; ECE 320 or cons inst.

312 Biomedical Engineering Laboratory. II; 1 cr. Application of engineering principles to problems in medicine and biology. Six experiments on biomedical instrumentation, prosthetic devices, measurement of physiological data and modeling of physiological systems. P: ECE 271 or con reg; ECE 340.

313 Optoelectronics Lab. I, II, SS; 1 cr. Light detection using photovoltaic and photoconductive detectors and phototransistors. Light generation using light emitting diodes and laser diodes. Light transmission using optical fibers. Optoisolators and optical switches. Light emitting diode and liquid crystal displays. P: ECE 271; 340; or cons inst.

315 Introductory. Microprocessor Laboratory. I, II, SS; 1 cr (P-I). Software and hardware experiments with a microcomputer system. Assembly language programming, simple input/output interfacing, and interrupt processing in microcomputer systems. P: ECE 351; ECE 353. Con reg in 353 is allowed if 315 is taken second half of semester.

316 Statistical Design and Control Laboratory-Plasma Aided Manufacturing. (Cross listed with Ind Engr, NEEP) Irr.; 1 cr. Students will be introduced to statistical methods for measurement, calibration, data logging, control, experimental design and analysis using plasma-aided manufacturing as the vehicle. P: Cons inst.

317 Sensors Laboratory. I, II; 1 cr. A hands-on introduction to a variety of different sensor types. Labs incorporate implementation concerns involving interference, isolation, linearity, amplification, and grounding. P: ECE 271, ECE 340 or cons inst.

320 Electrodynamics II. I, II; 3 cr (P-I). Static and dynamic electromagnetic fields; forces and work in electromechanical systems; magnetic circuits; plane wave propagation; reflection of plane waves; uniform transmission lines. P: ECE 220; Math 319 or 320 or con reg, or cons inst.

321 Transmission Lines for Digital Applications. I, II; 1 cr. Transmission line equations, transmission line analysis for pulse waveforms, lossless and lossy lines, dielectric properties of common on-chip and off-chip media, reflection diagrams, line termination, line simulation, serial and parallel lines, coupled lines and crosstalk. P: ECE 220. Stdts may not receive credit for both ECE 320 & 321.

330 Signals and Systems. I, II, SS; 3 cr (P-I). Time-domain response and convolution; frequency-domain response using Fourier series, Fourier transform, Laplace transform; discrete Fourier series and transform; sampling; z-transform; relationships between time and frequency descriptions of discrete and continuous signals and systems. P: ECE 230 or equiv.

331 Introduction to Random Signal Analysis and Statistics. I, II; 3 cr. Introduction to probability, random variables, and random processes. Confidence intervals, introduction to experimental design and hypothesis testing. Statistical averages, correlation, and spectral analysis for wide sense stationary processes. Random signals and noise in linear systems. P: ECE 330.

332 Feedback Control Systems. I, II, SS; 3 cr. Modeling of continuous systems; computer-aided solutions to systems problems; feedback control systems; stability, frequency response and transient response using root locus, frequency domain and state variable methods. P: ECE 330.

334 State Space Systems Analysis. II; 3 cr. Analysis of systems using matrix methods to write

and solve state-variable differential equations. Additional topics include stability, controllability, observability, state feedback, observers, and dynamic output feedback. P: Math 320 or 340 or con reg.

335 Microelectronic Devices. I, II; 3 cr (P-E). Characteristics of semiconductors; study of physical mechanisms and circuit modeling of solid state electronic and photonic devices; principles of microelectronic processing and examples of integrated circuits. P: ECE 220 & 230.

340 Electronic Circuits I. I, II, SS; 3 cr (P-I). A first course in modeling, characterization, and application of semiconductor devices and integrated circuits. Development of appropriate models for circuit-level behavior of diodes, bi-polar and field effect transistors, and non-ideal op-amps. Application in analysis and design of linear amplifiers. Frequency domain characterization of transistor circuits. P: ECE 230.

342 Electronic Circuits II. I, II; 3 cr. A second course in modeling and application of semiconductor devices and integrated circuits. Advanced transistor amplifier analysis, including feedback effects. Design for power amplifiers, op-amps, analog filters, oscillators, A/D and D/A converters, and power converters. Introduction to transistor level design of CMOS digital circuits. P: ECE 340.

345 Semiconductor Physics and Devices. II; 3 cr. Band model and carrier transport in semiconductors, excess carriers, p-n junctions, contacts and surfaces, physics of devices including bipolar and field effect transistors, diodes, photo devices, SCR's, thin film structures. P: ECE 335.

350 Professional Expression. I, II, SS; 3 cr (b). Typical communicative problems of the professional engineer; schedules, job specifications, equipment performance specifications, step-by-step directions, presentation of data, professional articles, abstracts, technical proposals, oral presentations; reports. P: Ece Sr with 102 cr or more, satisfaction of comm. skills requirement, & consent of dept.

351 Digital Logic Laboratory. I, II, SS; 1 cr. Logic gate characteristics, combinational logic, latches and flip-flops, synchronous and asynchronous sequential logic, simple systems. P: ECE 170, ECE/Comp Sci 352; ECE 230 or con reg.

352 Digital System Fundamentals. (Cross listed with Comp Sci) I, II, SS; 4 cr (r-P-I). Logic components, Boolean algebra, combinational logic analysis and synthesis, synchronous and asynchronous sequential logic analysis and design, digital subsystems, computer organization and design. P: Comp Sci 302 or equiv.

353 Introduction to Microprocessor Systems. I, II; 3 cr (P-I). Introduction to architecture, operation, and application of microprocessors; microprocessor programming; address decoding; system timing; parallel, serial, and analog I/O; interrupts and direct memory access; interfacing to static and dynamic RAM; microcontrollers. P: ECE 352, Comp Sci 354, ECE 340 or con reg.

354 Machine Organization and Programming. (Cross listed with Comp Sci) I, II; 4 cr (r-N-I). An introduction to computer organization using assembly and machine language. Number representation, computer artithmetic, instruction sets, I/O interrupts, and programming interrupts. Projects involve detailed study and use of a specific computer hardware and software system. P: Comp Sci 302. Open to Fr.

355 Electromechanical Energy Conversion. I, II; 3 cr. Energy storage and conversion, force and emf production, coupled circuit analysis of systems with both electrical and mechanical inputs.

Applications to electric motors and generators and other electromechanical transducers. P: ECE 230, ECE 320.

370 Advanced Laboratory. I, II, SS; 2 cr. Experiments related to the required core material. P: ECE 271, ECE 320, ECE 330, ECE 335, ECE 351.

376 Electrical and Electronic Circuits. I, II, SS; 3 cr. DC and AC electrical circuit analysis methods, and analog and digital circuit design and analysis including operational amplifier linear circuits, digital combinational logic circuits, and computer interface circuits which combine both digital and analog devices for interfacing physical systems. Includes five laboratory sessions. P: Math 222 & Physics 202.

377 Fundamentals of Electrical and Electro-mechanical Power Conversion. I, II; 3 cr. Fundamentals of electromagnetic induction and application to transformers and induction heating; Lorentz forces with a focus on the operation and control of DC and AC motors and linear actuators; electrical power conversion using power electronics for motor drives and direct power converters. Includes five laboratory sessions. P: Math 234, familiarity with ordinary differential equations, Physics 202 & ECE 376.

379 Special Topics in Electrical and Computer Engineering. Irr.; 1-4 cr. Topics of special interest to undergrads in electrical and computer engineering. P: So St and cons inst.

399 Independent Study. I, II, SS; 1-3 cr (A). P: Cons inst.

401 Electro-Acoustical Engineering. Irr.; 3 cr (P-I). Principles of plane and spherical sound waves; acoustical, mechanical, and electrical analogies; electroacoustic transducer materials and techniques; specific types of transducers such as microphones and loudspeakers. P: ECE 330, 340 or cons inst.

409 Introductory Feedback Control Laboratory. (Cross listed with ME) I; 4 cr. Concepts in modern feedback control applied to hardware-based design problems. This lab gives students a wide range of conceptual and hardware experience, rather than focusing on specific applications. Weekly exercises consist of theory, design, simulation, testing, and data analysis. P: ECE 332 or ECE 334 or ME 446 or ME 447.

411 Introduction to Electric Drive Systems. I; 3 cr. Basic concepts of electric drive systems. Emphasis on system analysis and application. Topics include: dc machine control, variable frequency operation of induction and synchronous machines, unbalanced operation, scaling laws, adjustable speed drives, adjustable torque drives, coupled circuit modeling of ac machines. P: ECE 355.

412 Power Electronic Circuits. II; 3 cr. Operating characteristics of power semiconductor devices such as Bipolar Junction Transistors, Igbts, Mosfets and Thyristors. Fundamentals of power converter circuits including dc/dc converters, phase controlled ac/dc rectifiers and dc/ac inverters. Practical issues in the design and operation of converters. Course available on videotape. P: ECE 342 or equiv or cons inst.

415 System Modeling, Identification and Simulation. Irr.; 3 cr (P-I). Principles of mathematical modeling of linear and nonlinear, continuous and discrete systems. Real-time computer-assisted

simulation and identification of engineering systems (electrical, mechanical, hydraulic, acoustic, etc.). Methods of on-line and off-line system identification. Introduction to the behavior of

forced and unforced nonlinear dynamic systems. P: Comp Sci 312 or 412, ECE 330, Math 340.

417 Digital Control. I; 3 cr. Fundamentals of sampled linear systems from a control perspective, encompassing both frequency-domain and time-domain control strategies. Topics covered include analysis of difference equations, the z-transform, sampling, stability, minimality, discrete approximation, and stabilization techniques. P: ECE 334; ECE 332 or con reg.

420 Electromagnetic Wave Transmission. I, II; 3 cr. Transmission lines: frequency domain analysis of radio frequency and microwave transmission circuits including power relations and graphical and computer methods. Electromagnetic waves: planar optical components, pulse dispersion, phase front considerations for optical components, conducting waveguides, dielectric waveguides. Radiation: retarded potentials, elemental dipoles, radiating antenna characterization, receiving mode. P: ECE 320.

427 Electric Power Systems. I; 3 cr. The electric power industry, operation of power systems, load flow, fault calculations, economic dispatch, general technical problems of electric power networks. P: ECE 330 or equiv.

431 Digital Signal Processing. I; 3 cr. Sampling continuous-time signals and reconstruction of continuous-time signals from samples; spectral analysis of signals using the discrete Fourier transform; the fast Fourier transform and fast convolution methods; z-transforms; finite and infinite impulse response filter design techniques; signal flow graphs and introduction to filter implementation. P: ECE 330.

432 Digital Signal Processing Laboratory. Odd yrs.; II; 3 cr. Implementation of digital signal processing algorithms on special-purpose and general-purpose hardware. Use of assembly and high-level languages, and simulator to develop and test IIR, FIR filters and the FFT for modern DSP chips. Scaling for fixed point arithmetic. Use of high level languages to implement real time, object oriented component based DSP systems in general purpose computers. DSP applications, including data and voice communication systems. P: ECE 431, Comp Sci 302.

434 Photonics. II; 3 cr. Introduction to ray optics, physical optics and interference, applications of Fourier optics, absorption, dispersion, and polarization of light. Second half of the course treats light sources, including lasers (gas, solid state, and semiconductor), modulation and detection of light. P: ECE 320, ECE 335 or con reg.

435 Introduction to Cryptography. (Cross listed with Comp Sci, Math) I or II; 3 cr (A). Cryptography is the art and science of transmitting digital information in a secure manner. This course will provide an introduction to its technical aspects. P: Math 320 or 340 or cons inst. Open to Fr.

436 Analog Communication Systems. I, II; 3 cr. Introduction to information transmission using electrical systems. Analog modulation techniques and performance analysis in the presence of noise, including amplitude, angle, pulse, and pulse-code modulation. P: ECE 331.

437 Digital Communication Systems. II; 3 cr. Principles of modern digital information transmission. Binary and M-ary modulation techniques. Optimum receivers and probability of error analysis.

Introduction to spread-spectrum modulation and error control coding. Applications to current communication systems. P: ECE 331; ECE 436 or con reg.

439 Introduction to Robotics. (Cross listed with ME) II; 3 cr. A system engineering approach to robotic science and technology. Fundamentals of manipulators, sensors, actuators, end effectors and product design for automation. Kinematics, control, and programming of manipulators, along with introduction to pattern recognition and computer vision. P: ME 340 or ECE 332 or equiv & familiarity with a high level programming language such as Pascal, C, or Matlab.

440 Electromagnetic Fields and Waves. II; 3 cr. Laplace's and Poisson's equations; conformal mapping and boundary value problems; Maxwell's equations; boundary conditions, plane wave propagation, reflection and refraction at oblique incidence, surface impedance concept; ionized media; anisotropic materials; radiation from antennas. P: ECE 420 or cons inst.

444 Microwave Theory, Devices and Applications. I; 3 cr (P-I). Advanced analysis of waveguides, stripline, and microstrip; microwave circuit and device theory including ferrites, junctions and resonators; high frequency generation and amplification, microwave systems. P: ECE 420.

447 Applied Communications Systems. I; 3 cr. Analysis with design problems of electronic communications circuits. Emphasis on the nonlinear effects of large-signal operation of active devices. Complete design of r.f. oscillator, amplifier, and mixer circuits. P: ECE 340 or cons inst.

453 Digital Microprocessors. II; 4 cr. Lecture and Lab. Microprocessor and microcomputer structures and applications; programming and design of hardware interfaces; emphasis on student projects. P: ECE 315 & 353.

461 Mathematical and Computer Modeling of Physiological Systems. (Crosslisted with Neurophy, BME) II; 3 cr. Mathematical and computer modeling of physiological systems; principal emphasis on cardiovascular system and individual nerve cells; other topics include respiratory system and skeletal-muscle system; extensive use of "hands-on" computer modeling using Acsl. P: ECE 330 or cons inst.

462 Medical Instrumentation. (Crosslisted with BME) I; 3 cr. Design and application of electrodes, biopotential amplifiers, biosensors, therapeutic devices. Medical imaging. Electrical safety. Measurement of ventilation, blood pressure and flow. Lecture and lab. P: ECE 342 or cons inst.

463 Computers in Medicine. (Crosslisted with BME) I; 3 cr. Study of microprocessor-based medical instrumentation. Emphasis on real-time analysis of electrocardiograms. Labs and programming project involve design of biomedical digital signal processing algorithms. P: ECE 330, Comp Sci 302.

466 Electronics of Solids. II; 3 cr (P-I). Electronic, optical and thermal properties of crystalline solids. Energy-momentum dispersion of fundamental particles and excitations in solids leading to microscopic theories of conductivity, polarizability and permeability. Influence of materials characteristics on the performance of electronic and photonic devices. P: ECE 335, 305, or cons inst.

468 Digital Computer Projects in Control and Instrumentation. I or II; 4 cr. On-line and real-time applications of digital computers in instrumentation and control systems; design of hardware interfaces

and software ; emphasis on student projects. P: Comp Sci 302, ECE 271, 332 (or a control crse); or cons inst.

489 Honors in Research. I, II, SS; 1-3 cr. Undergraduate honors research projects supervised by faculty members. Not available for graduate credit. P: Admission to ECE honors in research prgm.

491 Senior Design Project. I, II, SS; 3 cr. Engineering design projects supervised by faculty members. Not available for graduate credit. P: Sr st & cons inst.

504 Electric Machine & Drive System Laboratory. II; 2-3 cr. teady state and dynamic performance of electric machines in combination with power electronic converters. Parameter measurement, performance evaluation, design of experimental procedures for problem solving, use of digital data acquisition systems and signal processing equipment in system evaluation. P: ECE 304 and 411 or con reg 411 and cons inst.

511 Theory and Control of Synchronous Machines. II; 3 cr. The idealized three phase synchronous machine time domain model including saliency, time invariant form using Park's transformation, sudden short circuits and other transient conditions, reduced order models, excitation system and turbine/governor control, dynamics of multiple machine systems, transient stability and sub synchronous resonance. P: ECE 355, ECE 427, or cons inst.

512 Power Electronics Laboratory. I; 3 cr. This laboratory introduces the student to measurement and simulation of important operating characteristics of power electronic circuits and power semiconductor devices. Emphasis is on devices, circuits, gating methods and power quality. P: ECE 412 or con reg.

520 Foundations of Dynamic Physical Systems. I; Odd yrs.; 3 cr (D). Modern descriptions of dynamic physical systems, including classical mechanics, variational dynamics, statistical mechanics and thermodynamics, information theory, quantum mechanics, wave theory, and eigenvalue theory. Emphasis on application to electrical engineering, including circuits, optics, and control problems. A survey intended for engineering and physical science students. (Ph.D. graduate students in Physics will not be granted credit towards an ECE minor requirement as a result of taking this course.). P: ECE 320 & 335 or cons inst.

525 Introduction to Plasmas. (Cross listed with NEEP, Physics) I, II; 3 cr (P-A). Theory of plasmas. Plasma kinetic theory, collisional processes, orbit theory, and hydrodynamic theory. Applications to plasmas and their measurement. P: One course each in electromagnetic fields and in mechanics beyond elementary physics.

527 Plasma Confinement and Heating. (Cross listed with NEEP, Physics) Irr.; 3 cr (P-A). Principles of magnetic confinement and heating of plasmas for controlled thermonuclear fusion: magnetic field structures, single particle orbits, equilibrium, stability, collisions, transport, heating, modeling and diagnostics. Discussion of current leading confinement concepts: tokomaks, tandem mirrors, stellarators, reversed field pinches, etc. P: NEEP/Phys/ECE 525 or equiv.

528 Plasma Processing and Technology. (Cross listed with NEEP) II; 3 cr. Introduction to basic understanding and techniques. Plasma processing of materials for semiconductors, polymers, plasma

spray coatings, ion implantation, etching, arcs, extractive metallurgy and welding. Plasma and materials diagnostics. P: Physics 322 or ECE 320 or equiv or cons inst.

531 Speech Signal Processing. Irr.; 3 cr. Aerodynamic and acoustic mechanisms of sound production in speech. Multi-tube acoustic models of the vocal tract. Pitch detection, spectrographic analysis by Fourier

and LPC methods. Speech synthesis, low bit rate speech coding, feature extraction for speech recognition. P: ECE 431 & Comp Sci 302.

532 Theory and Applications of Pattern Recognition. (Cross listed with Comp Sci, ME) Even yrs.; II; 3 cr (P-A). Pattern recognition systems and components; decision theories and classification; discriminant functions; supervised and unsupervised training; clustering; feature extraction and dimensional reduction; sequential and hierarchical classification; applications of training, feature extraction, and decision rules to engineering problems. P: ECE 331 or Math 431 or cons inst.

533 Image Processing. (Cross listed with Comp Sci) I; 3 cr (P-A). Mathematical representation of continuous and digital images; models of image degradation; picture enhancement, restoration, segmentation, and coding; pattern recognition, tomography. P: ECE 330 or cons inst; Math 320 or 340 or equiv.

534 Optical Signal Processing and Holography. Irr.; 3 cr (P-A). Two-dimensional Fourier transform and linear system theory. Fourier theory of propagation and diffraction of coherent light. Coherent and incoherent imaging systems; optical transfer function; spatial filters; optical correlators. Holography. Analog and digital optical signal processing and computing. P: ECE 433 or cons inst.

535 Optical Fiber Communication. I;Odd yrs.; 3 cr. Theory of optical waveguides, step- and graded-index fiber, attenuation and dispersion, fiber preparation, measurement of fiber properties, sources (LED and lasers), detectors, transmitter and receiver design, modulation and multiplexing, illustrative examples of actual systems. P: ECE 434 or cons inst.

536 Integrated Optics and Optoelectronics. Even yrs.; I; 3 cr. This course introduces the student to the physical principles, design concepts, and technological consequences of passive, electro-optic, and optic-
electronic guided wave devices. P: ECE 320, 335, & ECE 434 or 420 or cons inst.

537 Communication Networks. Odd yrs.; II; 3 cr. Study of communication networks. Layered network architecture. Queuing theory: Little's theorem, M/M/. and M/G/1 queues, Jackson networks. Data link control: error detection, retransmission strategies, framing. Network layer: flow control (window flow control), routing (shortest-path routing, flow models, optimal routing). Multi-access communications: random access and Aloha, carrier sensing, multi-access reservations. Circuit switched networks. P: ECE 331 or Math/IE 632, or cons inst.

539 Introduction to Artificial Neural Network and Fuzzy Systems. (Cross listed with Comp Sci, ME) I;Odd yrs.; 3 cr (D). Theory and applications of artificial neural networks and fuzzy logic: multi-layer perception, self-organization map, radial basis network, Hopfield network, recurrent network, fuzzy set theory, fuzzy logic control, adaptive fuzzy neural network, genetic algorithm, and evolution computing. Applications to control, pattern recognition, nonlinear system modeling, speech and image processing. P: Comp Sci 302, or Comp Sci 310, or knowledge of C programming lang.

541 Analog MOS Integrated Circuit Design. Even yrs.; I; 3 cr. Analysis, design and applications of modern analog circuits using integrated bipolar and field-effect transistor technologies. Provides the student with a working knowledge of the basic circuits used in modern analog integrated circuits and techniques for analysis and design. P: ECE 342 or ECE 340 & cons inst.

543 Numerical Modeling of Semiconductor Devices and Processing. I; 3 cr. Study of semiconductor devices fabrication processes using advanced computer simulation tools. Specific devices are modeled from fabrication to electrical properties and parameters extraction. Deposition, lithography, etching, implant processes are discussed. Statistical methods are used to study the effect of process parameters (and variations) on device electrical properties. P: ECE 335.

544 Processing of Electronic Materials. (Cross listed with CBE, MS&E) Irr.; 3 cr (I). Physics and chemistry principles underlying microelectronic materials processing. Effects of processing on materials and structures important in microelectronic and opto-electronic devices. P: CBE 440, MS&E 351, ECE 335; or cons inst.

545 Advanced Microwave Measurements for Com-munications. II; 3 cr. Measurements at VHF and microwave frequencies; characteristics of microwave generators, amplifiers, passive devices and detection systems; measurement of frequency, noise and simple antenna patterns; time domain reflectometry, swept frequency network and spectrum analyzer techniques; lecture and lab. P: ECE 301, ECE 444 or cons inst.

546 Lasers. (Cross listed with Physics) II; 2-3 cr (P-A). General principles of laser operation; laser oscillation conditions; optical resonators; methods of pumping lasers, gas discharge lasers, e-beam pumped lasers, solid state lasers, chemical lasers, and dye lasers; gain measurements with lasers; applications of lasers. P: Physics 322 or ECE 420 or equiv; Physics 545, or 449 or 531.

547 Advanced Communications Circuit Design. Odd yrs.; II; 3 cr. Principles underlying the design of r.f. and microwave communications circuits. Analysis and design of wideband nonlinear power amplifiers, S-parameter techniques for r.f. active circuit design, computer aided design techniques, r.f. integrated circuits, fundamentals of low noise r.f. design. P: ECE 447, ECE 420 or con reg, or cons inst.

548 Integrated Circuit Design. I; 3 cr (P-A). Bipolar and MOS devices in monolithic circuits. Device physics, fabrication technology. Ic-design for linear and nonlinear circuitry. P: ECE 345.

549 Integrated Circuit Fabrication Laboratory. II; 3 cr. Monolithic integrated circuit fabrication; mask making, photolithography, oxidation, diffusion, junction evaluation, metallization, packaging, and testing. P: ECE 548 or cons inst.

551 Digital System Design and Synthesis. I, II; 3 cr. Introduction to the use of hardware description languages and automated synthesis in design. Advanced design principles. Verilog and Vhdl description languages. Synthesis from hardware description languages. Timing-oriented synthesis. Relation of integrated circuit layout to timing-oriented design. Design for reuse. P: ECE/Comp Sci 352 & Jr st.

552 Introduction to Computer Architecture. (Cross listed with Comp Sci) I, II; 3 cr (P-A). The design of computer systems and components. Processor design, instruction set design, and addressing; control structures and microprogramming; memory management, caches, and memory hierarchies; and interrupts and I/O structures. P: ECE/Comp Sci 352 & Comp Sci/ECE 354.

553 Testing and Testable Design of Digital Systems. I; 3 cr. Faults and fault modeling, test equipment, test generation for combinational and sequential circuits, fault simulation, memory and microprocessor testing, design for testability, built-in self-test techniques, and fault location. P: ECE/Comp Sci 352; Comp Sci 367; ECE 353 or cons inst.

554 Digital Engineering Laboratory. I, II; 4 cr. Practical aspects of computer system design. Design, construction, and testing of significant digital subsystems. Design, construction, microprogramming, and programming of bit-slice implemented digital computers. P: ECE 351; ECE/Comp Sci 552.

555 Digital Circuits and Components. II; 3 cr. Principles and characterization of logic circuits. Design and analysis techniques for applied logic circuits. Transmission lines in digital applications. Families of circuit logic currently in use and their characteristics. P: ECE 340; ECE/Comp Sci 352.

556 Design Automation of Digital Systems. II; 3 cr (P-A). Use of digital computers to simulate, partition, place and interconnect digital electronic systems. P: ECE/Comp Sci 352; Comp Sci 367; or cons inst.

561 Introduction to Charged Particle Accelerators. (Cross listed with Physics, NEEP 561.) Irr.; 3 cr (P-A). Charged particle accelerators and transport systems, behavior of particles in magnetic fields, orbit theory, stability criteria, acceleration theory. Applications to different types of accelerators. P: Math 322, EMA 202 or Phys 311, Phys 322 or cons. Inst.

562 Applied Superconductivity. (Cross listed with MS&E, NEEP) Irr.; 3 cr (A). Introduction to superconductivity; critical current models; metallurgy of type II superconductors; structure dependencies of critical currents; conductor and magnet design, cryogenic stabilities; alternating current effect; special systems engineering. P: MS&E 350 or 351; Phys 241 or cons inst.

577 Automatic Controls Laboratory. (Cross listed with ME) II; 4 cr. Control theory is reduced to engineering practice through the analysis and design of actual systems in the laboratory. Experiments are conducted with modern servo systems using both analog and digital control. Systems identification and modern controls design are applied to motion and torque control. P: ME 446 & 447 or ECE 332 & 416 or cons inst.

601 Special Topics in Electrical and Computer Engineering. Irr.; 1-4 cr. Advanced topics of special interest to students in various areas of Electrical and Computer Engineering. P: Jr st & cons inst.

602 Special Topics in Electrical and Computer Engineering. Irr.; 1-4 cr. Advanced topics of special interest to students in various areas of electrical and computer engineering. P: Jr st and cons inst.

641 Introduction to Error-Correcting Codes. (Cross listed with Math) Irr.; 3 cr (N-A). A first course in coding theory. Linear codes,decoding and encoding. Hamming codes, Shannon's theorem on the existence of good codes. The binary Golay code. Finite fields and BCH codes. Dual codes and the weight distribution. Cyclic codes: generator polynomial and check polynomial. Reed-Solomon codes and burst errors. The Euclidean algorithm for decoding BCH codes. Reed-Muller codes. P: Math 320 or 340; and Math 541 or cons inst.

699 Advanced Independent Study. I, II, SS; 1-6 cr (A). P: Cons inst.