Graduate Handbook
Energy Science and Engineering Program

Bredesen Center for Interdisciplinary Research and Graduate Education
The University of Tennessee, Knoxville

Spring 2014 Edition
# Table of Contents

- Executive Summary ................................................................. 3
- Introduction .................................................................................. 4
- Admission Requirements .............................................................. 5
- Diversity and Access ................................................................. 5
- Degree Requirements ................................................................. 5
- Major Professor (Advisor) ............................................................ 5
- Doctoral Committee ................................................................. 6
- Admission to Candidacy ............................................................. 6
- Summer Registration ................................................................. 6
- Doctoral Dissertation Research Credit (ESE 600) ....................... 6
- Graduate Student Examinations ................................................ 7
- Course Requirements ................................................................. 8
- Approved Courses ................................................................. 9
- Departmental Contacts ............................................................. 19
- About Gov. Bredesen ............................................................... 20
Bredesen Center for Interdisciplinary Research and Graduate Education

A new interdisciplinary doctoral degree in Energy Science and Engineering (ESE) has been developed at the University of Tennessee in order to educate students in energy-related fields that are of increasing importance to the state and the country. The ESE Faculty, based both at the University of Tennessee, Knoxville and Oak Ridge National Laboratory, provide research opportunities in various fields relating to the scientific and engineering challenges in energy supply and usage, including impacts on the environment and climate. The curriculum includes graduate courses specifically designed for the ESE program, but also draws on the graduate offerings of other departments and occasionally other universities to provide a broad interdisciplinary foundation for the ESE students. This program was initiated by Governor Phil Bredesen and funded by the State Legislature of Tennessee in 2010. This degree program is administered by the Bredesen Center for Interdisciplinary Research and Graduate Education, which has been established by the University of Tennessee, Knoxville and the Oak Ridge National Laboratory.

Lee Riedinger
Director, Bredesen Center
Professor of Physics
Introduction

The Bredesen Center for Interdisciplinary Research and Graduate Education has developed and offers one of the country’s first interdisciplinary PhD programs for a degree in Energy Science and Engineering. The Bredesen Center expands the graduate research campus of the University of Tennessee, Knoxville (UTK) to include Oak Ridge National Laboratory (ORNL), greatly increasing research opportunities by combining the educational resources of a comprehensive research university and the research capabilities of a major national laboratory. This teaming arrangement provides expanded opportunities for graduate students in energy-related sciences and engineering, fostering interdisciplinary research, large-scale problem-oriented research projects, innovation and entrepreneurship. The ESE PhD offers coursework that serves two purposes - (a) a broadening education in the issues of energy generation and use from many aspects and (b) a deep dive into issues of energy in a given area of research. The students work on doctoral research in one of six initial areas relating to energy in interdisciplinary teams of scientists and engineers working at the UTK and ORNL.

The Bredesen Center offers graduate students opportunities to engage in interdisciplinary research while preserving the rigor and depth of a traditional PhD program. In addition, the ESE graduate curriculum is structured to include educational broadening elements that allow for supplemental studies in entrepreneurship, policy, or other energy-related fields. Entrepreneurial aspects of the program include partnership opportunities with the UTK College of Business Administration in developing and implementing business plans to accelerate the deployment of new technologies, in addition to the opportunity to learn from experience science and engineering entrepreneurs at ORNL. Additionally, the Bredesen Center has developed opportunities for training in policymaking from UTK faculty and ORNL staff with experience in this area. The Bredesen Center is transformational in engaging graduate students in interdisciplinary projects, large-scale problem-oriented research programs, and science-to-applications research opportunities, enabling scientific breakthroughs and innovative solutions to energy-related challenges.

Energy science and engineering is an emerging field of study that builds on the conventional disciplines of science and engineering but is focused on the challenges and issues relating to the development and use of various sources of energy. The issues of energy supply and use provide our country and the world with some of the grandest challenges that citizens and institutions face now and for coming decades. Enabling research and development of alternative energy resources is necessary step towards ending global dependence on fossil fuels and providing renewable and sustainable sources of energy for the world. Electricity from nuclear power is a largely non-carbon based form of energy supply, but has been stalled for decades due to issues of safety, politics, and public acceptance. Electricity from solar or wind farms is increasing in volume, but is not close to being cost competitive and constant in output for mass adaptation. Long-term development of electricity from fusion reactors is proceeding but is still several decades away.
The Graduate Program

Admission Requirements

In order to be admitted to the PhD program in Energy Science and Engineering, student applicants must fulfill the general admission criteria for the Graduate School of the University of Tennessee, Knoxville. In addition, the student must have a Bachelor of Science degree in either engineering or a scientific field (physics, chemistry, biology, mathematics, computational science, etc.), or the equivalent. Students with other undergraduate degrees may also be admitted on a case-by-case basis by the Bredesen Center Graduate Coordinating Committee. Dependent on the student’s background, additional coursework may be required to satisfy co- and prerequisites.

Diversity and Access

Graduate students are nationally recruited for this doctoral program in a large annual campaign led by Oak Ridge National Laboratory. Recruiters from ORNL and the Bredesen Center visit 30 top universities across the U.S., to attend job fairs to advertise this ESE doctoral program and to talk to undergraduates at some of the top universities in the country. Diversity is a strong consideration in this recruitment process. Students are expected to understand and respect the diversity and access policies of UTK and ORNL and to conduct themselves in a professional manner at all times during their time in the program.

Students are expected to complete an orientation session hosted by the Bredesen Center before starting coursework. Additionally, graduate students who will be working at ORNL will be provided with additional supplementary information during a separate ORNL orientation. International students must complete any additional paperwork and training required by UTK or ORNL before set deadlines.

Degree Requirements

This graduate program leads to the Doctor of Philosophy (PhD) degree in Energy Science and Engineering (ESE). A minimum of 72 hours is required beyond the bachelor’s degree, exclusive of credit for a Master’s degree, and completion of the core requirements, as outlined in the section on Course Requirements. Of this number, a minimum of 24 and up to 36 hours of 600 Doctoral Research and Dissertation and six hours of 600-level coursework at UTK will be required. In addition to coursework, students must pass a qualifying exam, a comprehensive exam, and a final exam which includes the preparation and defense of a dissertation. The graduate work is performed under the supervision of an advisor/major professor and a graduate committee.

Major Professor (Advisor)

Each graduate student must have an advisor/major professor from the Bredesen Center faculty, who can be either an ORNL or UT based employee. This professor advises the student about course selection, supervises the student’s research, and facilitates communication within the degree program and/or student’s major department, to other departments, and with the Graduate
School relative to requirements. The Associate Director may act as a temporary advisor the entering during the period in which the student is becoming acquainted with the institutions and determining the focus of research interests. Once the major professor is determined, the major professor and the student together select a doctoral committee. The student is expected to maintain close consultation with the major professor and other members of the graduate committee with regard to progress in the program.

**Doctoral Committee**

The major professor directs the student’s dissertation research and chairs the doctoral committee. The student and major professor identify a doctoral committee composed of at least four faculty members holding the rank of assistant professor or above, three of whom, including the chair, must be approved by the Graduate Council to direct doctoral research. At least one member must be from outside the Bredesen Center faculty. Committee members should be chosen to insure interdisciplinary breadth. The Bredesen Center Director has oversight responsibility to insure the interdisciplinary nature of the committee. A doctoral student, in collaboration with the major professor, should begin to form the doctoral committee during the first year of study. Once formed, the doctoral committee, by request of the major professor, will meet annually, at the minimum, with the student to insure timely progress toward the degree.

**Admission to Candidacy**

Admission to candidacy indicates that the student has demonstrated ability to do acceptable graduate work and that satisfactory progress has been made toward the degree. This action usually connotes that all prerequisites to admission have been completed and a program of study has been approved.

A student may be admitted to candidacy for the doctoral degree after passing the comprehensive examination and maintaining at least a B average in all graduate coursework. Each student is responsible for filing the Admission to Candidacy form, which lists all graduate courses to be used for the degree, including courses taken at the University of Tennessee or at other institutions prior to admission to the doctoral program. The Admission to Candidacy form is signed by the doctoral committee.

**Summer Registration**

Graduate students must take a minimum of three credit hours in the summer, assuming they are engaged in research and/or courses at UT or ORNL. Before passing the qualifying exam, the student should register for ESE 502 – Registration for Use of Facilities to account for research hours. After passing the qualifying examination a student may enroll in ESE 600 – Doctoral Dissertation Research.

**Doctoral Dissertation Research Credit (ESE 600)**

After passing the qualifying exam, students should enroll in ESE 600 - Doctoral Dissertation Research to register their research hours. Therefore, a student could take 3 hours of ESE 600 credit as early as the fall semester of the second year. Once a student begins taking ESE 600 credit, they must take it every semester thereafter continuously. Students must begin taking
ESE 600 at least in the second summer, assuming the successful completion of the qualifying exam during the academic year.

**Graduate Student Examinations**

This section provides a description of the graduate student examination requirements for the PhD degree program. Three examinations are required as part of the doctoral program: qualifying examination, comprehensive examination, and defense of dissertation examination.

**Qualifying Exam**

A student must pass the qualifying examination to proceed in the PhD program. The qualifying examination is developed, administered, and graded by the Bredesen Center faculty (or designated subset of the faculty) of the PhD program under the coordination of the Bredesen Center Director. This examination must be taken no later than the end of the first year of ESE graduate studies. Given the research intensive focus of the Energy Science and Engineering doctoral program, it is expected that graduates of this program will possess the skills required to investigate and conduct research on a variety of problems. The qualifying exam will test these skills by challenging students to prepare a professional quality research proposal to address current important questions in energy science and engineering. Late in the spring semester the ESE faculty will present the first-year students a set of problems relating to various topics of energy science and engineering. Each student must select one of these problems and construct a research proposal to thoroughly investigate the problem. The proposal should include an introduction, a background of the problem, the significance of the proposed study, the methodology that would be used to investigate the problem, and references to back up any claims. The proposal should be around 10 pages in length, double-spaced, 12-pt Times New Roman font, and references should follow current APA formatting standards. At the time that problems are made available for selection, a due date for the completed proposals will be announced. **It is the responsibility of the student to organize a time to discuss and defend their proposal to their doctoral committee at a time that is at least two weeks after proposal submission, but before October 1 of the student’s second year in the program.** Once the committee has made its final decision about the result of the examination, the committee must inform the student and the director of the Bredesen Center. In case of failure, the candidate may appeal to retake the examination through the Bredesen Center Graduate Education Committee within 30 days of notification of the result. If the appeal is granted, the student must retake the examination at the next offering. The result of the second examination is final. The successful completion of the qualifying examination grants students permission to engage in ESE 600 dissertation research.

**Comprehensive Examination**

The Comprehensive Examination must be taken no later than the end of the second year following entrance into the PhD program and prior to admission to candidacy. The timing is late enough in a student’s academic program to permit most of his/her graduate course work to be covered on the examination, and early enough to permit modification of the student’s program based on the results of the exam.

Two requirements must be satisfied before a student takes the Comprehensive Examination:
1. A written Dissertation Proposal, approved by the major professor, must be submitted to each member of the student’s Doctoral Committee two weeks prior to the examination.

2. Each member of the student’s Doctoral Committee must agree that the student is ready to take the Comprehensive Exam. The committee members will communicate to the major professor when they are satisfied that the student is ready to take the Comprehensive Exam.

The Comprehensive Examination will consist of the student constructing and defending his or her dissertation research proposal to the committee in a format deemed acceptable by the student’s Doctoral Committee. Typically, an oral defense is sufficient for this examination, although a written component may be administered at the discretion of the Doctoral Committee.

Once the Comprehensive Examination is passed, the student should file for and be admitted to candidacy. At the discretion of the Doctoral Committee, supplemental reexaminations for the Comprehensive Examination and/or proposed dissertation research may be required. In case of failure, the candidate may not apply for reexamination until the following semester. The result of the second examination is final.

Defense of Dissertation Examination

A doctoral candidate must pass an oral examination on the dissertation. The dissertation, in the form approved by the major professor, must be distributed to the committee at least two weeks before the examination. The examination must be scheduled through the Office of the University Registrar at least one week prior to the examination and must be conducted in university-approved facilities. The examination is announced publicly and is open to all students and faculty members. The defense of dissertation will be administered by all members of the doctoral committee after completion of the dissertation and all course requirements. This examination must be passed at least two weeks before the date of submission and acceptance of the dissertation by Graduate Student Services. The major professor must submit the results of the defense by the dissertation deadline.

Course Requirements

A minimum of 72 hours is required for the ESE doctoral program, and of this total a minimum of 36 hours of coursework is required beyond the BS degree. The table below shows an expected average academic load for an ESE student, including 39 hours of coursework and 61 hours of research credit, totaling 100 credit hours. Of the 36 hours of required coursework, the following 30 hours of courses (or their equivalent) must be completed at a minimum, including the Core Curriculum, a Knowledge Breadth Curriculum, a Knowledge Specialization Curriculum, and Seminar Series, as summarized below. Student’s must maintain full-time status during the Fall and Spring semesters each year, and be engaged in at least three credit hours of dissertation research in the Summer semester. Students are encouraged to engage in summer courses and more than three credit hours of research. Each student is required to submit their proposed schedule of courses to the Assistant Director (Mike Simpson), the Student Services Specialist (Ben Allen), and their major professor before classes begin each semester. Students that do not have a major professor should consult
with the Assistant Director of the program in order to construct a course schedule that will sufficiently cover subject matter related to the student’s desired area of research.

A student may begin credited doctoral dissertation research - ESE 600 - after successfully completing the qualifying examination. Students who are deemed qualified by the director of the program may begin taking ESE 600 in the same semester as their qualifying examination. After beginning ESE 600, the student must continue to enroll in ESE 600 every semester until the completion of their degree. A total of 36 credit hours of ESE 600 are required in order to graduate for a student with a Bachelor’s degree. A total of 24 credit hours of ESE 600 are required in order to graduate for a student with a Master’s degree.

<table>
<thead>
<tr>
<th>Year</th>
<th>Semester</th>
<th>Expected course credit hours</th>
<th>Expected research credit hours</th>
<th>Exams</th>
<th>Activity</th>
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<tbody>
<tr>
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<td>Summer</td>
<td>10</td>
<td>2</td>
<td>Full-time research</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>Fall</td>
<td>10</td>
<td>2</td>
<td>Part-time research</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>Spring</td>
<td>10</td>
<td>2</td>
<td>Qualifying, Comprehensive, Dissertation defense, Full-time research</td>
</tr>
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<td>5</td>
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<td>Full-time research</td>
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<tr>
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<td>Fall</td>
<td>10</td>
<td>3</td>
<td>Part-time research</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>Spring</td>
<td>9</td>
<td>3</td>
<td>Part-time research</td>
</tr>
<tr>
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<td>7</td>
<td>Summer</td>
<td>3</td>
<td></td>
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<tr>
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<td>8</td>
<td>Fall</td>
<td>5</td>
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<td>Full-time research</td>
</tr>
<tr>
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<td>Spring</td>
<td>5</td>
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</tr>
<tr>
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<td>Summer</td>
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<td>Full-time research</td>
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<td>Summer</td>
<td>3</td>
<td></td>
<td>Dissertation defense, Full-time research</td>
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<tr>
<td>Sum</td>
<td></td>
<td></td>
<td>39</td>
<td>64</td>
<td></td>
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</tbody>
</table>

**Core Curriculum (6 credits)**

ESE 511 and ESE 512 Introduction to Energy Science and Technology (3, 3 credits); (lead instructor plus guest lecturers): Topics include: energy basics; history of energy and society; current and future supply and demand; political and environmental aspects of energy production; energy technologies (fossil fuels, biomass, nuclear fission, nuclear fusion, solar, wind, geothermal); energy conversion, storage, transportation, and distribution; energy efficiency; and innovation.

**Knowledge Breadth Curriculum (6 credits)**

The Knowledge Breadth courses include at least two courses selected from the three following areas:
1. Political, social, legal, ethical and security issues related to energy (3-4 courses, each 3 credits)
2. Entrepreneurship, leadership, and management (3-4 courses, each 3 credits)

**Knowledge Specialization Curriculum (15 credits)**

The Knowledge Specialization Curriculum is a deep dive into an area of science or engineering closely related to energy. In consultation with the advisor/major professor, each student must submit a proposed course of study that includes at least fifteen credit hours worth of approved courses (see section on Approved Courses). The Bredesen Center Assistant Director reviews and approves proposed courses of study. The course of study for each student must include at least 9 credit hours of 500-level fundamental courses and 6 hours of 600-level advanced courses.

A proposed course of study should focus on one of the following Bredesen Center themes:

1. Nuclear energy
2. Bioenergy and biofuels
3. Renewable energy
4. Energy Materials
5. Energy conversion and storage
6. Distributed energy and grid management
7. Environmental and climate sciences related to energy
8. Transportation Sciences
9. Cross-Cutting Energy Sciences

**Seminar Series (3 credits)**

The ESE 599 seminar series (1 credit) will provide topical seminars related to Bredesen Center research themes or knowledge breadth areas. ESE will be offered each fall and spring semester and students must attend at least three semesters of seminar.

**Approved Courses**

This section lists approved courses by department. As discussed above, these courses are needed for the minimum of 15 credit hours for the Knowledge Specialization Curriculum. Other courses may be used to fulfill this requirement only with the approval of the Bredesen Center Assistant Director.

**Knowledge Specialization**

**Nuclear Energy**

**Fundamentals (9 credits)**

*Reactor Design and Modeling emphasis*

ECE 575 - High Performance Computer Modeling and Visualization
NE 511 - Transport Processes in Nuclear Engineering
NE 571 - Reactor Theory and Design
NE 572 - Nuclear Systems Design
NE 583 - Radiation Transport Methods
NE 598 - Nuclear Engineering practice
ME 587 - Dynamic Modeling and Simulation

Fuel Cycle Emphasis

NE 404 - Nuclear Fuel Cycle
NE 440 - Introduction to Nuclear Fuels and Materials
CHEM 511 - Analytical Separations
CHEM 513 - Mass Spectrometry and Surface Characterization

Structural Materials Emphasis

ME 559 - Advanced Mechanics of Materials I
MSE 511 - Fundamentals of Materials Science and Engineering I
MSE 512 - Fundamentals of Materials Science and Engineering II
MSE 515 - Diffusion, Phase Transformations, and Microstructure of Materials
MSE 525 - Welding Metallurgy
MSE 532 - Metallurgy of Deformation and Fracture
MSE 556 - Materials for Energy
NE 540 - Fundamentals of Irradiation Effects in Nuclear Materials
NE 542 - Management of Radioactive Materials

Instrument and Controls Emphasis

ECE 505 - Digital Signal Processing I
ECE 506 - Digital Signal Processing II
ECE 551 - Digital System Design I
ECE 552 - Digital System Design II
NE 579 - Advanced Monitoring and Diagnostic Techniques
NE 521 - Nuclear Systems Dynamics and Control
NE 522 - Experimental Methods in Reactor Dynamics
NE 550 - Radiation Measurements Laboratory

Safety

NE 543 - Selected Topics in Nuclear Criticality Safety
NE 551 - Radiation Protection
NE 552 - Radiological Assessment and Dosimetry
NE 585 - Process System Reliability and Safety
Advanced (6 credits)

*Reactor Design and Modeling emphasis*

NE 611 - Selected Topics in Reactor Theory  
NE 640 - Nuclear Cross Section Modeling  
NE 697 - Special Topics in Nuclear Engineering

*Fuel Cycle Emphasis*

CHEM 610 - Selected Topics in Analytical Chemistry  
CHEM 670 - Selected Topics in Physical Chemistry

*Structural Materials Emphasis*

ME 659 - Advanced Mechanics of Materials II  
MSE 611 - Phase Transform and Simulations at Small Length Scales  
MSE 650 - Mechanical Behavior of Solids at Elevated Temperatures  
MSE 674 - Materials Physics  
MSE 675 - Advanced Structural Analysis

*Instrument and Control Emphasis*

NE 653 - Theory of Information Processing  
ECE 631 - Advanced Topics in Mixed-Signal Integrated Circuit Design  
ECE 632 - Advanced Topics in High-Speed Integrated Circuit Design  
NE 697 - Special Topics in Nuclear Engineering

*Nuclear Physics*

NE 615 - Transport Processes in Nuclear Engineering  
NE 641 - Charged Particle Transport Methods  
PHYS - 621 Nuclear Physics I  
PHYS - 622 Nuclear Physics  
PHYS - 642 Advanced Topics in Modern Physics

*Safety*

NE 621 - Selected Topics in Radiation Protection

*Energy Conversion and Storage*

Fundamentals (9 credits)

CBE 506 - Advanced Engineering Mathematics  
CBE 531 - Advanced Chemical Engineering Thermodynamics  
CBE 532 - Statistical Mechanics  
CBE 542 - Diffusive and Stagewise Mass Transfer Operations
CBE 547 - Advanced Transport Phenomena
CBE 551 - Chemical Reactor Analysis
CHEM 550 - Structure and Reactivity in Organic Chemistry
CHEM 551 - Organic Reactions
CHEM 552 - Applications of Organic Reactions
CHEM 553 - Spectropic Characterization of Organic Compounds
CHEM 570 - Quantum Chemistry and Spectroscopy
CHEM 572 - Thermodynamics and Statistical Mechanics
CHEM 573 - Chemical Kinetics and Transport
ECE 575 - High Performance Computer Modeling and Visualization
MATH 511 - Methods in Applied Mathematics I
MATH 512 - Methods in Applied Mathematics I
ME 476 - Fuel Cell Engines I
ME 521 - Thermodynamics 1
ME 522 - Thermodynamics 2
ME 527 - Thermal Systems Analysis I
ME 530 - Foundations of Nanomechanics
ME 559 - Advanced Mechanics of Materials I
ME 567 - Smart Structures and Materials
ME 572 - Sustainable Energy Engineering
ME 576 - Advanced Fuel Cell Engines
ME 587 - Dynamic Modeling and Simulation
MSE 540 - Basic Polymer Chemistry
MSE 556 - Materials for Energy
PHYS 521 - Quantum Mechanics I
PHYS 522 - Quantum Mechanics II
PHYS 551 - Statistical Mechanics
PHYS 555 - Solid State Physics

Advanced (6 credits)

CBE 631 - Advanced Topics in Statistical Thermodynamics and Molecular Dynamics
CBE 632 - Nonequilibrium Thermodynamics
CBE 633 - Multiscale Materials Modeling
CBE 647 - Advanced Topics in Transport Phenomena
ME 678 - Advanced Topics in Fuel Cells and Electrochemical Power Systems
MSE 611 - Fundamentals of Thermodynamics, Phase Transformation, and Material
MSE 672 - Introduction to Transmission EM and Electron Diffraction
MSE 680 - Advanced Transmission Electron Microscopy

Simulation at Small Length Scales

CBE 691 - Advanced Topics in Chemical Engineering
CHEM 690 - Selected Topics in Polymer Chemistry
ME 656 - Advanced Mechanics of Materials II
MSE 666 - Nanoindentation and Small-scale Contact Mechanics
MSE 673 - Introduction to Scanned Probe Microscopies
MSE 676 - Advanced Topics in Materials Science and Engineering
PHYS 671 - Advanced Solid State Physics I
PHYS 672 - Advanced Solid State Physics II

Bioenergy and Biofuels

Fundamentals (9 credits)

Biology emphasis

BCMB 401 - Biochemistry-Molecular Biology I
BCMB 402 - Biochemistry-Molecular Biology II
BCMB 512 - Advanced Molecular Biology
BCMB 515 - Experimental Techniques I
BCMB 522 - Advanced Plant Physiology I
BCMB 523 - Advanced Plant Physiology II
CBE 555 - Elements of Synthetic Biology and Metabolic Engineering
CBE 571 - STAIRMaster I: Fundamentals of Sustainable Technology
CBE 572 - STAIRCcase I: Sustainable Technology Case Studies
CBE 576 - Applied Microbiology and Bioengineering
CBE 579 - Advanced Biomolecular Engineering
ENVE 550 - Advanced Applications in Water and Waste Treatment
ENVE 576 - Applied Microbiology and Bioengineering
EPP 612 - Soil Borne Plant Pathogens
EPP 613 - Fungal Epidemiology and Disease Control
ESS 516 - Soil Biology and Biochemistry
ESS 554 - Environmental Soil Biology
PLSC 554 - Plant Biotechniques
MICR 410 - Microbial Physiology
MICR 411 - Microbial Genetics
MICR 576 - Applied Microbiology and Bioengineering
MICR 650 - Topics in Microbial and Molecular Genetics
MICR 670 - Advanced Topics in Environmental Microbiology
MICR 680 - Foundations in Microbiology
PLSC 465 - Bioenergy Crop Ecology
PLSC 475 - Professional Issues in Bioenergy
PLSC 532 - Environmental Plant Ecophysiology
PLSC 552 - Plant Biotechnology, Genetics and Breeding
PLSC 554 - Plant Biotechniques
PLSC 561 - Statistics for Biological Research
PLSC 571 - Design and Analysis of Biological Research

Chemistry and Materials emphasis

CBE 571 - STAIRMaster I: Fundamentals of Sustainable Technology
CBE 572 - STAIRCcase I: Sustainable Technology Case Studies
CHEM 510 - Analytical Spectrometry
CHEM 511 - Analytical Separations
CHEM 550 - Structure and Reactivity in Organic Chemistry
CHEM 551 - Organic Reactions
CHEM 552 - Applications of Organic Reactions
CHEM 590 - Polymer Chemistry
CHEM 594 - Organic Chemistry of Polymers
FORS 521 - Composite Materials from Renewable Resources
ME 525 - Combustion and Chemically Reacting Flows I
ME 526 - Combustion and Chemically Reacting Flows II
ME 559 - Advanced Mechanics of Materials I
ME 572 - Sustainable Energy Engineering
MSE 511 - Fundamentals of Materials Science and Engineering I
MSE 512 - Fundamentals of Materials Science and Engineering II
MSE 540 - Basic Polymer Chemistry
MSE 552 - Laboratory Methods in Polymer Engineering
MSE 556 - Materials for Energy
MSE 572 - X-Ray Diffraction

Advanced (6 credits)

CBE 631 - Advanced Topics in Statistical Thermodynamics
CBE 652 - STAIRCase II: Case Study for Sustainable Energy Production
CHEM 610 - Selected Topics in Analytical Chemistry
CHEM 670 - Selected Topics in Physical Chemistry
FWF 610 - Interdisciplinary Analysis of Natural Resource Problems
PLSC 653 - Advanced Plant Breeding and Genetics
ME 659 - Advanced Mechanics of Materials II
MSE 674 - Materials Physics
MSE 675 - Advanced Structural Analysis

Renewable Energy – Solar - Wind - Hydro - Geothermal

Fundamentals (9 credits)

AE 513 - Experimental Methods in Fluid Mechanics
AE 518 - Computational Fluid-Thermal Systems
CE 485 - Principles of Hydrogeology
CBE 539 - Polymer Engineering I
CBE 547 - Advanced Transport Phenomena
CBE 571 - STAIRMaster I: Fundamentals of Sustainable Technology
CBE 572 - STAIRCase I: Sustainable Technology Case Studies
CHEM 570 - Quantum Chemistry and Spectroscopy
CHEM 572 - Thermodynamics and Statistical Mechanics
CHEM 573 - Chemical Kinetics and Transport
GEOL 501 - Fractal Models in Earth Sciences
ECE 575 - High Performance Computer Modeling and Visualization
ENVE 520 - River Mechanics
ENVE 532 - Statistical Methods in Water Resources
ENVE 535 - Applied Ground Water Hydrology
ENVE 543 - Instrumentation and Measurement
ENVE 586 - Sustainable Engineering, Design, and Analysis
MATH 511 - Methods in Applied Mathematics I
MATH 512 - Methods in Applied Mathematics II
ME 521 - Thermodynamics I
ME 522 - Thermodynamics 2
ME 524 - Fracture Mechanics
ME 533 - Dynamics
ME 534 - Mechanical Vibrations
ME 541 - Fluid Mechanics I
ME 542 - Fluid Mechanics II
ME 559 - Advanced Mechanics of Materials I
ME 572 - Sustainable Energy Engineering
ME 584 - Turbomachinery Systems I
ME 585 - Turbomachinery Systems II
ME 586 - Mechanics and Control of Robotic Manipulators
ME 587 - Dynamic Modeling and Simulation
ME 591 - Advanced Engineering Analysis
MSE 551 - Solar Photovoltaics
MSE 556 - Materials for Energy
ECE 525 - Alternative Energy Sources
ECE 575 - High Performance Computer Modeling and Visualization
PHYS 531 - Classical Mechanics
PHYS 551 - Statistical Mechanics

Advanced (6 credits)

CBE 631 - Advanced Topics in Statistical Thermodynamics and Molecular Dynamics
CBE 633 - Multiscale Materials Modeling
CBE 652 - STAIRCase II: Case Study for Sustainable Energy Production
ECE 626 - Solid State Power Semiconductors
ME 644 - Theory of Turbulence
MSE 672 - Introduction to Transmission EM and Electron Diffraction
MSE 644 - Optoelectronic Processes in Polymeric Materials

Simulation at Small Length Scales

AE 681 - Advanced Viscous Flow Theory
CBE 691 - Advanced Topics in Chemical Engineering
CHEM 610 - Selected Topics in Analytical Chemistry - Electrochemistry
CHEM 690 - Selected Topics in Polymer Chemistry – Polymers for Renewable Energy
MSE 611 - Fundamentals of Thermodynamics, Phase Transformations, and Material Simulations at Small Length Scales
MSE 673 - Introduction to Scanned Probe Microscopies
MSE 676 - Advanced Topics in Materials Science and Engineering
PHYS 671 - Advanced Solid State Physics I
PHYS 621 - Advanced Solid State Physics II
Environmental and Climate Sciences

Fundamentals (9 credits)

ECE 575 - High Performance Computer Modeling and Visualization  
ESS 462 - Environmental Climatology  
ESS 516 - Soil Biology and Biochemistry  
ESS 554 - Environmental Soil Biology  
ENVE 521 - Climate Impacts on Water Resources  
ENVE 526 - Ecological Engineering for Stream Rehabilitation  
ENVE 532 - Statistical Methods in Water Resources  
ENVE 561 - Climate and Environmental Informatics  
ENVE 562 - Three Dimensional Climate Modeling  
ENVE 574 - Air Pollution Engineering and Control  
ENVE 577 - Air Pollution Climatology  
ENVE 586 - Sustainable Engineering, Design, and Analysis  
ENVE 590 - Special Problems in Environmental Engineering  
ENVE 595 - Special Topics  
FWF 610 - Interdisciplinary Analysis of Natural Resource Problems  
MATH 578 - Numerical Methods for Partial Differential Equations  
GEOG 512 - Environmental Modeling and Geospatial Analysis  
GEOG 517 - Geographic Information Management and Processing  
GEOG 534 - Topics in Climatology  
GEOL 525 - Data Analysis for Geoscientists  
GEOL 546 - Carbonate Sedimentology and Geochemistry  
GEOL 555 - Environmental Geology  
GEOL 558 - Global Climate Change  
PLSC 515 - Agroecology

Advanced (6 credits)

ESS 601 - Special Topics in Soil Science  
ENVE 671 - Advanced Concepts of Air Pollution Engineering  
ENVE 672 - Air Pollution Dispersion Modeling  
ENVE 691 - Special Topics in Environmental Engineering  
GEOL 660 - Seminar in Geochemistry  
GEOL 690 - Seminar in Earth and Environmental Science  
MICR 670 - Advanced Topics in Environmental Microbiology

Distributed Energy/Grid Management

Fundamentals (9 credits)

ECE 505 - Digital Signal Processing I  
ECE 506 - Digital Signal Processing II
ECE 511 - Linear Systems Theory
ECE 512 - Multivariable Linear Control System Design
ECE 521 - Power Systems Analysis I
ECE 522 - Power Systems Analysis II
ECE 523 - Power Electronics and Drives
ECE 525 - Alternative Energy Sources
ECE 529 - Application of Linear Algebra in Engineering Systems
ECE 543 - Digital Communication Systems I
ECE 544 - Digital Communication Systems II
ECE 551 - Digital System Design I
ECE 552 - Digital System Design II
ECE 553 - Computer Networks
ECE 571 - Pattern Recognition
ECE 575 - High Performance Computer Modeling and Visualization
PHYS 573 - Numerical Methods in Physics

Advanced (6 credits)

ECE 613 - Nonlinear Systems Theory
ECE 616 - Nonlinear Programming
ECE 617 - Special Topics in Systems Theory I
ECE 618 - Special Topics in Systems Theory II
ECE 621 - Computational Methods for Power System Analysis
ECE 622 - Power System Economics
ECE 623 - Advanced Power Electronics and Drives
ECE 625 - Utility Applications of Power Electronics
ECE 626 - Solid State Power Semiconductors

Cross-Cutting Energy Sciences

Transportation

CE 558 - Planning and Transportation
GEOG 549 - Topics in the Geography of Transportation
ME 572 - Sustainable Energy Engineering
ME 588 - Introduction to Hybrid Electric Vehicles
ME 589 - Hybrid Electric Vehicle Control Systems Design and Analysis

Knowledge Breadth

Economics

AREC 445 - Economics of Biomass for Renewable Energy
AREC 472 - Natural Resource Economics
AREC 670 - Advanced Topics in Natural Resource Economics
ECON 463 - Environmental Economics
ECON 677 - Environmental and Natural Resource Economics
IE 405 - Engineering Econ Analysis
Entrepreneurship

AGNR 530 - Entrepreneurship and Discovery Commercialization
ESE 593 – Energy Entrepreneurship Studies
IE 557 - Technology Product Development and Entrepreneurship
ME 519 - Technology Product Development and Entrepreneurship

Policy

AREC 470 - Policy Analysis: Environmental and Natural Resources Management
ESE 593 - Energy Policy Studies
ESE 597 – Energy Technology and Policy
PHIL 441 - Global Justice and Human Rights
PHIL 460 - Philosophy of Science
PS 548 - Public Policy Process
PS 549 - Environmental Policy
PHYS 405 - Science, Technology, and Public Policy

Science Communication

JREM 450 - Writing about Science and Medicine
JREM 451 - Environmental Writing
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The Bredesen Center is named in honor of Governor Phil Bredesen, who served Tennessee from 2003 to 2011, in recognition of his leadership in education and economic development for the state. In addition to his commitment to the Bredesen Center, Governor Bredesen’s vision for capitalizing on the great potential of the UT-ORNL partnership resulted in the UT-ORNL Governor’s Chairs program, the UT Biofuels Initiative, the Volunteer State Solar Initiative, and the UT-ORNL Joint Institutes for Computational Sciences, Biological Sciences, and Neutron Sciences.