Engineering was appointed. Although metal-
when a Professor of Physics and Electrical
in the University, but it was later dropped.
neering. By 1877 mining had found a place
studies was designated as mechanical engi-
courses followed, and in 1877 this body of
appeared in about 1847; other mechanical
history of the University when surveying was
knows no geographical bounds, and gradu-
profession in Tennessee; but engineering
may pursue advanced study in graduate
apply these principles to the solution of
urgent need for engineering graduates who
A certain understanding of mathe-
ical and scientific principles, who can
solve problems, and who can view the
solutions in their overall social perspective
that the actions that they recommend will
be truly beneficial. It is the purpose of the
College of Engineering to educate men and
women to the high levels of technical com-
petence and social understanding that will
enable them to fulfill their responsibilities as
professional engineers.
Graduates of the B.S. curricula offered by
the college may enter directly a position in
industry, government, or private practice, or
may pursue advanced study in graduate
school. Their professional activities include
research, development, design, operations
analysis, construction, production supervi-
sion, and technical sales. Many practice their
profession in Tennessee; but engineering
knows no geographical bounds, and gradu-
ates of the college serve throughout the
nation and in other countries as well.
The college had its beginnings early in the
history of the University when surveying was
introduced into the curriculum in 1838. In
1877 civil engineering was first recognized
as a curriculum. The first mechanical course
appeared in about 1847; other mechanical
courses followed, and in 1877 this body of
studies was designated as mechanical engi-
neering. By 1877 mining had found a place
in the University, but it was later dropped.
Electrical engineering appeared about 1896,
when a Professor of Physics and Electrical
Engineering was appointed. Although metal-
lurgy was announced in the catalog as early
as 1888, the program was dormant until it
was revived in the Department of Chemical
Engineering shortly after 1940. A separate
degree in metallurgical engineering was
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of chemical engineering appeared in the
form of industrial chemistry shortly after
1900, a full chemical engineering program
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number of qualified black engineering gradu-
ates.
The Engineering Experiment Station was
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The college has ten major undergraduate
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neering science.
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Ferris Hall. This building houses the
offices, classrooms, laboratories, and shops
of the electrical engineering department, and
the Water Resources Laboratory. There is
also a remote input/output terminal and com-
puter graphics facility connected with The
University of Tennessee Computing Center.
Estabrook Hall. Some operations of the
Departments of Civil Engineering and Engi-
neering Science and Mechanics are carried
out in Estabrook Hall. A basic engineering
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ratories, and engineering drawing staff
offices are located on the second floor.
Offices of the Co-Op and Minority Engineer-
ing Programs are located on the first floor
where there is also a personal computer lab-
oratory.
Perkins Hall. This building houses the
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Nuclear Engineering Building. This build-

William T. Snyder, Dean
William A. Miller, Associate Dean
Andrew W. Spickard, Associate Dean

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ing houses operations of the nuclear engineer-
ing department and contains laboratories and equipment for monitoring, con-
ing, and investigating various nuclear phenomena. It also houses subcritical re-
tors.

Nathan W. Dougherty Engineering

Building. This building, the most recent and largest of the engineering buildings, houses the Departments of Chemical, Materials Sci-
ence and Engineering, and Mechanical and Aerospace Engineering. In addition to class-
rooms and instructional laboratories, it provides modern facilities for various types of research.

Alumni Memorial Auditorium-Gymnasium

A portion of this building houses offices, classrooms, and laboratories of the Depart-
ment of Industrial Engineering.

Berry Hall. This building is used by the Department of Civil Engineering for mainte-
nance and research work.

East Stadium. This facility, recently decommissioned as a dormitory, provides space for graduate student offices.

Tau Beta Pi National Headquarters

The college is honored to have the National-
Headquarters of Tau Beta Pi, the National Engineering Honor Society, housed on our
campus. This honor was earned in part through the untiring efforts of R.C. "Red" Matthews, who served as secretary-
treasurer for the organization from 1905 to
1947. The suite of offices, located in Dough-
erty Hall, is occupied by Mr. J. D. Froula, secretary-treasurer, and his staff.

Cooperative Engineering Program

The five-year Cooperative Engineering
Program is offered to students in the college in order to provide an engineering education that affords the opportunity to combine significant experience in industry with acad-
emic preparation.

Cooperative work assignments differ from part-time or summer employment in that they involve regularly scheduled cycles of full-time academic quarters alternated with full-time work quarters—usually six, a minimum of five career-related, planned assignments of progressive complexity and responsibility.

In exposing the student in this manner to the world of work, the college and the facilities of industry join together to offer a broader and richer preparation for postgraduate employment and for life in general than can be provided by a conventional academic program alone. This experience in an industrial and professional environment contributes to the student's maturity, increases the scope of acquaintances and concepts, and enables the student to define more clearly educational and career interests and objectives. Some of the experience received is at a subprofes-
sional level and is available to an engineer after graduation, yet is of great significance in total education and effectiveness.

Admission to the Cooperative Engineering Program is on the basis of physically qualified freshman and sophomore students. A fall application period conducted in early Octo-
ber is the source of most candidates placed for the following summer or fall; a late appli-
cation period may be held in May for students who failed to apply during the pre-
vious fall and who hope for placement the subsequent winter. Students must be attending the College of Engineering at the time of application. Those in school fall quar-
ter who are undecided about co-op participation should nevertheless apply during the fall application period, and then request that the applications be held until they are ready to make a definite commit-
ment, since fall applicants take priority for all placements for which they are qualified.

In general, students begin their work peri-
ods after completing their freshman academic work and continue them until beginning their senior coursework. Appli-
cants must be able to schedule a minimum of five work periods alternating with academic quarters prior to beginning their senior year in order to qualify for co-op placement. With very few exceptions, transfer students must complete a minimum of two academic quarters in the College of Engineering at UTK before beginning co-op participation.

Students in the Cooperative Engineering Program are classified as follows in terms of quarter hours credit completed in the stan-
dard undergraduate program for their anticipated degree in engineering:

- Freshman: 0-52.9
- Sophomore: 53-100.9
- Junior: 101-149.9
- Senior: 150-187

Second degree and transfer students will be assigned "equivalent quarters com-
pleted" (not dependent upon hours completed) which will indicate progress toward the engineering degree. Total hours completed are not an applicable measure of the progress of such students.

Such students who wish to co-op must plan very carefully in order to fit into the established schedule of courses offered for co-ops. Students planning to transfer should begin working as soon as possible with an advisor from the department they plan to enter in order to meld into the co-op sched-
ule at an optimum time. A brochure with further details may be obtained from the Cooperative Engineering Program Office, University of Tennessee, Knoxville, Tennes-
see 37996-2350.

Graduate Program

Graduate programs leading to the degree of Master of Science are offered in all areas of study, and the degree of Doctor of Philos-
ophy is offered in eight major subjects: aerospace engineering, chemical engineer-
ing, electrical engineering, engineering science, mechanical engineering, metallurgi-
cal engineering, nuclear engineering, and polymer engineering. A Master of Engineer-
ing degree focusing on engineering design is offered in aerospace, civil, electrical, industrial, mechanical, and nuclear engineering. Information concerning graduate programs is given in the Graduate Catalog.

Graduate Program at the UT Space Institute

At The University of Tennessee Space Institute near Tullahoma, graduate-level courses are offered in engineering fields such as aerospace, electrical, and mechan-
cal engineering, and in mathematics and physics. Current programs lead to the M.S. and Ph.D. degrees. Information may be obtained from the Registrar, The University of Tennessee Space Institute, Tullahoma, TN 37388.
minor is to appear on the final transcript. Degree applications are handled by the UTK Records Office.

**COURSE LOAD**

The maximum number of hours which can be taken by an undergraduate engineering student without special permission is 19. The Associate Dean for Academic Affairs must give permission to take 20 hours or more.

**DROP DEADLINE**

The drop deadline for all undergraduate courses administered by any department in the College of Engineering shall be the end of the eighth calendar day of each quarter, counted from the beginning day of classes. This coincides with the Campus add deadline. Any drop action after this date on the part of any student (regardless of major) is subject to late drop regulations if the course is an engineering course. For other drop deadlines, refer to "Changes in Registration" in the general section of this catalog.

**GENERAL REQUIREMENTS**

**NOTE:** Students are advised to consult the University's degree requirements as stated in the front section of this catalog as well as departmental requirements.

**Inspection Trip.** Each candidate for graduation majoring in aerospace, mechanical, chemical, or metallurgical engineering must participate in inspection trips scheduled by the major department.

**Transfer Credit.** Every attempt will be made to give maximum credit for courses taken elsewhere and transferred to the college. Discussions concerning the evaluation of transfer credits should be conducted with the head of the department (or his designee) in which the student proposes to transfer (following the evaluation of transfer credits by the Admissions Office).

**Program for Second B.S. Degree.** Upon approval by the Dean of Engineering and the Committee on Degrees of a program of study recommended by the major engineering department, a student who already holds a bachelor's degree may obtain the appropriate first degree in engineering upon completion of a minimum of 48 quarter hours' credit. The prevailing University regulations shall apply (see page 22).

**Satisfactory/No Credit Courses.** An undergraduate engineering student may count towards a degree up to 12 quarter hours obtained by Satisfactory/No Credit (S/NC) grading. Such courses must be used for humanistic-social (non-technical) elective credit in engineering. Certain engineering courses carrying only S/NC grading do not count in this limit.

**Correspondence Courses.** A student should check with his or her major department to see what restrictions there are, if any, on the use of correspondence course credit to meet the minimum degree requirement.

**Humanities and Social Science Electives.** The college assumes an obligation to include in each of the engineering curricula a means whereby students gain greater insight into their interaction with society, both personally and professionally. For this purpose, a part of each engineering curriculum is devoted to humanities and social science electives.

Broadly stated, these electives serve a three-fold need: to provide an expanded sensitivity to the human aspects of the practice of engineering; to enrich the student's knowledge of the world in which he or she lives—its culture, behavior patterns, history, and governance; and to provide a basis for the appreciation of the capability to deal with complex interactions between technology and society in the contemporary world. Engineers are now working with new constraints that demand a consciousness of the social and political implications of their work. They are interacting with the public in explaining their work as the public demands greater participation in the decision-making process concerning the utilization of technology. Because of the significance of this technology-society interaction, engineering students are encouraged to seriously consider their selection of required electives in this area.

Students are urged to plan a non-technical electives program which will enhance their own interests and objectives. It is recognized that just as engineers show individual preference for concentration in one of the areas of engineering, they also have interests in the many areas of the humanities and social sciences. However, these subjects should be pursued with sufficient depth in terms of courses to permit a reasonable level of comprehension of the selected areas. In order to increase the effectiveness of this interest and to meet ABET accreditation guidelines, the Humanities and Social Studies Committee of the college provides a list of approved courses in the form of 13 coherent groups of courses identified in three broad areas as follows:

**Area I. Human, Economic, and Political Relationships to Engineering**

A. Governance and Political Science
B. Economics
C. Sociology and Psychology
D. Human Values

**Area II. Society—Its Culture, History, and Literature**

A. Fine Arts
B. American Culture
C. History
D. Literature
E. Anthropology

**Area III. Technology and Society**

A. Human Habitat
B. Technology Assessment
C. Communication
D. Resources

Courses in the list which follow are selected by the committee with revisions as course offerings and needs change. They are recommended as satisfying the non-technical (humanities-social sciences) electives requirement in the various curricula of the college. However, the structure and permissible courses of the non-technical elective content of each engineering curriculum are established by the respective departments. Therefore, individual departments may delete courses from this list, require certain courses, or require selection of courses from specific subgroups. Students should consult their departments for any restrictions.

This list is intended to eliminate paperwork for the most common in their interests to illustrate the kinds of suitable courses. The list is not all inclusive, and it is recognized that individual students may desire to take courses not on the approved list. Those students should discuss their interests and desires with their academic advisor prior to registering for elective courses if such courses are to be used to satisfy degree requirements. Also, the catalog may state prerequisites for upper-division courses in the list. In such cases, students are encouraged to consult the instructor in the particular course. With respect to student records these lists are handled by means of a substitution sheet which originates with the advisor. Courses which are primarily skill development courses, involve mathematics or science, are intended for specialists in another field (such as education), or which are very elementary in nature are usually not approved as humanities-social science electives in an engineering curriculum. A minimum of 24 quarter hours of acceptable humanities-social science electives are required in all programs.

**ELECTIVE COURSES IN HUMANITIES AND SOCIAL SCIENCES**

**Area I. Human, Economic, and Political Relationships to Engineering**

A. Governance and Political Science
   Economics 3340
   Geography 3610
   History 3795, 4310-20, 4370, 4380
   Political Science 2510-20, 3545-46, 3555, 3566, 3710-20, 3750-60, 3801-02-03-04, 3880, 4060, 4535-36, 4540-50, 4545, 4656-66
   Sociology 3030, 4530, 4560

B. Economics
   Economics 2510-20, 3210-11, 3220, 3230, 3240, 3210, 3310, 3410-20
   Geography 2110-20-30

C. Sociology and Psychology
   Geography 3000, 3600, 3660
   Psychology 2500, 2520, 2540, 3120, 3220, 3240
   Sociology 3420, 3430-40-50, 3410-20, 3610, 4330, 4560

D. Human Values
   Geography 3000
   History 3000, 3050, 3270
   Philosophy 1510-20, 2310, 2510, 3111-21-31-41-51, 3440, 3460
   Religious Studies 2610, 3600-10-20, 3611, 3740
   Zoology 3410 (Bioethics)

**Area II. Society—Its Culture, History, and Literature**

A. Fine Arts
   Music 1210-20-30, 2310-20-30-40, 3350
   Theatre 3252-53-54

B. Culture
   American Studies 3010
   Anthropology 3410
   Afro-American Studies 20-20, 3550-60
   French 2610-20
   Geography 3430, 3450, 3660, 3910-20-30-40
quarter to prior to anticipated graduation, each student shall discuss with an advisor the status of the program of study. Any necessary additions to or substitutions in the program, or electives requiring special approval, shall be cleared in written form at that time, and it is each student’s responsibility to see that all necessary approvals are secured. Inattention to such matters may delay graduation.

ADVISING CONFERENCE The relationship between an engineering student and an advisor is an important one, and a student should go to the advisor for assistance or information at any time. All students are required to see their advisor during the Fall Quarter (or during one other quarter if they are not in school during the fall). Engineering students normally are asked to see their advisors during the two-week period immediately preceding the advance registration period. A record of the advising conference is needed in order to advance register. During other quarters of the year, the student’s department determines whether or not an advisor must be consulted prior to advance registration. An advising conference record card must be presented in order to advance register for those quarters also, though an actual conference is required only once a year for most students.

CURRICULA, TABULAR VIEW

Following are the course requirements for the various engineering curricula. The numbers in the columns indicate the number of quarter hours of credit for each course. Columns represent the three principal quarters of the academic year—fall, winter, and spring. This is not a schedule, and courses are available in quarters other than those indicated here. This listing is a guide, not a rigid schedule. Individual course prerequisites should be strictly adhered to, even if courses are not taken in the quarters indicated. Although the requirements for each degree can be completed in four academic years (five for the cooperative program), the quality of the learning experience is much more important than the speed with which the curricula are completed.

Humanities and social science electives are the same as non-technical electives in these tabulations. Questions about individual courses should be directed to the department responsible for the course; questions about a particular curriculum should be directed to the major department.

Aerospace Engineering

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours Credit</th>
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<tbody>
<tr>
<td>Math 1840-50-60</td>
<td>4 4 4</td>
</tr>
<tr>
<td>Chemistry 110-20-30</td>
<td>3 3 3</td>
</tr>
<tr>
<td>English 1010-20-33</td>
<td>3 3 3</td>
</tr>
<tr>
<td>Graphics 1410-20</td>
<td>3 3 3</td>
</tr>
<tr>
<td>Basic Engineering 1310-20-30</td>
<td>4 4 4</td>
</tr>
<tr>
<td>Basic Engineering 1410</td>
<td>3 3 3</td>
</tr>
<tr>
<td>Aerospace Engr. 2040</td>
<td>3 3 3</td>
</tr>
<tr>
<td>Math 2840-50-60</td>
<td>3 3 3</td>
</tr>
<tr>
<td>Physics 2310-20-30</td>
<td>3 3 3</td>
</tr>
<tr>
<td>Met. Engr. 2110</td>
<td>3 3 3</td>
</tr>
<tr>
<td>Computer Science 3150</td>
<td>4 4 4</td>
</tr>
<tr>
<td>Humanities/social science electives</td>
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<tbody>
<tr>
<td>Agricultural Engineering 1130</td>
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<tr>
<td>Agriculture 1130-40</td>
<td>4 4 4</td>
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<tr>
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<tr>
<td>Basic Engineering 1410</td>
<td>3 3 3</td>
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<tr>
<td>1English 1010 or 1011: 1020: 1033</td>
<td>3 3 3</td>
</tr>
<tr>
<td>Graphics 1410-20</td>
<td>3 3 3</td>
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<tr>
<td>1Mathematics 1840-50-60</td>
<td>4 4 4</td>
</tr>
<tr>
<td>Aerospace Engr. 2040</td>
<td>3 3 3</td>
</tr>
<tr>
<td>Biology 1210 or 1220 or 1230</td>
<td>4 4 4</td>
</tr>
<tr>
<td>*Elective 1Primary History course</td>
<td>3 3 3</td>
</tr>
<tr>
<td>*Engineering Science and Mechanicals 3311</td>
<td>4 4 4</td>
</tr>
<tr>
<td>*Engineering Science and Mechanics 3310</td>
<td>3 3 3</td>
</tr>
<tr>
<td>*Elective</td>
<td>3 3 3</td>
</tr>
<tr>
<td>*Mathematics 2340-50-60</td>
<td>4 4 4</td>
</tr>
<tr>
<td>*Physics 2310-20-30</td>
<td>3 3 3</td>
</tr>
<tr>
<td>*Senior</td>
<td>3 3 3</td>
</tr>
<tr>
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<td>4 4 4</td>
</tr>
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</table>

*Technical electives: upper-division courses in engineering, mathematics, or physics as approved by the department.
Biomedical Engineering

Available in Engineering Science Degree Program

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<tbody>
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<td>I I I</td>
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Biological Engineering

Chemical Engineering

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<td>Math 1100-50-60</td>
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<td>Chemistry 1110-20-30</td>
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*Electrical Engineering/College of Engineering 121*
Systems and Networks
- Elec. Engr. 4180... 3
- Elec. Engr. 4370... 4
- Elec. Engr. 4350... 3
- Elec. Engr. tech. electives... 3
- Elec. Engr. tech. electives... 3
- Elec. Engr. 4510... 3
- Elec. Engr. 4750... 3
- Elec. Engr. 4610... 4
- Elec. Engr. 4630... 4
- Elec. Engr. 4690... 4
- Elec. Engr. 4800... 4
- Elec. Engr. 4830... 4
- Elec. Engr. 4850 or 4750... 4
- Economics 2510... 4
- Humanities/social science electives... 4

Total: 206 hours

Computer Engineering
- Elec. Engr. 4600... 3
- Elec. Engr. 4740... 4
- Elec. Engr. 4770... 4
- Elec. Engr. 4610... 4
- Elec. Engr. 4630... 4
- Elec. Engr. 4690... 4
- Elec. Engr. 4800... 4
- Elec. Engr. 4830... 4
- Elec. Engr. 4850 or 4750... 4
- Economics 2510... 4
- Elec. Engr. 4100... 4
- Humanities/social science electives... 4

Total: 206 hours

Electronics and Instrumentation
- Elec. Engr. 4680-90, 4600... 3
- Elec. Engr. 4370... 3
- Elec. Engr. 4740... 3
- Elec. Engr. 4610... 3
- Elec. Engr. 4800... 3
- Elec. Engr. 4740... 3
- Elec. Engr. 4610... 3
- Elec. Engr. 4850... 3
- Elec. Engr. 4820... 3
- Elec. Engr. 4350... 3
- Economics 2510... 4
- Elec. Engr. 4100... 4
- Humanities/social science electives... 4

Total: 206 hours

Bioelectric Option
- Biology 1210-20-30... 4
- Chemistry 2220... 4
- Zoology 3080-3089... 3
- Elec. Engr. 4850... 3
- Elec. Engr. 4820... 3
- Elec. Engr. 4800... 3
- Elec. Engr. 4370... 3
- Elec. Engr. 4820... 3
- Humanities/social science electives... 4

Total: 206 hours

Engineering Physics

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<tr>
<th>Hours</th>
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<tr>
<td>Freshman</td>
<td>Mathematics 1840-50-60</td>
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<tr>
<td>Sophomore</td>
<td>Mathematics 2840-50-60</td>
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<tr>
<td>Non-technical electives</td>
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<tr>
<td>Physics 2310-20-30</td>
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Total: 197 hours

Electives... 3
| Technical electives... 3 |
| Physics 4240 (or 3330) | 3 |
| Physics 4110-20-30 | 3 |
| Physics electives... 3 |
| Technical electives... 3 |
| Electives... 3 |
| Engineering electives... 3 |

Total: 199 hours

Mechanical Engineering

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<th>Hours</th>
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<td>Freshman</td>
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<tr>
<td>Sophomore</td>
<td>Math 2840-50-60</td>
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<tr>
<td>Physics 2310-20-30</td>
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<tr>
<td>Engr. Sci. and Mech. 3311, 3700</td>
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<tr>
<td>Ind. Engr. 2310</td>
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<tr>
<td>Statistics 3450, 3460</td>
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<tr>
<td>Humanities/social science electives</td>
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<tr>
<td>Ind. Engr. 3610</td>
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</table>

Total: 207 hours

*Humanities/social science electives: minimum of 24 hours required.

*Technical electives: upper-division courses in engineering, mathematics, or physics as approved by the department.

Industrial Engineering

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<td>Engr. Sci. and Mech. 3311, 3700</td>
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<tr>
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</tbody>
</table>

Total: 204 hours

*Humanities/social science electives: minimum of 24 hours required.

*Technical electives: upper-division courses in engineering, mathematics, or physics as approved by the department.
Agricultural Engineering

Basic Engineering and Graphics

Basic Engineering (179)

Basic Science (443)

Chemical Engineering/College of Engineering 123

State: J. W. Prados (Vice President for Academic Affairs), Ph.D. Tennessee; C. D. Scott, Ph.D. Tennessee; C. O. Thomas, Ph.D. Tennessee; J. S. Watson, Ph.D. Tennessee.

Associate Professors: P. H. Berkowitz, Ph.D. Purdue; D. B. Bruns, Ph.D. Houston; C. H. Byers, Ph.D. California (Berkeley); R. M. Counce, Ph.D. Tennessee; T. L. Donaldson, Ph.D. Pennsylvania; A. C. Shelf, Ph.D. Northwestern.

Assistant Professor: F. E. Weber, Ph.D. Minnesota.

Lecturer: D. W. Lane, Ph.D. Tennessee.

1Space Institute, Tottusima

2Adjunct Status

3Part-time

BACHELOR OF SCIENCE PROGRAM

Chemical engineering is a discipline dedicated to the development, design, operation and management of plants and processes for the conversion of chemical raw materials to useful products. It is a broadly based discipline, with heavy emphasis on chemistry and mathematics, and also including physics, materials and the humanities. Graduates of the program are quite versatile, with careers in such fields as food and pharmaceutical processing, biochemical engineering, fuels production and conversion, polymers and plastics, process control and instrumentation, and many others.

The curriculum provides a central core of required courses with flexibility in the upper-division years to permit emphasis on preparation for graduate school or professional employment. A minimum grade point average of 2.0 for all departmental courses is required for graduation.

Elective Courses in Humanities and Social Studies. A minimum of 24 quarter-hours of humanistic-social science courses are required, which are to be selected from the list under "Curricula in Engineering". A minimum of 12 hours must be taken from a single sub-group under one of the three major headings.

PROGRESSION TO UPPER-DIVISION PROGRAMS

Progression of chemical engineering students to departmental Upper-Division courses is competitive and is based on capacity. Factors considered include overall grade point average, performance in selected lower-division courses and evidence of satisfactory and orderly progress through the prescribed curriculum.

Upper-Division Status: A Lower-Division student may apply for progression to Upper-Division Status after completing 80 quarter hours of Lower-Division engineering curriculum course work with an overall GPA of at least 2.4. This must include Chemical Eng. 2010 and 2020.

 Provisional Status: Students who have completed 60 quarter hours of Lower-Division engineering curriculum course work with an overall GPA between 2.0 and 2.4 may apply for provisional status. The granting of PROVISIONAL UPPER-DIVISION STATUS is based on the availability of space in the departmental programs after UPPEER-
DIVISION STATUS students have been accommodated. Provisional students are required to demonstrate their abilities to perform satisfactorily in upper-division courses by taking the preliminary examinations described in Section 2.0 at least 12 hours of 3000-level required courses specified by the department. Further progression to upper-division courses is dependent upon this minimum level of performance.

Any student with an overall GPA below 2.0 will not be admitted to upper-division Chemical Engineering courses. Students who have not been admitted to an Upper-Division Status will be dropped from departmental class rolls.

Transfer Students at the Upper-Division level are admitted on a Provisional Status basis only. Any student presenting more than 42 hours of Lower-Division engineering curriculum course work by transfer credit is considered to be a Transfer student.

GRADUATE STUDY PROGRAMS

Graduate programs leading to the degrees of Master of Science and Doctor of Philosophy in Chemical Engineering are offered. The University's Graduate School operates a Resident Graduate Program at Oak Ridge, Kingsport, and Chattanooga. See the Graduate Catalog for detailed information.

Chemical Engineering (225)


2011 Sophomore Inspection Trip (0) Inspection of a chemical process plant. S/N/C. F.


3050 Thermophysical Properties (4) Estimation of equilibrium properties of gases, liquids, and solutions from macro- and microscopic approaches; enth-alphy, entropy, entropy of vapor pressure, surface tension, heat capacity, latent heat, fugacity, relationships among properties. Prereq: Chemistry 3410, W, S.

3230 Special Problems (3) Investigation of chemical engineering problems.

3410 Flow of Fluids (3) Differential and overall momentum balances, mechanical energy balances; flow in tubes, piping systems, and packed beds; metering devices, pumps. 3 hrs. and 1 lab. Prereq: Math 2840, 3 hrs. and 1 lab. W, S.

3420 Heat Transfer (3) Differential and overall energy balances; steady and unsteady state heat conduction in simple geometries; heat transfer in tubes and heat exchangers; condensation and boiling radiation. 3 hrs. and 1 lab. Prereq: 3410, F, S.

3440 Stagewise Operations (3) Analytical and graphical methods for stagewise separatory operations. Prereq: Chemistry 3420, S, SU.

3450 Diffusional Operations (3) Diffusion, simultaneous heat and mass transfer, applications including humidification, gas absorption, extraction, Prereq: 3420, Chemistry 3420, F, W.

3610 Introduction to Process Dynamics and Control (4) Process modeling and introduction to control system design. Mathematical models for several industrial processes are developed from a mass, component and energy balance basis. The models are compared to both industrial and laboratory data. Model linearization, linear feedback control, and model reference feedback control, basic and advanced feedback control concepts, block diagram algebra, transfer function models, industrial sensors and their values. Lab. Prereq: Math 2840, F, E, Chemistry 3410, 2.0. S, SU.

3620 Industrial Process Control (3) Design theory and practice for industrial process control. Experimental model process modeling (process identification), feedback design, sensor fault, set point, cascade control, degrees of freedom, stability analysis, controller tuning. Control systems will be designed for a number of typical industrial unit operations. Lab. Prereq: 3610, F, W, S.

4110 Chemical Engineering Data Analysis (3) Random and stochastic processes; statistical properties of samples and some systems; elements of probability; discrete and continuous distributions; statistical characterization of products and processes; empirical modeling of processes; statistical process control. Prereq: 3420, Math 3150, F, W, SU.

4150 Introduction to Optimization (3) Principles and applications of optimization techniques to chemical process design; unconstrained optimization, equality constrained optimization, inequality constrained optimization, and dynamic programming. Prereq: Math 2940.

4150 Computational Chemical Engineering (3) Introduction to computer-aided problem-solving in chemical engineering problems. Primary focus is on the application of existing computer programs. The applications studied include: Process design, simulation of mathematical models on computer graphics, and personal computing. The programs studied are: ASPEN, SAS, CSMP, NAG/IMSL and various other programs on the use of computers on the personal computer. Prereq: Coreq: 4110, Prereq: Math 3150. Limited enrollment.

4210 Chemical Engineering Laboratory I (3) Laboratory investigations of thermodynamics, fluid flow, and heat transfer in chemical engineering operations. Prereq: 3410, 3420, Chemistry 3410.

4220 Chemical Engineering Laboratory II (3) Laboratory investigations of mass transfer and reaction in chemical engineering operations. Prereq: 3440-50, 4210, 4530, F, W, S.

4230 Project Laboratory (3) Laboratory investigation of chemical engineering problem, stressing techniques of group effort. May be repeated. E.

4250 Introduction to Process Chemical Economics (3) Methods of cost estimating; analysis of product pricing based upon debt and equity financing methods; use of sensitivity analyses to deal with uncertainties, a detailed case study. Prereq: 4110, % 4310-20 Seminar (1,1) Prereq: Math 3150. Coreq: 4230. F, W, S.

4410 Design of Separation Processes (4) Design of multicomponent distillation systems, including layout of separation train, choice of operating variables; heat and mass balances; specification of major and peripheral equipment, including control systems. Selected problems emphasizing other separation methods, heat economy in complex systems, low temperature processes, equipment selection and optimization. Prereq: 3440-50, 3050, 3610, W, S.

4420 Process Design and Economic Analysis (4) Development of process information into an integrated plant design. Production specifications, equipment characteristics, capital investment, operating costs, and economic merit. Prereq: 4410, 4530, S, F.

4430 Special Problems in Design and Economics (3) Extension of course methods: student work in AICHE E. annual contest problem; other advanced design projects. Prereq: 4420.

4450 Hydrocarbon Processing (3) Study of specialized characterization of physical properties of fossil fuel raw materials, and other processes for conversion of fossil fuel raw materials into products needed in industrial processes, industrial raw material and consumer markets. Prereq: Coreq: 4410.

4480 Coal Processing to Liquid Fuels (3) Characterization of various coals with respect to current liquefaction methods; modeling of conversion processes and estimation of maximum yields; water and oxygen requirements; pyrolysis; catalytic hydrogenation; reactor design considerations; review of selected articles from both the current literature and patents. Prereq: Consent of instructor.

4510 Transport Phenomena (3) Momentum, heat and mass transfer with emphasis on similarities in mathematical formulation and solution; applications in chemical engineering systems. Prereq: 3450.

4530 Chemical Reactor Fundamentals (3) Brief review of homogeneous and heterogeneous reaction kinetics; idealized homogeneous reactor models, both for closed and flow systems; corrections for non-ideal reactor behavior; some distributed parameter models; catalyst effectiveness factors and conversion in fixed bed catalytic reactors. Prereq: 3420, Chemistry 3439, W, S.

4540 Fluid—Solid Operations (3) Heat and mass transport in fixed and fluidized beds: applications include adsorption, ion exchange, crystallization, Prereq: 3440-50.


4730 Mass and Energy Flow in Biological Systems (3) Basic physicochemical and organizational principles applicable to biological systems. Derivation of generic models of biomass and energy transfer, Thermodynamics of transport and equilibrium in biological systems. Discussion of Volterra's equation and biological clocks, etc. Prereq: Consent of instructor.

4740 Introduction to Transport Phenomena in Biological Systems (3) Application of principles of transport phenomena to biological systems. Transfer of chemical energy and various other cellular active transports, structure and rheology of physiological fluids, membrane and interfacial phenomena; analysis and design of artificial organs. Prereq: 3440 and 3450, or consent of instructor.

4750 Microbiological Process Engineering (3) Application of chemical engineering principles and design concept to microbiological processes; continuous culture of microorganisms, food processing and pharmaceutical processes. Prereq: 3440, 3450, or consent of instructor.

4780 Principles of Biochemical Separation (3) Fundamental aspects and similarities of modern bio—mass, biochemical, and separations process; classroom demonstrations, design of production and analytical systems. Prereq: Consent of instructor.

4900 Special Problems in Chemical Engineering (3) Chemical engineering problems related to recent developments in industrial practice or research. Prereq: Consent of instructor. May be repeated. Maximum credit 9 hours.

4910-20 Engineering Internship in Industrial Problems (6, 6) Selected students work in small groups on real industrial problems. Work will be directed by a faculty instructor and by engineers from a host company. Internship will require two quarters of participation. Prereq: Coreq: 4910 S/N/C. Prereq: 3610-20 and consent of instructor.

GRADUATE Consult the Graduate Catalog for listing of graduate level courses.

Civil Engineering Including Environmental Engineering Professors: W. L. Grecco (Head), Ph.D., Michigan State University, P.E., E. G. Burdette, Ph.D., Illinois Institute of Technology, P.E., M. S. Bronzini (Director, Transportation Center), Ph.D., California Polytechnic State University, P.E.; A. Chatterjee, Ph.D., North Carolina State University, P.E.; W. T. Davis, Ph.D., Tennessee; D. W. Goodpasture, Ph.D., Illinois Institute, P.E.,
Civil Engineering/College of Engineering

BACHELOR OF SCIENCE PROGRAM

The curriculum in civil engineering is designed to provide training in fundamental engineering sciences and in certain non-technical and basic subjects in various civil engineering fields to serve as a basis for entrance into civil engineering practice, and for preparation for graduate study. By use of technical electives (15 hours maximum), a student can specialize as primary or secondary areas of study in construction, environmental engineering, geotechnical/materials, structural engineering, transportation, or water resources. Primary specialization will be shown on the student's transcript.

Students are required to maintain a cumulative grade point average of at least 2.00 in all civil engineering and environmental engineering courses taken at The University of Tennessee, Knoxville, and used to satisfy the graduation requirements.

Electives

The department maintains lists of acceptable technical electives and humanities/social science electives at the departmental office. Students must consult these lists prior to registering for elective courses.

MASTER OF SCIENCE AND MASTER OF ENGINEERING PROGRAMS

Graduate programs in civil engineering and environmental engineering leading to the degrees of Master of Science and Master of Engineering are offered to graduates of recognized undergraduate curricula.

The general requirements for the masters' degrees are stated in the Graduate Catalog.

DOCTORAL PROGRAM

Graduate work leading to the degree of Doctor of Philosophy with a major in civil engineering is offered. Major fields of study include structural engineering, geotechnical/materials, structural engineering, transportation, and water resources.

The general requirements for the doctoral degree are stated in the Graduate Catalog.

Civil Engineering (254)

2260 Engineering Surveys (4) Measurement through the application of surveying techniques; the theory of errors and their analysis; fundamental concepts of horizontal and vertical surveying; basic surveying operations and computations. 3 hrs. lectures and 1 hr. lab. Prereq: Math 1850.

2310 Seminar (1) Presentation and discussion of topics related to civil engineering.

2360 Route Surveying (3) Emphasis on basic principles and applications of horizontal and vertical alignment of transportation routes, specifically covering simple, compound, reverse and parabolic curves and earthworks. Earthwork computations. Prereq: 2260.

2510 Computer Application in Civil Engineering (3) Computer solution of civil engineering programs involving single variable equations and systems of linear, non-linear and differential equations. Emphasis on student written programs; introduction to microcomputers. Coreq: Math 2860.


3230 Design of Framed Structures (3) Selection of rolled beams; design of compression and tension members for axial and bending stresses. Prereq: 3210, coreq: 4410.


3320 Computer Applications in Civil Engineering (1) Solution of civil engineering problems through the use of digital computers. Prereq: Basic Engr. 1410.

3360 Surveying Practice (3) Route surveying procedures. Two 3-hr. labs. Coreq: 2360.

3600 Transportation Planning (3) Emphasis on transportation problems and perspectives, both rural and urban; use of the planning process to establish existing travel systems; feeling of demand, proposing alternatives and their evaluation, and plan implementation. Prereq: Junior standing.

3610 Transportation Engineering (3) Introductory course on design, construction, maintenance, and operation of various transportation modes, their guideways and terminals. Prereq: Junior standing.


4110 Concrete Design (3) Reinforced concrete beams and columns; use of standard specifications. Prereq: 3210 and 3710.

4120 Concrete Design (3) Reinforced concrete continuous beams, floor slabs and column footings and retaining walls. Prereq: 4110 and 4410.


430 Legal and Ethical Aspects of Engineering (3) Legal principles underlying engineering work; laws of contracts, torts, agency, real property; problems of professional registration and ethics.

4240 Structural Design (3) Plate girders, composite steel and concrete beams, connections and details, and design of small industrial building. Two 3-hr. periods. Prereq: 3230 and 4410.

4260 Photogrammetry (3) Methods of plotting maps from aerial photographs. Principles of stereoscopic plotting instruments; applications. Prereq: 2360, or Foresty Summer Camp for forestry majors.

4310 Soil Mechanics II (3) The compressibility of fine grain soils and the theory of time rate of consolidation. Shear strength of soils. Failure theories. 2 hrs. lecture and 1 lab.

4320-30 Seminar (2,1) Selected topics dealing with historical and modern civil engineering achievements and professional and ethical responsibilities. Prereq: Senior standing and completion of all junior level non-elective engineering courses.

4410 Reactions and statically indeterminate Structures (3) Reactions and influence lines of indeterminate beams, trusses, bents, and frames. Prereq: 3210.

4420 Analysis of Framed Structures II (2) Maximum forces due to moving load effects; influence lines of influence lines, lateral forces due to earthquake and wind; analysis of portals, building frames, and space frames. Coreq: 4410.

4430 Construction Methods and Equipment (3) Fundamental operations in construction and selection of equipment; production rates, balancing of equipment, and cost estimates. Prereq: 3710.

4460 Land Surveying (3) Procedures of locating property; evaluating evidence; procedures to describe property, to create land divisions, and to prepare plots; laws of land surveying. Prereq: 2260 or equivalent.

4510-20 Advanced Structural Design (3,3) Plastic design in steel in 4510; design of typical short span steel highway bridges in 4520. Prereq: 3230 for 4510; 3230 and 4110 for 4520.

4540 Computer Utilization (3) Computer use, economic justification, and extent of use by industry. Utilization of computers for solution of civil engineering problems. Basic computer knowledge.

4560 Stabilization of Soils (3) Mechanical stabilization of soils by compaction, drainage, and blending; chemical stabilization of soils with admixtures; waterproofing and modifying soils and additives. 2 hrs. of lecture and 1 lab. Prereq: 4310.

4570 Geotechnical Aspects of Construction (3) Unbraced and braced excavations, in situ densification by vibration and deep dynamic compaction methods; applications of well point systems, sand drains, silt drains, filter design and geoelectrics. Prereq: 4420.

4600 Highway Engineering I (3) Design, construction, operation, and maintenance of highway facilities; integration of system planning and project planning to design and construction procedures. Prereq: 3600 and 3610.

4620 Airport Planning and Design I (3) Emphasis on airport master planning. Included for consideration on the airside are runway configuration, capacity, geometries, and lighting; and on the land-side are included terminal layout and design, and ground access systems and parking. Prereq: 3600, 3610.

4640 Traffic Engineering (3) Characteristics of driver, vehicle, and roadway and their interrelationship; traffic studies; basic considerations of traffic circulation and control; elements of urban transportation planning. Prereq: Senior Standing.

4650 Highway Engineering II (3) Integration and application of various engineering principles and techniques to process of planning, locating, and design of highway facility through comprehensive team project. 1 lecture and 2 labs. Prereq: 4600.

4660 Airport Planning and Design II (3) Integration and application of principles of airport master planning for the purpose of site selection and design of an airport facility through a comprehensive team project; includes environmental evaluation of design. 1 lecture and 2 labs. Prereq: 4620.

4710 Portland Cement Concrete Mix Design (3) Principles and tests of portland cement concrete, methods of concrete mix design, non-destructive concrete evaluation testing, use of concrete admixtures. 2 lectures and 1 lab. Prereq: 3710.

4720 Asphalt and Bituminous Concrete (3) Properties and tests of asphalt and asphaltic mixes, mix design and bituminous concrete. Emphasis on use of asphalt in transportation construction projects. 2 lectures and 1 lab. Prereq: 3710.

4731-32 Earthquake Resistant Structure I, II (4,4) (Same as Architecture 4731-32)
4800 Introduction to Civil Engineering Systems (3) Meets the technical requirements of engineering systems and their specific application to problems of transportation, environment, water resources, and materials. Prereq: Senior standing or consent of instructor.

4850 Elementary Structural Matrix Methods (4) (Same as Asst. Prof. A. A. 4850 and Engineering Science and Mechanics 4850.)

4860 Structural Wood Design (3) The application of structural design principles to structural members of various combinations of wood products. Beams, columns, and trusses are designed. Knowledge of wood properties is assumed. Prereq: Senior standing or consent of instructor.

4880 Civil Engineering Systems Design and Management (3) Introduction to basic systems engineering concepts including system engineering as a multi-disciplinary context; discussion of the role of decision maker and use of optimal principles of engineering planning. Prereq: 2510 or Computer Science 3150.

4900 Senior Design Project (6) Open-end design projects including problem formulation, specifications, feasibility and various design components. Topics will vary but generally be real world problems designed by Civil Engineering consulting firms. Prereq: Completion of all technical courses through junior year.

4910 Special Topics (1-3) Topics relating to recent developments and current practice in civil engineering through supervised self-study. Prereq: Consent of individual instructor and approved by department head. May be repeated.

GRADUATE Consult the Graduate Catalog for listing of graduate level courses.

Environmental Engineering (344)

3120 Hydraulics (3) Application of basic and developed analysis techniques, flow measurements in closed conduits; uniform and nonuniform open channel flow; pumps and turbines; basic hydrodynamics; flow, stream and river mechanics. One lecture and one 3-hr. lab. Prereq: Engr. Mech. 3110.


3520 Engineering Aspects of Air Pollution and Solid Waste Systems (3) Engineering aspects of solid waste and air pollution systems. Specifically, quantitative capabilities will be developed related to management, generation, collection, treatment and disposal of solid wastes and air pollutants. Prereq: Math 2360.

4000 Environmental Protection (3) A rationale is developed for managing water resources, bodily wastes and wastewaters, air environment, solid wastes commercial and residential, food and exacerbation of physical energy to prevent the impairment of health, to promote efficiency and comfort, and to safeguard the balances in natural ecosystems. The principles of environmental protection are emphasized. Includes objectives of design and practice without detailing design or practice methods. Prereq: Senior standing.

4030 Environmental Engineering Chemistry (3) Fundamentals of chemistry which relate to generation, formation analysis, and removal of environmental contaminants. Prereq: Chemistry 1130 and senior standing.

4150 Urban Water Management (3) Introduction to urban water resources, water quality, treatment, water policies; formulation of system constraints and analysis of decision-making process; management of storm water for beneficial use. Prereq: 3330.

4210 Water Resources Engineering Design (3) Planning, designing and managing water resources project alternatives; achieving project optimality; single- and multi-purpose projects; environmental assessment procedures; risk assessment methods for making water resource project decisions. Prereq: 3330 or consent of instructor.

4330 Hydrologic Design (3) Application of frequency and regression analysis to hydrologic design of water resources system; unsteady surface runoff and streamflow modeling; urban peak runoff design using kinematic wave theory; evaluation of effects of land use changes on stream flow quantity and quality. Prereq: 3330.

4510 Elements of Water and Wastewater Transport Systems (3) Introduction to theory and design of water transportation and distribution systems and wastewater collection systems. Prereq: 3120.

4520 Elements of Water and Wastewater Treatment Systems (3) Technical knowledge of unit operations and processes employed in physical, chemical, and biological treatment of water and wastewater. Application of unit operations and processes in design of water and wastewater treatment plants. Prereq: Engr. Sci. and Mech. 3110 or consent of instructor.

4525 Water and Wastewater Treatment Plant Design (3) Detailed process design of water and/or municipal industrial wastewater treatment plants; sludge handling systems, and ultimate disposal of residuals. Prereq: 4520 or equivalent.

4530 Environmental Engineering Laboratory (3) Standard analytical techniques for evaluation of specific air, water, and/or wastewater. Two 2-hrs. and 1 lab. Prereq: 4030 or consent of instructor.

4600 Solid and Hazardous Waste Management (3) Magnitude and characteristics of solid and hazardous waste problems; collection systems, disposal systems including landfill, incineration, composting, fixation, resource recovery, and proposed new technologies; current and future regulations. Prereq: Junior standing.

4700 Air Pollution-Air Resource Management (3) Introductory course on concepts of air pollution; analysis of relationship among emission sources, meteorology and transport of pollutants; engineering approaches for air pollution control. Prereq: Senior standing.

4820 Environmental Engineering Law (3) Legal aspects of water and air pollution, drainage, land use controls, and environmental impact statements with emphasis upon federal-state relations, recent legislation and court decisions, and enforcement. Prereq: Senior standing.

4850 Environmental Engineering Law (3) Legal aspects of water and air pollution, drainage, land use controls, and environmental impact statements with emphasis upon federal-state relations, recent legislation and court decisions, and enforcement. Prereq: Senior standing.

4880 Civil Engineering Systems Design and Management (3) Introduction to basic systems engineering concepts including system engineering as a multi-disciplinary context; discussion of the role of decision maker and use of optimal principles of engineering planning. Prereq: 2510 or Computer Science 3150.

4920 Environmental Engineering Law (3) Legal aspects of water and air pollution, drainage, land use controls, and environmental impact statements with emphasis upon federal-state relations, recent legislation and court decisions, and enforcement. Prereq: Senior standing.

4910 Special Topics (1-3) Topics relating to recent developments and current practice in civil engineering through supervised self-study. Prereq: Consent of individual instructor and approved by department head. May be repeated.

GRADUATE Consult the Graduate Catalog for listing of graduate level courses.

Electrical Engineering (320)

Professors:
W. L. Green (Head), Ph.D. Texas A & M; I. Alexeff, Ph.D. Wisconsin; P.E.; J. M. Bailey, Ph.D. Georgia Institute of Technology; A. O. Bishop, Jr., Ph.D. Case Institute of Technology, M.S. New York; J. W. Chamberlain, Ph.D. Tennessee; R. E. Bodenheimer, Ph.D. Northwestern; R. W. Rochelle, Ph.D. Tennessee; C. H. Weaver, Ph.D. Wisconsin, P.E.

Associate Professors:

Assistant Professors:
D. Brzkazick, Ph.D. Florida University; J. M. Chapman, Ph.D. Tennessee.

Research Assistant Professor:
M. A. Scott, Ph.D. Tennessee.


H. P. Neff, Ph.D. Auburn, P.E.; M. O. Pace, Ph.D. Tennesee; R. C. Gonzalez, Ph.D. Northwestern; D. Rosenberg, Ph.D. Tennessee; J. M. Rochelle, Ph.D. Tennessee; H. P. Neff, Ph.D. Auburn, P.E.; M. O. Pace, Ph.D. Tennesee; R. C. Gonzalez, Ph.D. Northwestern.

Assistant Professors:

Assistant Professors:
D. Brzkazick, Ph.D. Florida University; J. M. Chapman, Ph.D. Tennessee.

Research Assistant Professor:
M. A. Scott, Ph.D. Tennessee.

Undergraduate

The Bachelor of Science in Electrical Engineering is planned to provide a foundation in both the basic sciences and specialized areas of modern technology. The course of study also contains a suitable amount of cultural work to enhance the growth of the student toward the goal of becoming a professional person with strong social awareness. In the senior year, the student may specialize in any one of the following areas of electrical engineering: bioelectric engineering, computer engineering, electromagnetic fields and communications, electronics and instrumentation, energy conversion and power systems, plasma and electro-optics engineering, and systems and networks. All of these areas except the bioelectric engineering option are continued through the M.S. and Ph.D. programs. The senior year curriculum is sufficiently flexible to allow a student to take several courses outside of the chosen area of specialization.

Generally, all sophomore and junior course work is offered every quarter and the senior work is scheduled so that the student may enter at the beginning of any quarter. This arrangement allows maximum flexibility, since the student may select the normal four-year schedule, may choose to graduate in three calendar years, or may take the Cooperative Engineering Program. In addition to the usual research and teaching facilities in the computer, electromechanical, solid state devices, and control equipment, the department has both digital and analog computers.

PROGRESSION TO UPPER-DIVISION STATUS

Progression of electrical engineering majors to the upper-division programs of the department is competitive and is based on the space available in the department. Factors considered in the decision include overall academic performance, grades earned in courses required in the lower-division curriculum of the College of Engineering, and seriousness of purpose and interest in departmental programs as exemplified by time spent on the normal four-year schedule, may choose to graduate in three calendar years, or may take the Cooperative Engineering Program. In addition to the usual research and teaching facilities in the computer, electromechanical, solid state devices, and control equipment, the department has both digital and analog computers.

PROGRESSION TO UPPER-DIVISION STATUS

Progression of electrical engineering majors to the upper-division programs of the department is competitive and is based on the space available in the department. Factors considered in the decision include overall academic performance, grades earned in courses required in the lower-division curriculum of the College of Engineering, and seriousness of purpose and interest in departmental programs as exemplified by time spent on the normal four-year schedule, may choose to graduate in three calendar years, or may take the Cooperative Engineering Program. In addition to the usual research and teaching facilities in the computer, electromechanical, solid state devices, and control equipment, the department has both digital and analog computers.
quarterm hours in departmental courses before evaluation if EE 2030 transfer credit is given. Those who are not accepted into the upper-division program of the department will not be permitted to register for any upper-division courses in the department. Such students will also be counseled and advised of certain educational alternatives.

MASTER OF SCIENCE PROGRAM
Graduate work leading to the Master of Science degree is offered during one academic year of full-time study or the degree may be obtained in two or three years of study in the evening. Graduate assistantships and scholarships are available for outstanding students. Graduate assistants may obtain the master's degree in one calendar year.

Course work leading to the degree of Master of Science in Electrical Engineering is offered in the evening. Each course meets for two and one-half hours each week.

THE DOCTORAL PROGRAM
Graduate work leading to the degree of Doctor of Philosophy with a major in electrical engineering is offered. The department also participates in the engineering science doctoral program.

General policies of the Graduate School, regarding grades, examinations, and admission to candidacy requirements are explained in the Graduate Catalog.


3010 Transient Analysis (3) Analysis of transient response of networks and systems; Laplace transform method and classical differential equation methods for system analysis; complex frequency concept and pole-zero concepts; application to engineering problems. Prereq: 2030. E.


3050 Basic Field Theory (3) Forces between charges, electricity and magnetism, law of gravitation, force, energy, potential, and line integrals, material bodies, polarization, magnetic circuits, Maxwell's equations, dynamic potentials. Prereq: Math 2860. E.

3060 Propagation I (3) Propagation of waves in transverse wave systems; the guided wave concept and reflection and refraction analysis of waves, standing wave and travelling wave measurements. Introductions to impedance, transmission line, waveguide, microwave circuits, graphical and computer aided design methods. 3 hrs. including bi-weekly lab. E.

3080 AC Power (3) Magnetic circuits, iron core coiled transformers, construction, calculation of performance from the equivalent circuit, parameters for the equivalent circuit, equivalent circuit, equivalent circuit, the "per unit" notation; induction motors, construction, features, analysis of performance using equivalent circuits, 1-phase and 3-phase applications. Prereq: 3050. Includes bi-weekly lab. E.

3090 Energy System Operation (3) Power system component modeling and system structure. Basic analysis techniques for power generations, transmission, storage, transient stability, faults, and system protection. Prereq: 3080. E.

3100 Random Signals and Noise in Engineering (3) Theory of random signals and spectral analysis of noise as applied to electronic systems. Random signal response of linear systems. Transformation of random signals by non-linear networks. Prereq: 3080 and 3400. 3 hrs. including biweekly lab. E.

3110 Basic Electrical Engineering—Circuits and Fields (3) For non-electrical engineering majors. Prereq: Math 2850, Physics 2310-20. 3 hrs. including biweekly lab. E.

3120 Basic Electrical Engineering—Electronics (3) For non-electrical engineering majors. Prereq: 3110. 3 hrs. including biweekly lab. E.

3130 Basic Electrical Engineering—Mechanics (3) For non-electrical engineering majors. Prereq: 3110. 3 hrs. including biweekly lab. E.

3180 Logic Design of Digital Systems (3) Introduction to Boolean algebra and design of combinational and sequential systems. Use of standard logic structures and system components to include basic structure and function of Arithmetic, Storage, Input/Output, and Control System. Instruction set capabilities and machine language programming. Prereq: 3040. (Same as Computer Science 3180). E.

3190 Plasma I (3) Engineering applications of physical electronics, magnetic confinement, and related devices. Topics include electron precipitators and plasma light sources, laser operation and applications (electro-optics), and microwave theory and applications. Prereq: Math 2860. 3 hrs. including biweekly lab. Prereq: Physics 2330 and EE 3000. E.

3720 Linear Systems Analysis (3) Steady-state and transient response; log-frequency, gain-phase, and polar plots; block diagram transformation; signal flow graphs; analogous systems, properties of second order systems; introduction to feedback theory; stability criteria. Prereq: 3010 and Math 3150; coreq: 3180. 3 hrs. including occasional labs. E.

3810 Basic Electronics I (3) Band theory fundamentals; theory and applications of p-n junctions; simple power amplifiers and detectors; transistors and applications in simple circuits. Prereq: 2020. 3 hrs. including project laboratory. E.

3820 Basic Electronics II (3) Physical operation of bipolar transistors and vacuum tubes with applications in basic amplifiers. Integrated circuit fundamentals. Prereq: 3810. 3 hrs. including project laboratory. E.

3830 Basic Electronics III (3) Frequency and transient response of openloop transistor amplifiers. Theoretical fundamentals of integrated circuit operational amplifiers and applications in basic feedback configurations. Basic digital switching circuits. Prereq: 3820. 3 hrs. including project laboratory. E.

4020 Direct Energy Conversion (3) Background physics: conversion devices including photovoltaic power sources, thermoelectric generators and heat pumps, magnetic, thermodynamics, fuel cells, and related aspects of dc-ac inversion and energy storage. Prereq: 3810, 3090.

4080 Microwave Circuits and Electronics (3) Scattered wave description of circuits, to include isolators and amplifiers, couplers, transformers, circulators, phase shifters, loading and interconnection of systems. Power generation and amplification by vacuum devices. Microwave electronics. Prereqs: Microwave switching, filtering and multiplexing. Prereq: 3060. 3 hrs. including biweekly lab. E.


4210 Introduction to Artificial Intelligence (3) (Same as Computer Science 4210.)


4370 Introduction to Feedback System Design (3) Mathematical formulation of control systems; stability criteria and error constants; root locus methods; optimum gain adjustment; compensation networks; introduction to compensation. Prereq: 3720. Lab optional.

4381 Introduction to Applied Modern Control Theory (3) Project-oriented course stressing applications of optimal control theory. Topics include state-space representation of systems, controllability and observability, minimum principle, contribution of the Hamilton-Jacobi equation for deterministic systems, optimal linear systems design with quadratic criteria, pole placement and observers for linear systems, stability theory. Prereq: 3720, Computer Science 3150, Math 2860 and 4120.


4410 Power System Components and Control (3) Modeling of transmission lines and cables; R-L-C calculations and power flow limitations. Control of real and reactive power flows in interconnected power systems; the PF and QV control problems. Prereq: 3090.


4430 Transmission, Distribution, and Protection (3) Studies in underground and d. c. transmission; consideration of over-voltages and insulation requirements; system protection against faults. Prereq: 3060, 3090.

4445 Introduction to High Temperature Plasmas (3) Basic concepts of plasma physics relevant to fusion plasmas. Electrodynamic, kinetic theory, plasma transport, plasma waves, equilibrium and stability, plasma heating, and radiation processes. Prereq: consent of instructor. (Same as Nuclear Engr. 4445.)

4455 Principles of Fusion Reactors (3) Energy balance of magnetic fusion reactors. Fundamental limits on the performance of fusion reactors, Lawson's criterion, and principles of mainline and alternate magnetic confinement concepts. Prereq: 4445 or consent of instructor. (Same as Nuclear Engr. 4455.)


4465 Introduction to Fusion Technology (3) Those aspects of fusion technology characteristic of fusion energy development. The application of two and three devices. Plasma heating, reactor ignition, control, and power balance. Superconducting magnet technology, diver-
4460 Electric Amplifiers (3) Feedback amplifier principles. Linear and nonlinear operation. Audio and radio frequency power amplifiers. Prereq: 3830. 3720. 3 hrs. including project laboratory.

4690 Communications Electronics (3) Receiver and transmitter circuits for communications. Prereq: 3640, 3830. 3 hrs. including project laboratory.

4700 Digital Integrated Electronics (3) Comparators, logic gates, flip-flops, registers, counters, memories, analog switches, A/D and D/A conversion, clipping, clamping, and sweep circuits. Prereq: 3630, 3180. 3 hrs. including project laboratory.

4740 Integrated Circuits (3) Processing and fabrication of active and passive components for monolithic and hybrid circuits. Design techniques for linear and digital circuits. Prereq: 3830. 3 hrs. including project laboratory.

4750 Interactive Computer Graphics (3) (Same as Computer Science 4750 and Geography 4750.)

4780 Synchronous Machines (3) Construction and application of synchronous machines, analysis of perturbers from equivalent circuit models for round rotor and salient pole machines; Park's transformation to the 2-axis model, use of this model in transient state phenomena and transient troubles and examples of their application in control system. Prereq: 3090.

4790 Controllable Motor Drives (3) Constructional features and design parameters for the usual variations of the d.c. motor; A.C. servomotor; stepping motor; dc motors. Receptance of transformation and examples of their application in control system. Prereq: 3090.

4800 Hardware-Software Interface in Microcomputer Systems (3) (Micro)computer and microprocessor interface design. Hardware-software interaction and trade-off. Priority interrupt systems. Telecommunications. Project oriented, contract course. Completion of two projects, one utilizing a microcomputer and the other a microcomputer, are minimal course requirements. Prereq: 3180.

4810 Discrete-Data Systems (3) Introduction to analysis and design of discrete data control systems using frequency domain techniques. Realtime digital filtering techniques; application of digital computers in closed-loop feedback systems. Prereq: 3720.

4820 Introduction to Pattern Recognition (3) Role of pattern recognition within framework of artificial intelligence. Design of learning and adaptive machines. Typical applications of pattern recognition to problems of practical significance. Use of visual schemes to approach the 2-axis model, use of this model in transient state phenomena and transient troubles and examples of their application in control system. Prereq: Either 3100 and Computer Science 3150, or Statistics 3450 and Computer Science 1510. (Same as Computer Science 4820.)

4830 Digital Image Processing (3) Principles of coding, storing, and processing images by means of digital computers. Computation algorithms for image operations. Prereq: 3100 and Computer Science 3150, or Statistics 3450 and Computer Science 1510. (Same as Computer Science 4830.)

4850 Small Computer Systems (3) Basic structure of small computer systems, input-output techniques, interrupt structures, peripheral devices, system software, and assembly language programming. Course is project oriented. Prereq: Basic Eng. 1410. Computer Science 1510 or 3150, or consent of instructor. (Same as Computer Science 4850.)

4910-20-30 Special Electrical Engineering Problems (3,3,3) Problems in electrical engineering involving library and experimental research.

GRADUATE Consult the Graduate Catalog for listing of graduate level courses.

Engineering Physics

Professor W. M. Bugg (Head); Physics staff as shown on following page.

The curriculum in engineering physics is designed to fulfill the educational requirements for professional work in various fields of applied science which are based upon a thorough knowledge of physics. The first two years are concerned with fundamental courses in engineering, science, and mathematics. In the upper division, the curriculum allows some choice of courses in engineering and in physics depending upon the interests of the student. The undergraduate program is a complete, professional program, equipping the student for entry into a variety of work in industry and research. The program also leads to graduate work in either physics or engineering.

The courses in the engineering physics curriculum are shown in tabular form on page 122. Descriptions of the physics courses are found on page 198.

Engineering Science and Mechanics

Professors:

Research Professor: T. F. Moriarty, Ph.D. Illinois, P.E.

Associate Professors:
J. E. Caruthers, Ph.D. Georgia Institute of Technology; R. C. Engels, Ph.D. Virginia Polytechnic Institute, A. Mathews, Ph.D. Illinois, P.E.; C. J. Myers, Ph.D. Indiana University, W. E. Scott, Ph.D. Johns Hopkins; M. O. Soliman, Ph.D. Tennessee; P. E.; J. Steinhoff, P. E. Chicago; J. E. Stoneking, Ph.D. Cincinnati, P. E.

Assistant Professors:
J. A. M. Boulet, Ph.D. Stanford; W. F. Jones, Ph.D. Clemson.

The curriculum in engineering science provides students an opportunity for education with breadth in engineering science, mathematics, and physical (or biological) science. Such a program prepares students for a career in engineering development and research, professional education at the M.S. level, or additional graduate study leading to the master's or the doctoral degree. The curriculum provides students with broad engineering education which permits a strong emphasis on engineering principles and basic science.

In the first two years students in the engineering science program study engineering, science, and mathematics. The engineering science program in the upper-division years is essentially an elective curriculum which provides for those special interests of students not accommodated in other programs. Examples of special interest electives currently available in the
engineering science program are biomedical engineering, engineering mechanics, engineering materials, environmental sciences, engineering materials, and non-destructive evaluation. Other elective groups are currently being developed and will be available in the future.

The basic engineering sciences elective group provides the basic background for an engineer to contribute to the fields of biology and medicine in such technical areas as the design of research and diagnostic equipment, the development of artificial organs, and the application of the engineering sciences to further the basic understanding of biological systems. With some modifications, the program can emphasize other areas such as the use of computer systems to automate hospital operations, analyze medical data, and contribute to the broad area of health care delivery systems. Interested and qualified students may choose to use this program as a background for graduate study in engineering or the life sciences. The program includes the courses required for entrance into most medical schools, including the University of Tennessee Center for the Health Sciences in Memphis.

The engineering mechanics elective group focuses on analytical, computational, and experimental methods used in investigating the interaction of forces and matter. It is designed to help students become capable of engaging in research and development in industrial and governmental research laboratories. Because such preparation involves emphasis on the link between the basic sciences and engineering fundamentals, the engineering mechanics elective group provides a good theoretical background for students wishing to pursue engineering graduate studies. The engineering analysis and synthesis elective group affords a concentration on the application of such mathematical techniques as numerical analysis and simulation for the solution of practical engineering problems. As such, heavy emphasis is placed on the use of digital computers.

The environmental sciences elective group provides the opportunity for the student to apply engineering principles to the solution of environmental and ecological problems. This program gives the necessary background to achieve a high level of competence in professional practice or graduate study.

The engineering materials elective group provides background in the use of materials in the solution of engineering problems. This includes the selection of the proper materials to support the anticipated loads during the design life of the structural system. There is a special need in industry for individuals with background in both stress/structural analysis and materials properties. The engineering mechanics elective group provides the student an opportunity to acquire this background.

The non-destructive evaluation elective group provides background in the application of techniques for evaluating material properties and determining material flaws. Demand for this background is increasing in high technology industries. Techniques studied include ultrasonics, X-rays, dye penetration, and radiometry.

The basic engineering sciences curriculum provides an opportunity to study significant blocks of the engineering science areas recognized by the American Society for Engineering Education: (1) mathematical sciences; (2) electrical science, electric and magnetic fields, circuits, and electronics; (3) thermodynamics and statistical mechanics; (4) materials science; (5) information science; (6) transfer and rate processes such as heat, mass, and momentum transfer; and (7) environmental sciences. No student will study all the engineering sciences but will structure a course plan to provide depth in some of the engineering sciences.

Because of the large number of elective courses to be selected in the engineering science degree program, faculty advising plays an essential role in the process of developing the student's course of study. Before the end of the sophomore year, students in the engineering science program are required to develop, in concert with a faculty advisor, a statement of objectives and a course plan for the upper-division years.

For students with more than 90 quarter hours, this course plan must be filed with the Office of Administration and Records before they can register for additional courses, and before a senior standing sheet can be prepared.

MASTERS OF SCIENCE AND DOCTORAL PROGRAMS

Graduate programs leading to the degrees of Master of Science and Doctor of Philosophy in engineering science are available to graduates of recognized curricula in engineering, mathematics, or one of the physical or biological sciences. Program options include solid mechanics, fluid mechanics, biomedical engineering, and other engineering sciences. In the biomedical and engineering science option, interdisciplinary programs are arranged to meet individual needs or interests. Each applicant is advised as to any prerequisite courses before entering a program; the student's program of study must be approved by his or her advisory committee, and must comply with the requirements of the Graduate School. The student's major professor may be selected from a department other than the Department of Engineering Science and Mechanics.

The flexibility and interdisciplinary aspects of the program options are intended to be of particular interest to prospective students currently employed in research, development, or design activities and whose interests in continuing education (either full-time or part-time) lie at one of the interfaces between science and engineering, or can best be met by interdisciplinary study in engineering. The department's course offerings and research activities are also intended to meet the needs of students who seek preparation for employment in engineering areas requiring specialization in mechanics, or in related interdisciplinary studies.

General policies of the Graduate School relating to admission, residence, examinations, and research are described in the Graduate Catalog.

Engineering Science and Mechanics (335)

2720 Dynamics (3) Absolute and relative kinematics of rigid bodies; kinetics of rigid bodies using Newton's laws, work-energy, and conservation of momentum. Prereq: Basic Engr. 1320, Math 2840.


3110 Fluid Mechanics (3) Basic conservation laws of fluids, integral forms, heat, work, differential forms, variables, circulation, wave motion, and irrotational flow. Prereq: 2720 or 3700, Math 2840.

3120 Fluid Mechanics (3) Compressible flow, isentropic flow, shocks, duct flows with heat transfer and friction; open channel flow, best cross-section, energy methods; pumps and turbines, similarity, and performance analysis. Prereq: 3110; Coreq: 3129.

3129 Fluid Mechanics Laboratory (1) Experiments to amplify and support 3120. To be taken concurrently with 3120.


3311 Mechanics of Materials (4) Concepts of stress and strain; stress strain relations and Mohr's circle; static analysis of members; area moment of inertia; stress and displacement analysis of axially-loaded members; torsion; bending. Not for departmental graduate credit. Prereq: Basic Engr. 1310; coreq: Math 2840.

3410 Introduction to Biomedical Engineering (4) Introduces the facets and opportunities of biomedical engineering and provides basic terminology and background knowledge for further courses in the field. Subjects include anatomy, physiology, biometrics, and medical imaging. Prereq: Math 1130 or BE 130; Coreq: Math 2840 or consent of instructor.

3420 Introduction to Clinical Engineering (3) Introduces students to the clinical/hospital setting; description of health care delivery systems; hospital organization and structure; clinical use of biomedical equipment; equipment acquisition, principles of safety engineering in the hospital and applicable codes, standards and regulations. Prereq: 3410, Physics 2320, or consent of instructor.

3700 Dynamics (4) Kinematics of rigid bodies; mass moments of inertia; coulomb friction; kinetics of rigid bodies using force, mass, acceleration; work-energy; impulse-momentum. Not for departmental graduate credit. Prereq: Basic Engr. 1320, Math 2840.

3710 Intermediate Dynamics (3) Three-dimensional kinematics of particles and rigid bodies; dynamics of bodies with varying force, mass, acceleration; work-energy; impulse-momentum. Not for departmental graduate credit. Prereq: Basic Engr. 1320, Math 2840.

4010 Project in Design and Development (4) Investigation, design, and report of an engineering science project. Prereq: Student in good standing and a grade of C or better in 3110, 3700, and 3110.

4020 Computer-Aided Design (3) Use of computer graphics and analysis programs for design of selected systems, structures, and components. Evaluation of design alternatives. Prereq: 4810 or consent of instructor.

4011 Project in Design and Development (3) Investigation, design, and report of a project in the engineering sciences. Prereq: 4010.

410 Materials of Engineering (3) Obtaining and processing data on mechanical properties of engineering materials for use in design; emphasis on time-dependent and cyclic properties, deformation, creep, fatigue, and wear. Prereq: 4 hrs. and 1 lab. Prereq: 3311 and Materials Science and Engineering 2110.

4520 Biomedical Fluid Mechanics (3) Discusses objectives, review foundations, and present current developments in biopulsion fluid mechanics. Properties of human blood and blood vessels, analysis and measurement of flow and pressure in arteries, non-newtonian flow with its sumations of forces, and microcirculation. Applications to areas of hemolysis,
thrombosis, and fluid dynamics of artificial internal organs. Prereq: 3110 or consent of instructor.

4530 Biomechanics (3) Discusses objectives, review foundation, and updates developments in areas of biomechanical properties of living tissue, biomechanics of injury and prostheses, material compatibility of prosthetics, and industrial biomechanical problems related to impact. Prereq: 3311, 3700 or 2720.

4540 Fracture-Safe Design (3) A critical review of biomechanics of materials that are indicative of fracture, including transition temperature, R-curves, stress intensity factors, and J-integrals; the use of these properties in design. 3 hrs. or 2 hrs. and 1 lab. Prereq: 3311 and Met. Engr. 2110. (Same as Met. Engr. 4540.)

4550 Design of Artificial Internal Organs (3) Study of the design, development and evaluation of artificial internal organs including Federal regulation and ethical considerations. Review of currently available devices and new developments. Prereq: 3110, 3410, Math 2850.

4560 Principles of Non-destructive Testing (3) (Same as Physics 4560.)

4590 Magnetic Induction Phenomena (3) (Same as Physics 4590.)

4610 Experimental Stress Analysis (3) Basic concepts: theory, techniques, and instrumentation of resistance strain gauges; theory and techniques of brittle coating method; introduction to other stress analysis methods. Prereq: 3311, Elec. Engr. 2020 or 3110, 2 hrs. and a 3-hr. lab.

4620 Dynamic Data Acquisition (4) Instrumentation of measuring systems for dynamic events and responses; signal conditioning; oscillographs, oscilloscopes, and magnetic tape recording; telemetry and data transmission; data processing. Prereq: 3311, 4710, Elec. Engr. 3120. 3 hrs. and a 3-hr. lab.

4630 Introductory Photomechanics (3) Introduction to photoelasticity, photoelastic coating method, Moire method, interferometry, and holography. Prereq: 3311, Physics 2320. 2 hrs. and a 3-hr. lab.

4710 Fundamentals of Vibrations (3) Free and forced vibrations of damped and undamped lumped paramter systems; energy methods, free vibration of continuous bodies. Prereq: 2720 or 3700, Math 2860.


4810 Engineering Analysis (4) Integration of fundamental physical laws and mathematical methods of analysis with emphasis on numerical analysis and digital computer solutions of engineering problems. Prereq: 3110, 3311, and Computer Science 3150.

4820 Engineering Analysis (3) Dimensional analysis and similitude; Buckingham's Theorem; model testing; dimensional equations and similarity. Prereq: 3110, 3311, 3700.

4850 Elementary Structural Matrix methods (4) (Same as Architecture 4850 and Civil Engineering 4850.)

4910-20 Special Engineering Science Topics (3,3) Problems related to recent developments and practices. Open to juniors or seniors with consent of instructor. May be repeated for credit once.

GRADUATE Consult the Graduate Catalog for listing of graduate level courses.

Industrial Engineering (556)

Professors: J. N. Snider (Head), Ph.D. Ohio State; P.E.; W. W. Claycombe, Ph.D. V.P.I. & S.U.; P.E.; E. L. DePorter, Ph.D. V.P.I. & S.U.; D. C. Doulet, M.S. Tennessee, P.E.; H. E. Emerson (Emeritus); S.B. Massachusetts Institute of Technology, P.E.;


Associate Professors: D. H. Hutchinson, Ph.D. Georgia Institute of Technology; K. E. Kirby, Ph.D. Tennessee.


Instructor: D. D. Ford, M.S. Tennessee.

Lecturers: J. A. Bontadelli, Ph.D. Ohio State; S. Douglass, Ph.D. Tennessee; J. C. Mitchell, Ph.D. Vanderbilt.
in workplace layout; working environment specifications; work place layout; service areas, inventory control applications, and operating procedures design. Prereq: 3630, 4520, and Engr. Mech. 3310.

4200 Production Facilities Design (4) Design of production facilities including materials handling, plant layout, service areas, inventory control applications, and operating procedures design. Prereq: 3630, 3510-20, 4060, 4520.


4250 Work Measurement Applications (3) Application of learning curves, queueing theory, standard data methods, and incentive systems to the design of industrial work situations. Prereq: 3630.

4310 Seminar (1) Discussions, lectures, and trips to unify student’s educational experience. Prereq: Senior standing in industrial engineering.

4520 Engineering Economy (3) Methods and problems in selection or replacement of equipment. Decisions among engineering alternatives involving capital recovery, economic life of equipment, and rate of return on investment.

4530 Case Studies in Engineering Economy (3) Extension of basic engineering economy principles to actual problems faced by competitive firms and regulated industries. Case studies taken from literature form basis of classroom discussion. Out-of-class assignments may include working with companies to evaluate make or buy options, leasing versus cash purchases, equipment replacement studies, energy source economies, etc. Prereq: 4520.

4540 Industrial Development (3) Factors other than management activity which enter into successful establishment of manufacturing enterprise. Cost and location studies and market analysis to determine the commercial feasibility of new plants or projects.

4560 Production Systems Planning and Control I (3) Design of workplace layout, flow, layout, and activity chart analysis. Applications of time studies, cost analysis, and material requirements planning. Prereq: Junior standing in College of Engineering consent of instructor.

4600 Determined Time Systems (3) Work design and measurement using a predetermined time system as the basis for determining the performance of individual employees. Prereq: 3630.

4610 Human Factors in Work Design II (3) Human capabilities and limitations affecting workplace layouts, working environments, design of tools and equipment, and communication and response in machine systems. Prereq: 3630, 3630, or consent of instructor.

4830 Health Systems Engineering (3) Hospital management systems and means by which they may be improved through application of modern industrial engineering principles and techniques. Prereq: 3620.

4840 Industrial Plant Problems Analysis (3) Analysis of typical industrial problems, application of industrial engineering, field assignment in local industry, problem definition, analysis, and presentation. Prereq: 3340, 3440, 3510, 3520, 4520, 4680.

4870 Mini-Computer Applications in Industrial Engineering (3) Introduction to computer hardware and micro-computer interfaces; emphasis on small computers as an element of larger system; applications and limitations of small computers in solving industrial engineering problems. Prereq: Senior standing.

4910-20-30 Special Industrial Engineering Topics (3,3,3) May be repeated for credit. Prereq: Consent of instructor.

4950 Industrial Safety (3) Development of organization and programs for prevention and control of accidents with emphasis on OSHA Rules and Regulations. Prereq: Senior standing.

GRADUATE
Consult the Graduate Catalog for listing of graduate level courses.

Materials Science and Engineering

Professors: J. E. Spruille (Head), Ph.D. Tennessee; D. C. Bogue, Ph.D. Delaware; B. S. Borshe, Ph.D. Massachusetts Institute of Technology; C. R. R. Brooks, Ph.D. Tennessee; R. A. Buchanan, Ph.D. Vanderbilt; E. S. Clark, Ph.D. California (Berkeley); D. A. Cronin, Ph.D. Lehigh; J. F. Fellers, Ph.D. Akron; J. S. Lin, Ph.D. Kansas; C. D. Lundin, Ph.D. Rensselaer Polytechnical Institute; C. J. McHargue, Ph.D. Kentucky; K. J. Mackenzie, Ph.D. Cornell; B. F. Oliver, Ph.D. Pennsylvania State; P. J. Phillips, Ph.D. Liverpool (England); E. E. Stansbury (Emeritus), Ph.D. Cincinnati.

Associate Professors: W. T. Becker, Ph.D. Illinois; J. Bentley, Ph.D. Univ. of Salford (England); C. L. Brown, Ph.D. Virginia; D. M. Kroeger, Ph.D. Vanderbilt; W. J. Lackey, Ph.D. North Carolina State; C. T. Liu, Ph.D. Brown University; A. J. Pedraza, Ph.D. National University (Argentina); C. L. White, Ph.D. Michigan Tech. University.

Lecturer: George D. Wignall, Ph.D. Sheffield (England).

BACHELOR OF SCIENCE PROGRAM
The department currently offers an undergraduate curriculum in Metallurgical Engineering. This curriculum is designed to provide education and training in the fundamental and engineering sciences with special attention given to the production, development, and utilization of engineering materials. Emphasis is placed on developing the expertise needed to participate in selection and development of materials for the major engineering systems of the future. The first two years of the curriculum is similar to that of the other engineering disciplines and, hence, students in other engineering curricula may transfer into the program during the sophomore year. The curriculum is arranged to provide a central core of courses with flexibility in the upper-division years to permit emphasis on preparation for graduate study or technical employment. By judicious choice of technical electives, a student can develop a broader materials perspective (e.g., polymer engineering, ceramic materials) or a specialty area (e.g., materials processing, mechanical behavior of materials, corrosion behavior).

A minimum of 24 quarter-hours of humanities-social studies courses must be taken. The above courses are selected from the list provided in a prior section of this catalog entitled Curricula in Engineering (p.). A minimum of 12 hours must be taken from a single subgroup under one of the three major headings.

Graduation in metallurgical engineering requires a minimum grade point average of 2.00 for all departmental courses.

PROGRESSION TO UPPER-DIVISION PROGRAMS
Progression of metallurgical engineering students to departmental Upper-Division courses is competitive. Factors considered include overall grade point average, performance in selected lower-division courses and evidence of satisfactory and orderly progress through the prescribed curriculum.

UPPER-DIVISION STATUS: A Lower-Division student formally applies for Upper-Division Status after completing 80 quarter hours of Lower-Division coursework with an overall GPA of at least 2.4. This must include Materials Science and Engineering 2010 and 2030.

PROVISIONAL STATUS: Students who have completed 80 quarter hours of Lower-Division engineering curriculum course work with an overall GPA between 2.0 and 2.4 may apply for provisional status. The granting of PROVISIONAL UPPER-DIVISION STATUS is based on the availability of space in the departmental programs after UPPER-DIVISION STATUS students have been accommodated. Provisional students are required to demonstrate satisfactory performance in upper-division courses by attaining a minimum GPA of 2.0 in at least 12 hours of 3000-level required courses specified by the department. Further progression to upper-division courses is dependent upon this minimum level of performance.

Any metallurgical student with an overall GPA below 2.0 will not be admitted to upper-division Metallurgical Engineering courses. Students who have not been admitted to an Upper-Division Status will be dropped from departmental class rolls.
or 2030 with emphasis on materials of significance in aqueous, and gaseous environments. Prereq: 2110 with emphasis on mechanisms and control of reaction.

3150 Engineering Materials V (3) Extension of 2110 with emphasis on materials processing, specification, and control. Prereq: 2110 or 2030 with emphasis on significance in nuclear engineering; nuclear reactor construction materials, nuclear fuel materials, and interaction of radiation with materials. Suggested for nuclear and mechanical engineering.

3170 Engineering Materials VII (3) Extension of 2110 or 2030 to biomedical applications of materials. Engineering materials in biomedical applications; metals, polymers, and ceramics; prosthetic devices; dental applications; corrosion problems; failure analysis; fabrication. Prereq: 2110 or equivalent.

4510 X-Ray Diffraction and Its Application (4) Lectures and laboratory work in the basic principles and applications of x-ray diffraction from materials. Diffraction theory, powder technique, precision lattice constants, identification, preferred orientation. 3 hrs. and 1 lab.

Metallurgical Engineering (679)

3010 Industrial Inspection Trips (1) Technology of metallurgical industries, emphasizing Tennessee industry; plant trips. S/JNC.

3040 Metallurgical Thermodynamics (4) Applications of laws of thermodynamics to problems of metallurgical interest. Second law and entropy; auxiliary functions; relationship between free energies and phase diagrams; reaction kinetics, equilibrium between gases and condensed phases. Use of heat capacity and free energy data in calculations. Concepts of activity and activity coefficient with T, P, and composition. Prereq: Materials Science and Engr. 2020; Chemistry 1130; coreq: Math 2840. 3 hrs. and 1 lab period.

3050 Production Metallurgy (3) Principles of casting, smelting, and refining. Gas liquid equilibria, slag-metal processes and solution behavior, correlation with phase diagram; kinetics of reactions, rate laws, activated complex theory, adsorption and catalysis and applications. Prereq: 3040; Chem. Engr. 3410 and 3420 or equivalent.

3210 Plastic Deformation (4) Phenomena and theory of plasticity of single and polycrystalline materials. Applicable concepts of crystallography and x-ray diffraction; use of stereographic projections. Prereq: Chem. Engr. 2030. 3 hrs. and 1 lab. F.

2220 Diffusion and Annealing (3) Introduction to solid state kinetics: point defects, solute diffusion, equations and mechanisms, annealing of cold worked structures. Prereq: 3040. W.

2230 Phase Transformations (4) Thermodynamic and structural factors governing binary equilibrium, ternary systems, aging in Al-Mg systems, and precipitation phases and phase transformations in simple and complex systems. Prereq: 3220. 3 hrs. and 1 lab. S, F.

3520 Materials Behavior and Chemical Process Equipment (3) Basic chemical, mechanical, and chemical considerations in design of chemical processing equipment. Prereq: Materials Science and Engr. 2030 or equivalent; 3150; Chem. Engr. 3420.

3710 Metallurgical Applications in Manufacturing Technology (3) Fabrication methods and principles of mechanical/thermal processing for finished and semifinished articles: casting, powder metallurgy, plastic forming, joining, heat treatment. Prereq: 2110.

4010-20 Thesis (3-6, 3-6) Investigation and report on metallurgical engineering problem. By prior approval of professor.

4230 Project Laboratory (3) Laboratory investigation of polymer engineering problem. Written report required for each quarter.

4910 Applied Polymer Science (3) First course in physical properties of polymers. Polymer structure, crystalline and glass transitions, physical properties of amorphous and crystalline polymers, crystallization kinetics, and mechanical properties are discussed. Prereq: Senior standing in engineering or science. Not for graduate credit by polymer engineering majors.

4920 Polymer Processing (3) Rheological properties of polymer melts and solutions, viscometry, unit operations of fibers, plastics, and rubber industries: dimensional analysis and scale-up, flow through pipes and capillaries, screw extrusion, spinning of fibers, injection molding. Prereq: Senior standing in engineering or science. Not for graduate credit by polymer engineering majors.

4930 Principles of Fiber and Textile Engineering (3) Chemical and crystalline structure of important fibers, melt, wet and dry spinning of man-made fibers; drawing and drawing; preparation of yarn, dyeing, weaving, and knitting. Emphasis on quantitative aspects. Prereq: Senior standing in engineering or science.

4940 Plastics Fabrication Operations (3) Lecture and laboratory course treating unit operations of plastics industry. Types and mechanisms of operation of machinery used and structure and properties of fabricated parts. Operations to include extrusion, co-extrusion, injection molding, blow molding, rotational molding, forming, blowing, molding, rotational molding, etc. Prereq: Senior standing in engineering or science.

Graduate Catalog for listing of graduate level courses.

Rheological properties of polymer melts and solutions, viscometry, unit operations of fibers, plastics, and rubber industries: dimensional analysis and scale-up, flow through pipes and capillaries, screw extrusion, spinning of fibers, injection molding. Prereq: Senior standing in engineering or science. Not for graduate credit by polymer engineering majors. F.

4920 Polymer Processing (3) Rheological properties of polymer melts and solutions, viscometry, unit operations of fibers, plastics, and rubber industries: dimensional analysis and scale-up, flow through pipes and capillaries, screw extrusion, spinning of fibers, injection molding. Prereq: Senior standing in engineering or science. Not for graduate credit by polymer engineering majors. F.

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Graduate Catalog for listing of graduate level courses.

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solid and fluid mechanics, thermodynamics, heat transfer, structures, vibrations, mechanical design, and manufacturing processes, and instrumentation in order to resolve the complex engineering problems of the real world.

**PROGRESSION TO UPPER-DIVISION PROGRAMS**

Progression to Upper Division Programs is competitive with respect to the student's performance and capacity. Factors considered include overall grade point average, performance in selected lower division courses, and evidence of satisfactory and orderly progress through the program of work. Full Status: A Lower Division student in the department may apply for progression to Upper Division Programs after completing 81 quarter hours of Lower Division engineering curriculum course work with an overall GPA of at least 2.4.

**Provisional Status:** Students who have completed 81 quarter hours of Lower Division engineering curriculum course work with an overall GPA of 2.0 and a concurrent GPA of 2.0 may apply for provisional status. The granting of Provisional Status is based on the availability of space in departmental programs after Full status students have been accommodated. Provisional Status students are required to demonstrate their abilities to perform satisfactorily in Upper Division courses by attaining a minimum GPA of 2.0 in at least 12 hours of 300-level required engineering courses (including 9 specified hours in the department). Further progression to upper division courses is dependent upon this minimum level of performance. Any student with an overall GPA below 2.0 will not be admitted to mechanical or aerospace engineering courses with the exception of ME and Aero Eng. 2040. Students who have not been progressed to an Upper Division Program will be dropped from departmental class rolls.

**TRANSFER STUDENTS** at the Upper Division level are admitted on a Provisional Status basis only. Any student presenting more than 24 hours of 300-level required engineering curriculum course work by Transfer Credit is considered a Transfer Student.

**LOSS OF FULL STATUS**

Students who progress to Upper Division Programs are expected to maintain an overall GPA of at least 2.0 and a concurrent GPA of at least 2.0 in departmental courses. Failure to maintain these minimum levels of performance will result in a review of the overall progress of the student through the prescribed curriculum and probable loss of Full Status.

**GRADUATE STUDY PROGRAMS**

Graduate programs leading to the degrees of Master of Science, Master of Engineering, and Doctor of Philosophy with specialization in mechanical engineering or aerospace engineering are available to graduates of recognized undergraduate curricula in mechanical or aerospace engineering and to graduates of other curricula who satisfy the necessary prerequisite courses. The general requirements for advanced degrees are summarized in the Graduate Catalog.
4710 Thermal Environmental Systems (3) Vapor compression and absorption cycles; heat pumps; building control systems; air conditioning systems; heating systems; air quality; psychrometrics. Prereq: 3330, 3440. A.

4720 Thermal Environmental Systems (3) Design analysis of air washers, cooling towers and extended surface coils; solar radiation; building heat transmission; physiological effects. Prereq: 4420, 4710.


4740 Solar Energy Utilization (3) Nature and availability of solar radiation; review of selected heat transfer topics pertinent to solar energy collection and use; design analysis of solar energy collectors and method of storage; selected applications. Prereq: 3321, 4420, or consent of instructor.

4770 Thermal Engineering I (3) Analysis of selected topics in thermal engineering including modeling of thermal systems and components; energy resources, environmental impact, combustion, turbomachinery, hydrodynamic lubrication. Prereq: 3330 and Aerospace Engr. 3511. F, W.

4780 Thermal Engineering II (3) Analysis of selected topics in thermal engineering including modeling of thermal systems and components; multi-mode heat transfer, heat exchanger design, and second law analysis. Prereq: 3330 and 4420. W, S.

4810 Internal Combustion Engines (3) Thermochemical phenomena in combustion and propulsion engines. Combustion, detonation, equilibrium, dissociation. Analysis of internal combustion engines using ideal and real fluids. Prereq: 3330, 3440. S.

5100-20 Selected Topics in Mechanical Engineering (1-4) Problems and topics related to developments and practice in mechanical engineering. Prereq: Consent of instructor.

GRADUATE Consult the Graduate Catalog for listing of graduate level courses.

Aerospace Engineering (018)

2040 Introduction to Aerospace Engineering (1) Presentation and discussion of topics related to aerospace engineering. SNC. F, W, S.

3040 Seminar (1) Presentation and discussion of topics related to aerospace engineering. Prereq: Junior standing. SNC.

3511 Fluid Flow (4) Continuity, momentum, and energy principles in complex beams and structures. Prereq: 3630, 3650, and Computer Science 3150 or consent of instructor. Prereq: 4520. F, W, S.


4830 Manufacturing Processes (3) Comparison of machining methods; plastic production; metrology. Prereq: 3650 or consent of instructor. A.

4832 Tool Design (3) Principles underlying tool and die design, design of high-volume production tools and molds, work holding fixtures. Prereq: 3650-60 or consent of instructor.

4823 Numerical Control Processing (3) Application of digital computers to machine measurements of force, length, time, temperature, pressure, transport rates, and physical properties. Planning, conducting, analyzing, and reporting experimental tests run according to test standards and other specifications. Prereq: 3620 or Mechanical Engr. 3630, Mech. Engr. 3321, 3410, 3440, and Ind. Engr. 3650 for 4471; 4491-F; 4491-W.

4860 Materials and Manufacturing Process (3) Selection of materials in design process, emphasizing relationship between stress and strain analysis, material properties, environment, temperatuer, manufacturing technology, and cost. Prereq: 3650, 3690.


4891-91 Experimental Mechanical Engineering (3,3) Senior projects. Prereq: 3440 and Engr. Sci. & Mech. 3320 for 4471; 4491-F; 4491-W.

4741-91 Experimental Mechanical Engineering (3,3) Senior projects. Prereq: 3440 and Engr. Sci. & Mech. 3320 for 4471; 4491-F; 4491-W.

4810 Airplane Performance (3) Introduction to airfoil and wing characteristics, drag, propellers, static performance and maneuvers; theory and design of control surfaces; stability. Prereq: 3511, W.

4920 Selected Topics in Aerospace Science (1-4) Current and future problems in aerospace science; topics in science and engineering required for an understanding of the several areas of aerospace science. Prereq: Consent of instructor. Title will vary. May be repeated.

GRADUATE Consult the Graduate Catalog for listing of graduate level courses.

Nuclear Engineering (716)

Professors: H. L. Dodds, Ph.D. Tennessee, P.E.; J. B. Fussell, Ph.D. Georgia Institute of Technology; T. W. Kerlin, Jr., Ph.D. Tennessee; H. C. Roland, Ph.D. Tennessee; T. W. Kerlin, Jr., Ph.D. Tennessee; H. C. Roland, Ph.D.

Associate Professors: E. M. Katz, Ph.D. Tennessee, P.E.; L. F. Miller, Ph.D. Texas A&M; M. B. R. Upadhyaya, Ph.D. California (San Diego), P.E.

'Distinguished Professor of Engineering
Nuclear Engineering/College of Engineering

Honorary Associate Professor:
G. de Saussure, Ph.D. Massachusetts.

BACHELOR OF SCIENCE PROGRAM

The curriculum in nuclear engineering is designed to provide basic training in many of the fields encountered in the applications of nuclear and radioactive materials. The first two years are concerned with the fundamental courses in engineering, physics, mathematics, chemistry, and English. The last two years encompass scientific and engineering courses equipping the student for entry into a variety of work in industry, research, or graduate studies.

MASTER OF SCIENCE AND MASTER OF ENGINEERING PROGRAMS

A graduate program leading to a degree of Master of Science and Master of Engineering is available to graduates of recognized undergraduate curricula in engineering and physics. Each applicant will be advised as to the necessary prerequisite courses before entering the program.

The general requirements of the masters’ degrees are summarized in the Graduate Catalog.

DOCTORAL PROGRAM

A program leading to the Ph.D. degree is available in nuclear engineering. For details, see the Graduate Catalog.

2310-20-30 Seminar (1,1,1) Presentation and discussion of topics related to nuclear engineering. S/NC.


3150 Dynamics and Controls (3) Systems differential equations; solution by classical methods; Laplace transform method; frequency response, stability, and control. Coreq: 4110.

3210-20 Thermodynamics (4,4) Properties and laws of thermodynamic systems. First and second laws used to analyze power plant systems—both fossil and fission. Prereq: Math 2860 and Basic Engr. 1330.


4110-20-30 Introduction to Nuclear Reactor Theory (3,3,3) Nuclear structure; radioactive decay laws; neutron interaction; fission process, chain-reacting systems; diffusion equation including multigroup diffusion theory; neutron moderation; reactivity coefficients; perturbation theory. Prereq: Physics 3730 or consent of instructor.

4210-20-30 Nuclear Engineering Laboratory (3,3,3) Nuclear structure; radioactive decay laws; neutron interaction; fission process, chain-reacting systems; diffusion equation including multigroup diffusion theory; neutron moderation; reactivity coefficients; perturbation theory. Prereq: Physics 3730 or consent of instructor.

4410-20-30 Introduction to Nuclear Reactor Theory (3,3,3) Nuclear structure; radioactive decay laws; neutron interaction; fission process, chain-reacting systems; diffusion equation including multigroup diffusion theory; neutron moderation; reactivity coefficients; perturbation theory. Prereq: Physics 3730 or consent of instructor.


4445 Introduction to High Temperature Plasmas (3) (Same as Elect. Engr. 4445.)

4455 Principles of Fusion Reactors (3) (Same as Elect. Engr. 4455.)

4465 Introduction to Fusion Technology (3) (Same as Elect. Engr. 4465.)

4610-20-30 Reactor Power Systems (3,3,3) Nuclear structure, decay laws, neutron diffusion, time behavior of reactors, heat removal, analysis of reactor power plants; economic, safety, and environmental aspects of nuclear power. Prereq: Math 4610; non-nuclear engineering students only.

4710 Energy Transport (4) Development of differential and integral energy conservation equations; conduction, convection, and radiation heat transfer; application of nuclear reactor fuel elements and heat exchangers. Prereq: 3010.

4720 Reactor Thermal Design (4) Hydrodynamics and heat transfer in boiling systems; boiling crises; fuel element thermal design, steam generator design. Prereq: 4710.

4730 Nuclear Reactor Design (3) First order reactor design, integration with non-nuclear heat transfer and power conversion system, economic evaluation; optimization procedures, description of typical systems. Coreq: 4130.


4820 Reactor Kinetics and Controls (3) Derivation of kinetic equations; basic kinetic parameters; transient response with feedback; control and protective systems. Prereq: 4110.

4840 Nuclear Reactor Safety (3) Presentation of safety concepts and criteria, credible accidents, fission product release and transport, containment systems; accident analysis; engineered safeguards. Prereq: 4120.

4930 Nuclear Fuel Management (3) Discussion of problems associated with processing of nuclear materials; fuel cycle analysis; burn-up calculation. Prereq: 4120.

GRADUATE

Consult the Graduate Catalog for listing of graduate level courses.