The University of Georgia

University Council
Athens, Georgia 30602

March 17, 2017

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Dear Colleagues:

The attached proposal from the College of Engineering for the following new areas of emphasis under the majors in Engineering (M.S.) and Engineering (Ph.D.) will be an agenda item for the March 24, 2017, Full University Curriculum Committee meeting:

Areas of Emphasis under the major in Engineering (M.S.):
- Area of Emphasis in Civil Engineering
- Area of Emphasis in Electrical and Computer Engineering
- Area of Emphasis in Mechanical Engineering

Areas of Emphasis under the major in Engineering (Ph.D.):
- Area of Emphasis in Biochemical Engineering
- Area of Emphasis in Biomedical Engineering
- Area of Emphasis in Dynamical Systems and Control
- Area of Emphasis in Electrical and Computer Engineering
- Area of Emphasis in Energy Systems
- Area of Emphasis in Environment and Water

Area of Emphasis in Fluid and Thermal Systems
Area of Emphasis in Mechanics and Material
Area of Emphasis in Resilient Infrastructure

Sincerely,

Alison Alexander

Alison F. Alexander, Chair
University Curriculum Committee

cc: Provost Pamela S. Whitten
Dr. Rahul Shrivastav

UNIVERSITY OF GEORGIA
College of Engineering

**College:** Engineering

**School:** Environmental, Civil, Agricultural and Mechanical Engineering

**Degree/Major:** M.S. in Engineering

**Requirements:**
Candidates for the M.S. in Engineering (Civil Engineering Emphasis), M.S. in Engineering (Mechanical Engineering Emphasis) are expected to synthesize and create new knowledge, make original and substantial contributions to their discipline, and demonstrate mastery of knowledge in one of the following specialty areas consistent with their emphasis: *Structural and Geotechnical Engineering; Environment and Water; Design, Optimization, and Manufacturing; Energy, Fluid, and Thermal Systems; or Mechanics and Materials.*

A minimum of 30 semester credits of approved graduate work must be taken, 12 credit hours of which must be semester hours of coursework open only to graduate students (exclusive of 7000, 7010, and 7300). No grade below C will be accepted in the program of study. To be eligible for graduation, a student must maintain a 3.0 (B) average on the graduate transcript and a 3.0 (B) average in the program of study. All M.S. students are required to enroll in one semester of ENGR 8950 Graduate Seminar.

A thesis must be written. A maximum of 6 hours of 7000/7010 and 3 hours of 7300 may be applied toward the 30 hours. A minimum of 3 hours of 7300 must be listed on the program of study.

**Emphasis Title (as it will appear):** Civil Engineering
**Proposed Start Date:** Fall 2017

**Emphasis Area Description:**
The M.S. in Engineering with an Emphasis in Civil Engineering degree provides specialized expertise in civil engineering by providing a rigorous curriculum and innovative research in two distinctive areas: Structural and Geotechnical Engineering and Environment and Water. Specifically, the program offers students the opportunity to conduct state-of-the-art research in asphalt and concrete pavements, pavement evaluation and preservation, bridge engineering, non-destructive testing and evaluation, structural and materials modeling, transportation geotechnics and geomechanics, hydrology and hydraulics, urban water, environmental processes, sustainable coastal and river engineering, environmental fluid mechanics, water resources planning and management, and interdependence of infrastructure systems. Students may tailor a plan of coursework to their interests by drawing from extensive course offerings spanning several engineering disciplines as well as other schools and colleges at UGA.

As a requirement of the M.S. in Engineering (Civil Engineering Emphasis) degree, students must complete a minimum of 9 credit hours selected from the list below. Students will work with their graduate advisor to select the most appropriate specialty area and coursework to ensure breadth of understanding as well as mastery of knowledge in a specific subject area. In addition to completing 9 credit hours selected from the list below, students may work with their graduate advisor to develop an interdisciplinary plan of coursework drawing from the extensive graduate course offerings available at UGA.

Structural and Geotechnical Engineering

- ENGR 4650/6650 HVAC Systems for Buildings and Industry
- ENGR 8103 Computational Engineering: Fundamentals, Elliptic, and Parabolic

Differential Equations

- CVLE 4330/6330 Advanced Structural Analysis
- CVLE 4340/6340 Design of Bridges
- CVLE(MCHE) 8350 Nonlinear Finite Element Analysis
- CVLE(MCHE) 4640/6640 Advanced Strength of Materials
- CVLE 8550 Design of Prestressed Concrete Structures
- CVLE 6470 Pavement Design
- CVLE 8420 Geomechanics
- CVLE 8460 Soil Improvement
- STAT 6315 Statistical Methods for Researchers

Environment and Water

- ENGR 4440/6440 Environmental Engineering Unit Operations
- ENGR 4450/6450 Environmental Engineering Remediation Design
- ENGR 8103 Computational Engineering: Fundamentals, Elliptic, and Parabolic Differential Equations
- ENGR 4410 Open Channel Hydraulics
- ENGR 6430 Advanced Open Channel Design
- ENVE 4440/6440 Computer Modeling in Water Resources
- ENVE 6450 Engineering Hydrology and Hydraulics
- ENVE 4460/6460 Groundwater Hydrology for Engineers
- ENVE 6430* Natural Resources Engineering
- ENGR 8160 Advanced Fluid Mechanics
- CVLE 8140 Transport and Mixing in Natural Flows
- CRSS(GEOL) 8710 Watershed-Scale Modeling
- WASR 8200 Hillslope Hydrology Seminar
- GEOL(WASR) 8740 Hydrologic Flow and Transport Modeling
- STAT 6315 Statistical Methods for Researchers

* Courses does not exist in CAPA System

UNIVERSITY OF GEORGIA
College of Engineering

# PROPOSAL FOR AREA OF EMPHASIS

**College:** Engineering

**School:** Electrical and Computer Engineering

**Degree/Major:** M.S. in Engineering

**Requirements:**
A minimum of 30 credit hours are required as follows:

- Research Methods (3 credit hours) and Graduate Seminar (1 credit hour).
- 12 credit hours must be taken in the area of emphasis at the 8000 level (see list below).
- 6 credit hours of research (7000 or 7010)
- 8 additional credit hours from any school or college at UGA. These must be at the 6000 or higher level.

**Emphasis Title (as it will appear):** Electrical and Computer Engineering
**Proposed Start Date:** Fall 2017

**Emphasis Area Description:**
12 credit hours of coursework may be chosen from one or more of the areas below. Emphasis courses will be reviewed each academic year and updated as needed to reflect new areas in the field:

**Track 1: Control Systems** - *Analysis and controller design for complex, large-scale systems. The need for improved safety and a cleaner environment have posed countless challenges that can only be addressed through the design and implementation of intelligent feedback controls. Numerous emerging applications for controls include cyber-physical systems (e.g., smart grids and intelligent transportation systems) and biological networks.*

| | | |
|---|---|---|
| ENGR 8240 | | Instrumentation Programming |
| CSCI(ENGR) 8940 | | Computational Intelligence |
| ENGR 8990 | 201408 | Advanced Topics in Engineering: Optimization Theory and Applications |
| ENGR 8990 | 201402 | Advanced Topics in Engineering: Nonlinear Control Systems |
| ENGR 8990 | 43299 | Advanced Topics in Engineering: Stochastic Control Systems |

**Track 2: Electronics & Photonics -** *Design and analysis of systems involving electromagnetic waves from RF electronics to photonic systems for signal processing and communication and optical systems for image capture and processing. High-speed communication and signal processing at gigabit speeds requires sophisticated electro-optic systems that must be understood at both the device and the systems levels. Modern optical imaging systems use a wide variety of electrical and photonic technologies to achieve everything from imaging biological systems at the nanometer scale to imaging distant galaxies.*

| | |
|---|---|
| ELEE 8510 | Microwave Photonics |
| ENGR 8570 | Topics in Advanced Optical Microscopy |
| ELEE 8530 | Advanced Optics and Photonics |

PHYS 8201 Advanced Electromagnetic Theory I
PHYS 8202 Advanced Electromagnetic Theory II
ENGR 8270 Computational Nanomechanics
ENGR 8310 MEMS Design
ENGG(CSCI) 8840 Advanced Image Analysis

**Track 3: Cyber-physical Systems -** *Understanding of engineered systems that are built from, and depend upon, the seamless integration of computational algorithms and physical components. Advances in CPS will enable capability, adaptability, scalability, resiliency, safety, security, and usability that will far exceed the simple embedded systems of today. CPS technology will transform the way people interact with engineered systems—just as the Internet has transformed the way people interact with information. New smart CPS will drive innovation and competition in sectors such as agriculture, energy, transportation, building design and automation, healthcare, and manufacturing.*

ENGR 8990 Advanced Topics in Engineering: Real Time Programming
ENGR 8980 Advanced Topics in Biological Engineering: Haptic/Tactile Sensors
CSEE 8830 Virtual Reality and Augmented Reality User Interface Design
ENGR 8240 Instrumentation Programming
CSCI(ENGR) 8940 Computational Intelligence
CSCI 8820 Computer Vision and Pattern Recognition
CSCI 8380 Advanced Topics in Information Systems
CSCI 8250 Advanced Network and Security Systems
ENGG(CSCI) 8840 Advanced Image Analysis
ENGR 8990 Advanced Topics in Engineering: Optimization Theory and Applications
INFO 8000 Foundations of Informatics for Research and Practice

UNIVERSITY OF GEORGIA
College of Engineering

**College:** Engineering

**School:** Environmental, Civil, Agricultural and Mechanical Engineering

**Degree/Major:** M.S. in Engineering

**Requirements:**
Candidates for the M.S. in Engineering (Civil Engineering Emphasis), M.S. in Engineering (Mechanical Engineering Emphasis) are expected to synthesize and create new knowledge, make original and substantial contributions to their discipline, and demonstrate mastery of knowledge in one of the following specialty areas consistent with their emphasis: *Structural and Geotechnical Engineering; Environment and Water; Design, Optimization, and Manufacturing; Energy, Fluid, and Thermal Systems; or Mechanics and Materials.*

A minimum of 30 semester credits of approved graduate work must be taken, 12 credit hours of which must be semester hours of coursework open only to graduate students (exclusive of 7000, 7010, and 7300). No grade below C will be accepted in the program of study. To be eligible for graduation, a student must maintain a 3.0 (B) average on the graduate transcript and a 3.0 (B) average in the program of study. All M.S. students are required to enroll in one semester of ENGR 8950 Graduate Seminar.

A thesis must be written. A maximum of 6 hours of 7000/7010 and 3 hours of 7300 may be applied toward the 30 hours. A minimum of 3 hours of 7300 must be listed on the program of study.

**Emphasis Title (as it will appear):** Mechanical Engineering
**Proposed Start Date:** Fall 2017

**Emphasis Area Description:**
The M.S. in Engineering with an Emphasis in Mechanical Engineering degree provides specialized expertise in mechanical engineering by providing a rigorous curriculum and innovative research in three distinctive areas: Design, Optimization, and Manufacturing; Energy, Fluid, and Thermal Systems; and Mechanics and Materials. Specifically, the program offers students the opportunity to conduct state-of-the-art research in a number of areas with pressing societal problems. The Design, Optimization, and Manufacturing option provides a basis of study in product design and the process for building those products. The Energy, Fluid, and Thermal Systems provides a basis for study of diverse topics, such as energy or fluid power systems. Finally, the Mechanics and Materials provides the student with insight into methods for analyzing new materials and systems and how new products and technologies use these materials.

As a requirement of the M.S. in Engineering (Mechanical Engineering) degree, students must complete a minimum of 9 credit hours selected from among the lists below. Students will work with their graduate advisor to select the most appropriate specialty area and coursework.

Design, Optimization, and Manufacturing

- ENGR 4350/6350 Introduction to Finite Element Analysis
- ENGR 4210/6210 Linear Systems
- ENGR 4220/6220 Feedback Control Systems
- ENGR 4230/6230 Sensors and Transducers

- ENGR 4260/6260 Introduction to Nanoelectronics
- ENGR 4540/6540 Applied
- ENGR 6920 Theory of Design
- ENGR 8310 MEMS Design
- CVLE(MCHE) 4640/6640 Advanced Strength of Materials
- MCHE 4360/6360 Robotic Manipulators
- MCHE 6390 Advanced Mechanical Vibrations
- CHEM 8880 Nanomaterials: Engineering and Characterization
- STAT 6315 Statistical Methods for Researchers

Energy, Fluid, and Thermal Systems

- ENGR 4490/6490 Renewable Energy Engineering
- ENGR 4350/6350 Introduction to Finite Element Analysis
- ENGR 4650/6650 HVAC Systems for Buildings and Industry
- ENGR 8103 Computational Engineering: Fundamentals, Elliptic, and Parabolic Differential Equations
- ENGR 8160 Advanced Fluid Mechanics (Sp)
- ENGR 8170 Advanced Heat Transfer
- ENGR 8180 Advanced Mass Transfer
- MCHE 8380 Continuum Mechanics
- PHYS 4300/6300 Thermodynamics and Kinetic Theory
- PHYS 8301 Statistical Mechanics I
- STAT 6315 Statistical Methods for Researchers

Mechanics and Materials

- ENGR 4350/6350 Introduction to Finite Element Analysis
- ENGR 4740/6740 Biomaterials
- ENGR 4760/6760 Biomechanics
- ENGR 8103 Computational Engineering: Fundamentals, Elliptic, and Parabolic Differential Equations
- ENGR 6270 Computational Nanomechanics
- ENGR 8270 Computational Nanomechanics
- CVLE(MCHE) 8350 Nonlinear Finite Element Analysis
- CVLE(MCHE) 4640/6640 Advanced Strength of Materials
- MCHE 8380 Continuum Mechanics

UNIVERSITY OF GEORGIA
College of Engineering

# PROPOSAL FOR AREA OF EMPHASIS

**College:** Engineering

**School:** Chemical, Materials and Biomedical Engineering

**Degree/Major:** Ph.D. in Engineering

**Requirements:**

If entering with a B.S. degree, a minimum of 72 hours beyond the bachelor's is required, including a minimum of 32 credit hours of coursework and 40 credit hours of research as follows:

- 19 credit hours of coursework must be taken in the chosen area of emphasis. See lists below for either Biochemical or Biomedical Emphasis.
- A minimum of 13 elective credit hours must be taken with the approval of the student's Graduate Advisory Committee.
- A minimum of 40 credit hours of research (9000 or 9010)

If the students have taken a course in their M.S. program (at UGA or elsewhere) that is on the School of Chemical, Materials, and Biomedical Engineering graduate course list, then they can petition to be exempted from having to retake that course. Courses are selected by the student with the concurrence of the student's advisory committee.

**Emphasis Title (as it will appear):** Biochemical Engineering
**Proposed Start Date:** Fall 2017

The University of Georgia Biochemical Engineering program offers students an advanced education at the frontiers of both science and engineering. Through a wide range of multidisciplinary coursework and research experiences, students develop team-building and entrepreneurial skills to engage in translational research motivated by societal needs for renewable products and energy, and sustainability. The focus of the biochemical engineering emphasis is to prepare future leaders in the dynamic pharmaceutical, biotechnology, materials, and chemical industries.

**Emphasis Area Description:** 19 credit hours of coursework must be chosen from one or more of the areas below:

***Required Courses (10 credit hours)***

1) ENGR 6910 Foundations for Engineering Research (3 credit hours)
2) FORS(ENGR) 8020 Bio-Based Economy Seminar (4 semesters, 1-3 credit hours)
3) ENGR 8103 Computational Engineering: Fundamentals, Elliptic, and Parabolic Differential Equations (3 credit hours)

***Required Course (Choose any three of the following) (9 credit hours)***

1) BCHE 8150 Heterogeneous Reactor Design and Bio/Catalysis (3 credit hours)
2) ENGR 8160 Advanced Fluid Mechanics (3 credit hours)
3) ENGR 8170 Advanced Heat Transfer (3 credit hours)
4) ENGR 8180 Advanced Mass Transfer (3 credit hours)
5) BCHE 8210 Fermentation Engineering Laboratory (3 credit hours)

**Emphasis Title (as it will appear):** Biomedical Engineering
**Proposed Start Date:** Fall 2017

The University of Georgia Biomedical Engineering program provides an environment for multidisciplinary research that is motivated by state, national, and global healthcare needs. The focus of the emphasis in biomedical engineering is to prepare engineers with expertise in the fields of biomaterials, tissue engineering and regenerative medicine, medical device design, and computational biology.

**Emphasis Area Description:** 19 credit hours of coursework must be chosen from one or more of the areas below:

***Required Courses (13 credit hours)***

1) ENGR 6910 Foundations for Engineering Research (3 credit hours)
2) BCHE(BIOE) 8970 Bioengineering Seminar (4 semesters, 1 credit hour)
3) ENGR 8103 Computational Engineering: Fundamentals, Elliptic, and Parabolic Differential Equations (3 credit hours)
4) BIOE 8490: Advanced Biomaterials (3 credit hours)

***Required Course (Choose any two of the following) (6 credit hours)***

1) BCHE 8150 Heterogeneous Reactor Design and Bio/Catalysis (3 credit hours)
2) ENGR 8160 Advanced Fluid Mechanics (3 credit hours)
3) ENGR 8170 Advanced Heat Transfer (3 credit hours)
4) ENGR 8180 Advanced Mass Transfer (3 credit hours)
5) BIOE 8530 Advanced Biomedical Instrumentation (3 credit hours)

UNIVERSITY OF GEORGIA
College of Engineering

**College:** Engineering

**School:** Environmental, Civil, Agricultural and Mechanical Engineering

**Degree/Major:** Ph.D. in Engineering

**Requirements:**

Candidates for the Ph.D. degree are expected to synthesize and create new knowledge, make original and substantial contributions to their discipline, and demonstrate mastery of knowledge. Students may select to pursue an emphasis area within the Ph.D. in Engineering in one of the following emphasis areas: Resilient Infrastructure Systems, Energy Systems, Environment and Water, Dynamical Systems and Control, Fluid and Thermal Systems, or Mechanics and Materials.

A minimum of 72 semester credits of approved coursework and research beyond the B.S. degree is required. A master's degree from an approved university may be accepted for 30 credits hours, in which case a minimum of 42 credit hours of approved coursework and research beyond the master's degree would be required. The Ph.D. program of study consists of 16 or more hours of 8000- and 9000-level courses in addition to research, dissertation writing, and directed study. The program of study must include three hours of dissertation writing (9300). No grade below C will be accepted in the program of study. To be eligible for graduation, a student must maintain a 3.0 (B) average on the graduate transcript and a 3.0 (B) average in the program of study. The program of study for a student who bypasses the M.S. degree must contain 4 semester hours of University of Georgia courses open only to graduate students in addition to 16 semester hours of 8000- and 9000-level courses. Doctoral research (9000), independent study courses, and dissertation writing (9300) may not be counted in these 20 hours. All Ph.D. Engineering students are required to enroll in one semester of ENGR 8950 Graduate Seminar.

**Emphasis Title (as it will appear):** Dynamical Systems and Control
**Proposed Start Date:** Fall 2017

**Emphasis Area Description:**
Much of our technological systems now require complex control functions to operate. The Dynamic Systems and Control program draws from many disciplines to develop new approaches and effective solutions to analysis of systems and the design of control functions for them. The program offers students tremendous flexibility in designing a graduate program that builds in-depth skills and breadth of knowledge that will relate to their area of interest.

As a requirement of the Ph.D. in Engineering with an Emphasis in Dynamical Systems and Control, students must complete a minimum of 9 credit hours selected from the list below. Students work with their graduate advisor to select the most appropriate coursework to ensure breadth of understanding as well as mastery of knowledge in a specific subject area. In addition to completing 9 credit hours selected from the list below, students may work with their graduate advisor to develop an interdisciplinary plan of coursework drawing from the extensive graduate course offerings available at UGA.

- ENGR 4350/6350 Introduction to Finite Element Analysis (F)
- ENGR 4210/6210 Linear Systems (F)
- ENGR 4220/6220 Feedback Control Systems (Sp)
- ENGR 4230/6230 Sensors and Transducers (F)

- ENGR 4260/6260 Introduction to Nanoelectronics (F)
- ENGR 6560 Engineering Design Optimization
- ENGR 4540/6540 Applied Machine Vision
- ENGR 6920 Theory of Design (Sp)
- ENGR 8103 Computational Engineering: Fundamentals, Elliptic, and Parabolic Differential Equations (Sp)
- ENGR 8310 MEMS Design (F)
- CVLE(MCHE) 4640/6640 Advanced Strength of Materials (Sp)
- MCHE 4360/6360 Robotic Manipulators
- CHEM 8880 Nanomaterials: Engineering and Characterization (F)
- STAT 6315 Statistical Methods for Researchers (Sp)

UNIVERSITY OF GEORGIA
College of Engineering

# PROPOSAL FOR AREA OF EMPHASIS

**College:** Engineering

**School:** Electrical and Computer Engineering

**Degree/Major:** Ph.D. in Engineering

**Requirements:**

If entering with a B.S. degree, a minimum of 73 hours beyond the bachelor's is required as follows:

- Research Methods (3 credit hours) and Graduate Seminar (1 credit hour).
- 12 credit hours of coursework must be taken in the area of emphasis at the 8000 level (see list below).
- 21 additional credit hours must be taken. At least 9 hours must be at the 8000 level. The remainder must be at the 6000 level or higher.
- 36 credit hours of research (9000 or 9010)

If entering with an M.S. degree, a minimum of 43 hours beyond the master's is required as follows:

- Graduate Seminar (1 credit hour)
- 9 credit hours of coursework must be taken in the area of emphasis at the 8000 level (see list below).
- 6 additional hours of coursework at the 8000 level.
- 27 hours of research (9000 or 9010).

**Emphasis Title (as it will appear):** Electrical and Computer Engineering
**Proposed Start Date:** Fall 2017

**Emphasis Area Description:** Credit hours of coursework in the amount described above may be chosen from one or more of the tracks below. Emphasis courses will be reviewed each academic year and updated as needed to reflect new areas in the field:

**Track 1: Control Systems -** *Analysis and controller design for complex, large scale systems. The need for improved safety and a cleaner environment have posed countless challenges that can only be addressed through the design and implementation of intelligent feedback controls. Numerous emerging applications for controls include cyber-physical systems (e.g., smart grids and intelligent transportation systems) and biological networks.*

| | | |
|---|---|---|
| ENGR 8240 | | Instrumentation Programming |
| CSCI(ENGR) 8940 | | Computational Intelligence |
| ENGR 8990 | 201408 | Advanced Topics in Engineering: Optimization Theory and Applications |
| ENGR 8990 | 201402 | Advanced Topics in Engineering: Nonlinear Control Systems |
| ENGR 8990 | 43299 | Advanced Topics in Engineering: Stochastic Control Systems |

**Track 2: Electronics & Photonics -** *Design and analysis of systems involving electromagnetic waves from RF electronics to photonic systems for signal processing and communication and optical systems for image capture and processing. High-speed communication and signal processing at gigabit speeds require sophisticated electro-optic systems that must be understood at both the device and the systems levels. Modern optical imaging systems use a wide variety of electrical and photonic technologies to achieve everything from imaging biological systems at the nanometer scale to imaging distant galaxies.*

ELEE 8510 Microwave Photonics
ENGR 8570 Topics in Advanced Optical Microscopy
ELEE 8530 Advanced Optics and Photonics
PHYS 8201 Advanced Electromagnetic Theory I
PHYS 8202 Advanced Electromagnetic Theory II
ENGR 8270 Computational Nanomechanics
ENGR 8310 MEMS Design
ENGG(CSCI) 8840 Advanced Image Analysis

**Track 3: Cyber-physical Systems -** *Understanding of engineered systems that are built from, and depend upon, the seamless integration of computational algorithms and physical components. Advances in CPS will enable capability, adaptability, scalability, resiliency, safety, security, and usability that will far exceed the simple embedded systems of today. CPS technology will transform the way people interact with engineered systems—just as the Internet has transformed the way people interact with information. New smart CPS will drive innovation and competition in sectors such as agriculture, energy, transportation, building design and automation, healthcare, and manufacturing.*

ENGR 8990 Advanced Topics in Engineering: Real Time Programming
ENGR 8980 Advanced Topics in Biological Engineering: Haptic/Tactile Sensors
CSEE 8830 Virtual Reality and Augmented Reality User Interface Design
ENGR 8240 Instrumentation Programming
CSCI(ENGR) 8940 Computational Intelligence
CSCI 8820 Computer Vision and Pattern Recognition
CSCI 8380 Advanced Topics in Information Systems
CSCI 8250 Advanced Network and Security Systems
ENGG(CSCI) 8840 Advanced Image Analysis
ENGR 8990 Advanced Topics in Engineering: Optimization Theory and Applications
INFO 8000 Foundations of Informatics for Research and Practice

UNIVERSITY OF GEORGIA
College of Engineering

**College:** Engineering

**School:** Environmental, Civil, Agricultural and Mechanical Engineering

**Degree/Major:** Ph.D. in Engineering

**Requirements:**

Candidates for the Ph.D. degree are expected to synthesize and create new knowledge, make original and substantial contributions to their discipline, and demonstrate mastery of knowledge. Students may select to pursue an emphasis area within the Ph.D. in Engineering in one of the following emphasis areas: Resilient Infrastructure Systems, Energy Systems, Environment and Water, Dynamical Systems and Control, Fluid and Thermal Systems, or Mechanics and Materials.

A minimum of 72 semester credits of approved coursework and research beyond the B.S. degree is required. A master's degree from an approved university may be accepted for 30 credits hours, in which case a minimum of 42 credit hours of approved coursework and research beyond the master's degree would be required. The Ph.D. program of study consists of 16 or more hours of 8000- and 9000-level courses in addition to research, dissertation writing, and directed study. The program of study must include three hours of dissertation writing (9300). No grade below C will be accepted in the program of study. To be eligible for graduation, a student must maintain a 3.0 (B) average on the graduate transcript and a 3.0 (B) average in the program of study. The program of study for a student who bypasses the M.S. degree must contain 4 semester hours of University of Georgia courses open only to graduate students in addition to 16 semester hours of 8000- and 9000-level courses. Doctoral research (9000), independent study courses, and dissertation writing (9300) may not be counted in these 20 hours. All Ph.D. Engineering students are required to enroll in one semester of ENGR 8950 Graduate Seminar.

**Emphasis Title (as it will appear):** Energy Systems
**Proposed Start Date:** Fall 2017

**Emphasis Area Description:**
Providing sustainable energy for a rapidly growing world population is a grand challenge of the 21st century. Power generation and environmental emissions are a technical, social, and political issue that affects economies and the environment on local, national, and global scales. The Energy Systems program examines diverse technical, socio-political, and ecological dimensions of power generation and consumption including:

- energy generation, storage, and conversion technologies,
- impacts of energy and environmental policy on the power generation sector,
- quantitative, qualitative, and descriptive models of energy flows and storages that illuminate the role of energy in the functionality of the biosphere and modern society,
- ecological systems functionality and how this pertains to ecosystem health and ecological services provided to support humankind, and
- interconnections with food and water systems.

The Energy Systems Emphasis Area stresses a holistic approach and offers exposure to many disciplines beyond engineering, including natural and social sciences, public policy, and business. The curriculum is highly flexible and offers personalized plans of study.

As a requirement of the Ph.D. in Engineering with an Emphasis in Energy Systems, students must complete a minimum of 9 credit hours selected from the list below. Students will work with their graduate

advisor to select the most appropriate coursework to ensure breadth of understanding as well as mastery of knowledge in a specific subject area. In addition to completing 9 credit hours selected from the list below, students may work with their graduate advisor to develop an interdisciplinary plan of coursework drawing from the extensive graduate course offerings available at UGA.

- ENGR 8103 Computational Engineering: Fundamentals, Elliptic, and Parabolic Differential Equations (Sp)
- ENGR 8160 Advanced Fluid Mechanics (Sp)
- ENGR 8170 Advanced Heat Transfer
- ENGR 8180 Advanced Mass Transfer
- ENGR 8250* Combustion Science
- MCHE 8850 Gas Dynamics
- MCHE 8380 Continuum Mechanics (F)
- PHYS 8301 Statistical Mechanics I
- STAT 6315 Statistical Methods for Researchers (Sp)
- MIST 4550/6550 Energy Informatics

* Course does not exist in CAPA System

UNIVERSITY OF GEORGIA
College of Engineering

**College:** Engineering

**School:** Environmental, Civil, Agricultural and Mechanical Engineering

**Degree/Major:** Ph.D. in Engineering

**Requirements:**

Candidates for the Ph.D. degree are expected to synthesize and create new knowledge, make original and substantial contributions to their discipline, and demonstrate mastery of knowledge. Students may select to pursue an emphasis area within the Ph.D. in Engineering in one of the following emphasis areas: Resilient Infrastructure Systems, Energy Systems, Environment and Water, Dynamical Systems and Control, Fluid and Thermal Systems, or Mechanics and Materials.

A minimum of 72 semester credits of approved coursework and research beyond the B.S. degree is required. A master's degree from an approved university may be accepted for 30 credits hours, in which case a minimum of 42 credit hours of approved coursework and research beyond the master's degree would be required. The Ph.D. program of study consists of 16 or more hours of 8000- and 9000-level courses in addition to research, dissertation writing, and directed study. The program of study must include three hours of dissertation writing (9300). No grade below C will be accepted in the program of study. To be eligible for graduation, a student must maintain a 3.0 (B) average on the graduate transcript and a 3.0 (B) average in the program of study. The program of study for a student who bypasses the M.S. degree must contain 4 semester hours of University of Georgia courses open only to graduate students in addition to 16 semester hours of 8000- and 9000-level courses. Doctoral research (9000), independent study courses, and dissertation writing (9300) may not be counted in these 20 hours. All Ph.D. Engineering students are required to enroll in one semester of ENGR 8950 Graduate Seminar.

**Emphasis Title (as it will appear):** Environment and Water
**Proposed Start Date:** Fall 2017

**Emphasis Area Description:**
Environmental, water, and human systems are fundamentally interdependent; thus, the complex water, energy, food, environmental quality, and resource allocation issues facing society require integrated and comprehensive approaches to problem solving. The Environment and Water program draws from many disciplines to develop new approaches and effective solutions to the major water and environmental challenges of our times. The program offers students tremendous flexibility in designing a graduate program that builds in-depth skills and breadth of knowledge in their area of interest. Students conduct cutting edge research on a wide range of topics, including environmental fluid dynamics, hydrology and hydraulics, water resources management and sustainability, marine ecosystem and coastal ocean circulation models, coupled human-natural systems, solid waste, stream and watershed restoration, drinking water and wastewater treatment, diffuse pollution abatement, systems modeling, and life cycle analysis. The program leverages UGA's broad strengths in building multidisciplinary teams that include experts in ecology, environmental design, public health, social sciences, and policy.

As a requirement of the Ph.D. in Engineering with an Emphasis in Environment and Water, students must complete a minimum of 9 credit hours selected from the list below. Students work with their graduate advisor to select the most appropriate coursework to ensure breadth of understanding as well as mastery of knowledge in a specific subject area. In addition to completing 9 credit hours selected from the list below, students may work with their graduate advisor to develop an interdisciplinary plan of coursework drawing from the extensive graduate course offerings available at UGA.

- ENGR 4440/6440 Environmental Engineering Unit Operations
- ENVE 6450 Engineering Hydrology and Hydraulics
- ENVE 4550/6550 Environmental Life Cycle Analysis
- ENVE 8110 Ecological Energetics
- ENGR 8103 Computational Engineering: Fundamentals, Elliptic, and Parabolic Differential Equations
- CRSS(GEOL) 8710 Watershed-Scale Modeling
- CVLE 8140 Transport and Mixing in Natural Flows
- ENGR 8160 Advanced Fluid Mechanics
- ENVE 4250/6250 Energy Systems and the Environment
- ENVE 4440/6440 Computer Modeling in Water Resources
- ENVE 6450 Engineering Hydrology and Hydraulics
- ENVE 4460/6460 Groundwater Hydrology for Engineers
- GEOL(WASR) 8740 Hydrologic Flow and Transport Modeling
- MARS 8030 General Physical Oceanography
- MARS 8100 Estuarine and Coastal Oceanography
- MARS 7380 Quantitative Methods in Marine Science
- MARS 8150 Ocean Waves
- MARS 8510 Modeling Marine Systems
- STAT 6315 Statistical Methods for Researchers
- WASR 8200 Hillslope Hydrology Seminar
- CHEM 8880 Nanomaterials: Engineering and Characterization

UNIVERSITY OF GEORGIA
College of Engineering

**College:** Engineering

**School:** Environmental, Civil, Agricultural and Mechanical Engineering

**Degree/Major:** Ph.D. in Engineering

**Requirements:**

Candidates for the Ph.D. degree are expected to synthesize and create new knowledge, make original and substantial contributions to their discipline, and demonstrate mastery of knowledge. Students may select to pursue an emphasis area within the Ph.D. in Engineering in one of the following emphasis areas: Resilient Infrastructure Systems, Energy Systems, Environment and Water, Dynamical Systems and Control, Fluid and Thermal Systems, or Mechanics and Materials.

A minimum of 72 semester credits of approved coursework and research beyond the B.S. degree is required. A master's degree from an approved university may be accepted for 30 credits hours, in which case a minimum of 42 credit hours of approved coursework and research beyond the master's degree would be required. The Ph.D. program of study consists of 16 or more hours of 8000- and 9000-level courses in addition to research, dissertation writing, and directed study. The program of study must include three hours of dissertation writing (9300). No grade below C will be accepted in the program of study. To be eligible for graduation, a student must maintain a 3.0 (B) average on the graduate transcript and a 3.0 (B) average in the program of study. The program of study for a student who bypasses the M.S. degree must contain 4 semester hours of University of Georgia courses open only to graduate students in addition to 16 semester hours of 8000- and 9000-level courses. Doctoral research (9000), independent study courses, and dissertation writing (9300) may not be counted in these 20 hours. All Ph.D. Engineering students are required to enroll in one semester of ENGR 8950 Graduate Seminar.

**Emphasis Title (as it will appear):** Fluid and Thermal Systems
**Proposed Start Date:** Fall 2017

**Emphasis Area Description:**
Many of the key challenges for society involve systems that include fluid transport or thermal processes. The challenges include areas such as energy production or in the consumption of energy to the heat transfer or fluid processes in complex systems. This program provides the opportunity to investigate several topics that provide a fundamental background to address these challenges.

As a requirement of the Ph.D. in Engineering with an Emphasis in Fluid and Thermal Systems, students must complete a minimum of 9 credit hours selected from the list below. Students work with their graduate advisor to select the most appropriate coursework to ensure breadth of understanding as well as mastery of knowledge in a specific subject area. In addition to completing 9 credit hours selected from the list below, students may work with their graduate advisor to develop an interdisciplinary plan of coursework drawing from the extensive graduate course offerings available at UGA.

- ENGR 4490/6490 Renewable Energy Engineering
- ENGR 4350/6350 Introduction to Finite Element Analysis (F)
- ENGR 4650/6650 HVAC Systems for Buildings and Industry
- ENGR 8103 Computational Engineering: Fundamentals, Elliptic, and Parabolic Differential Equations (Sp)
- ENGR 8160 Advanced Fluid Mechanics (Sp)

- ENGR 8170 Advanced Heat Transfer
- ENGR 8180 Advanced Mass Transfer
- MCHE 8380 Continuum Mechanics (F)
- PHYS 4300/6300 Thermodynamics and Kinetic Theory
- PHYS 8301 Statistical Mechanics I
- STAT 6315 Statistical Methods for Researchers (Sp)
- MIST 4550/6550 Energy Informatics

UNIVERSITY OF GEORGIA
College of Engineering

**College:** Engineering

**School:** Environmental, Civil, Agricultural and Mechanical Engineering

**Degree/Major:** Ph.D. in Engineering

**Requirements:**

Candidates for the Ph.D. degree are expected to synthesize and create new knowledge, make original and substantial contributions to their discipline, and demonstrate mastery of knowledge. Students may select to pursue an emphasis area within the Ph.D. in Engineering in one of the following emphasis areas: Resilient Infrastructure Systems, Energy Systems, Environment and Water, Dynamical Systems and Control, Fluid and Thermal Systems, or Mechanics and Materials.

A minimum of 72 semester credits of approved coursework and research beyond the B.S. degree is required. A master's degree from an approved university may be accepted for 30 credits hours, in which case a minimum of 42 credit hours of approved coursework and research beyond the master's degree would be required. The Ph.D. program of study consists of 16 or more hours of 8000- and 9000-level courses in addition to research, dissertation writing, and directed study. The program of study must include three hours of dissertation writing (9300). No grade below C will be accepted in the program of study. To be eligible for graduation, a student must maintain a 3.0 (B) average on the graduate transcript and a 3.0 (B) average in the program of study. The program of study for a student who bypasses the M.S. degree must contain 4 semester hours of University of Georgia courses open only to graduate students in addition to 16 semester hours of 8000- and 9000-level courses. Doctoral research (9000), independent study courses, and dissertation writing (9300) may not be counted in these 20 hours. All Ph.D. Engineering students are required to enroll in one semester of ENGR 8950 Graduate Seminar.

**Emphasis Title (as it will appear):** Mechanics and Materials
**Proposed Start Date:** Fall 2017

**Emphasis Area Description:**
Many new technology developments involve new materials with different properties than would be considered ”typical.” This program provides the student with insight into methods for analyzing new materials and systems and how they can be used to solve new and pressing issues.

As a requirement of the Ph.D. in Engineering with an Emphasis in Mechanics and Materials, students must complete a minimum of 9 credit hours selected from the list below. Students work with their graduate advisor to select the most appropriate coursework to ensure breadth of understanding as well as mastery of knowledge in a specific subject area. In addition to completing 9 credit hours selected from the list below, students may work with their graduate advisor to develop an interdisciplinary plan of coursework drawing from the extensive graduate course offerings available at UGA.

- ENGR 4350/6350 Introduction to Finite Element Analysis (F)
- ENGR 4740/6740 Biomaterials (F)
- ENGR 4760/6760 Biomechanics (Sp)
- ENGR 8103 Computational Engineering: Fundamentals, Elliptic, and Parabolic Differential Equations (Sp)
- ENGR 6270 Computational Nanomechanics (Sp)
- ENGR 8270 Computational Nanomechanics

- CVLE(MCHE) 8350 Nonlinear Finite Element Analysis (Sp)
- CVLE(MCHE) 4640/6640 Advanced Strength of Materials (Sp)
- MCHE 8380 Continuum Mechanics (F)
- ENGG(CHEM) 4615/6615 Soft Materials
- CHEM 8880 Nanomaterials: Engineering and Characterization (F)
- PHYS 4300/6300 Thermodynamics and Kinetic Theory
- STAT 6315 Statistical Methods for Researchers (Sp)

UNIVERSITY OF GEORGIA
College of Engineering

**PROPOSAL FOR AREAS OF EMPHASIS**

**College:** Engineering

**School:** Environmental, Civil, Agricultural and Mechanical Engineering

**Degree/Major:** Ph.D. in Engineering

**Requirements:**

Candidates for the Ph.D. degree are expected to synthesize and create new knowledge, make original and substantial contributions to their discipline, and demonstrate mastery of knowledge. Students may select to pursue an emphasis area within the Ph.D. in Engineering in one of the following emphasis areas: Resilient Infrastructure Systems, Energy Systems, Environment and Water, Dynamical Systems and Control, Fluid and Thermal Systems, or Mechanics and Materials.

A minimum of 72 semester credits of approved coursework and research beyond the B.S. degree is required. A master's degree from an approved university may be accepted for 30 credits hours, in which case a minimum of 42 credit hours of approved coursework and research beyond the master's degree would be required. The Ph.D. program of study consists of 16 or more hours of 8000- and 9000-level courses in addition to research, dissertation writing, and directed study. The program of study must include three hours of dissertation writing (9300). No grade below C will be accepted in the program of study. To be eligible for graduation, a student must maintain a 3.0 (B) average on the graduate transcript and a 3.0 (B) average in the program of study. The program of study for a student who bypasses the M.S. degree must contain 4 semester hours of University of Georgia courses open only to graduate students in addition to 16 semester hours of 8000- and 9000-level courses. Doctoral research (9000), independent study courses, and dissertation writing (9300) may not be counted in these 20 hours. All Ph.D. Engineering students are required to enroll in one semester of ENGR 8950 Graduate Seminar.

**Emphasis Title (as it will appear):** Resilient Infrastructure Systems
**Proposed Start Date:** Fall 2017

**Emphasis Area Description:**
Infrastructure systems support the basic needs and functions of modern industrialized society, including energy, water and sewage, transportation, communications, and public facilities. Resilience is the capacity of individuals, communities, and systems to anticipate, prepare for, and adapt to changing conditions, recover from threats, and thrive in the future. The Resilient Infrastructure Systems program focuses on innovative solutions that help communities, businesses, and governments mitigate risks—and seize opportunities—associated with environmental change, extreme weather, and climate-related events by rethinking, transforming, and adapting infrastructure systems to strengthen economic, environmental, and social resilience. The program offers students the opportunity to conduct integrative research focused on built and natural infrastructure systems related to transportation, environment, water, energy, and food, and their interconnections. Students may tailor a plan of coursework to their interests by drawing from UGA's extensive course offerings spanning several engineering disciplines, earth and atmospheric sciences, environmental design, ecology, public health, law and policy, and the social sciences.

As a requirement of the Ph.D. in Engineering with an Emphasis in Resilient Infrastructure Systems degree, students must complete a minimum of 9 credit hours selected from the list below. Students will work with their graduate advisor to select the most appropriate coursework to ensure breadth of

understanding as well as mastery of knowledge in a specific subject area. In addition to completing 9 credit hours selected from the list below, students may work with their graduate advisor to develop an interdisciplinary plan of coursework drawing from the extensive graduate course offerings available at UGA.

- CRSS(GEOL) 8710 Watershed-Scale Modeling
- CVLE 4330/6330 Advanced Structural Analysis (F)
- CVLE 4340/6340 Design of Bridges
- CVLE 4470/6470 Pavement Design
- CVLE(MCHE) 8350 Nonlinear Finite Element Analysis (Sp – Every Other Year)
- CVLE(MCHE) 4640/6640 Advanced Strength of Materials (Sp- Every Other Year)
- CVLE 8550 Design of Prestressed Concrete Structures (F)
- CVLE 8420 Geomechanics (F)
- CVLE 8460 Soil Improvement (F)
- CVLE 8140 Transport and Mixing in Natural Flows (Sp)
- CVLE 8130 Mechanics of Jets and Plumes (Sp)
- ENGR 4350/6350 Introduction to Finite Element Analysis
- ENGR 4490/6490 Renewable Energy Engineering
- ENGR(LAND) 4660/6660 Sustainable Building Design
- ENGR 8103 Computational Engineering: Fundamentals, Elliptic, and Parabolic Differential Equations (Sp)
- ENGR 8160 Advanced Fluid Mechanics (Sp)
- ENVE 4230/6230 Energy in Nature, Civilization, and Engineering
- ENVE 4250/6250 Energy Systems and the Environment
- ENVE 4440/6440 Computer Modeling in Water Resources
- ENVE 6450 Engineering Hydrology and Hydraulics
- ENVE 4460/6460 Groundwater Hydrology for Engineers
- ENVE 4530/6530 Energy and Environmental Policy Analysis
- ENGR 4440/6440 Environmental Engineering Unit Operations
- ENVE 4550/6550 Environmental Life Cycle Analysis
- MCHE 4650/6650 HVAC Systems for Buildings and Industry
- GEOL(WASR) 8740 Hydrologic Flow and Transport Modeling
- MARS 8030 General Physical Oceanography (Sp)
- MARS 8100 Estuarine and Coastal Oceanography (F)
- MARS 7380 Quantitative Methods in Marine Science (F)
- MARS 8150 Ocean Waves (F)
- MARS 8510 Modeling Marine Systems (F)
- WASR 8200 Hillslope Hydrology Seminar

# UNIVERSITY OF GEORGIA

College of Engineering

**APPROVAL PAGE**
**College of Engineering**
**Curriculum Proposals**

**Proposals:**

**Area of Emphasis in Biochemical Engineering for the PhD in Engineering**
**Area of Emphasis in Biomedical Engineering for the PhD in Engineering**

School Curriculum Committee Chair — Date: 02/22/17

School Chair — Date: 2/23/17

Curriculum Committee Chair — Date: 2/22/2017

Associate Dean for Research and Graduate Studies — Date: 2/22/17

Dean — Date: 2/22/17

Dean of Graduate School — 2-28-17

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UNIVERSITY OF GEORGIA

College of Engineering

**APPROVAL PAGE**
**College of Engineering**
**Curriculum Proposals**

**Proposals:**

Area of Emphasis in Civil Engineering for the MS in Engineering
Area of Emphasis in Mechanical Engineering for the MS in Engineering
Area of Emphasis in Resilient Infrastructure Systems for the PhD in Engineering
Area of Emphasis in Energy Systems for the PhD in Engineering
Area of Emphasis in Environment and Water for the PhD in Engineering
Area of Emphasis in Fluid and Thermal Systems for the PhD in Engineering
Area of Emphasis in Mechanics and Materials for the PhD in Engineering

Thos M Lawrence — 2/7/2017
School Curriculum Committee Chair — Date

Sidney Thompson — 2-7-2017
School Chair — Date

Thos M Lawrence — 2-22-2017
Curriculum Committee Chair — Date

[signature] — 2/22/17
Associate Dean for Research and Graduate Studies — Date

[signature] — 2/22/17
Dean — Date

[signature] — 2-28-17
Dean of Graduate School

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UNIVERSITY OF GEORGIA

College of Engineering

**APPROVAL PAGE**
**College of Engineering**
**Curriculum Proposals**

**Proposals:**

**Area of Emphasis in Electrical and Computer Engineering for the MS in Engineering**
**Area of Emphasis in Electrical and Computer Engineering for the PhD in Engineering**

Peter Kner — 2/8/2017

School Curriculum Committee Chair — Date

Takoi Hamrita — 2/22/17

School Chair — Date

Thee Mhaw — 2/22/2017

Curriculum Committee Chair — Date

[signature] — 2/22/17

Associate Dean for Research and Graduate Studies — Date

[signature] — 2/22/17

Dean — Date

[signature] — 2-28-17

Dean of Graduate School

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# Approvals on File

**Proposal:** Area of Emphasis in Biochemical Engineering Under the Major in Engineering (Ph.D.)

Area of Emphasis in Biomedical Engineering Under the Major in Engineering (Ph.D.)

**Department:** School of Chemical, Materials, and Biomedical Engineering

**College:** College of Engineering

**Proposed Effective Term:** Semester after approval

Department:

- School of Chemical, Materials and Biomedical Engineering Chair, Dr. Ramaraja Ramasamy, 2/23/2017

School/College:

- College of Engineering Associate Dean, Dr. Larry Hornak, 2/17/17
- College of Engineering Dean, Dr. Donald Leo, 2/22/2017

Graduate School:

- Graduate School Dean, Dr. Suzanne Barbour, 3/1/2017

# Approvals on File

**Proposal:** Area of Emphasis in Electrical and Computer Engineering under Engineering (M.S.)
Area of Emphasis in Electrical and Computer Engineering under Engineering (Ph.D.)

**Department:** School of Electrical and Computer Engineering

**College:** College of Engineering

**Proposed Effective Term:** Semester after approval

Department:

- School of Electrical and Computer Engineering Chair, Dr. Takoi Hamrita, 2/22/2017

School/College:

- College of Engineering Dean, Dr. Donald Leo, 2/22/2017

Graduate School:

- Graduate School Dean, Dr. Suzanne Barbour, 3/1/2017

# Approvals on File

**Proposal:** New Areas of Emphasis under the Major in Engineering (M.S.):

Area of Emphasis in Civil Engineering
Area of Emphasis in Mechanical Engineering

New Areas of Emphasis under the Major in Engineering (Ph.D.):

Area of Emphasis in Dynamical Systems and Control
Area of Emphasis in Energy Systems
Area of Emphasis in Environment and Water
Area of Emphasis in Fluid and Thermal Systems
Area of Emphasis in Mechanics and Materials
Area of Emphasis in Resilient Infrastructure Systems

**Department:** School of Environmental, Civil, Agricultural and Mechanical Engineering

**College:** College of Engineering

**Proposed Effective Term:** Semester after approval

Department:

- School of Environmental, Civil, Agricultural and Mechanical Engineering Chair, Dr. Sidney Thompson, 2/7/2017

School/College:

- College of Engineering Dean, Dr. Donald Leo, 2/22/2017

Graduate School:

- Graduate School Dean, Dr. Suzanne Barbour, 3/1/2017