



A. JAMES CLARK  
SCHOOL OF ENGINEERING

## **Department of Mechanical Engineering**

# **Graduate Handbook**

**2019-2020**

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# I. MESSAGE FROM THE DIRECTOR OF GRADUATE STUDIES

Welcome to the 2019-2020 academic year.

This is an exciting time to be pursuing your graduate studies in the Department of Mechanical Engineering at the University of Maryland – a department that has been ranked by U.S. News and World Report in the Top 25 nationally. Graduate education and research is an essential mission of the Mechanical Engineering Department; and the most critical component of our research program is the dedicated and highly accomplished student body that carries out the theoretical and experimental studies under the guidance of our faculty.

Your education here will expose you to an exciting modern curriculum and unprecedented cross-disciplinary research opportunities, orchestrated by over 45 energetic and active faculty members with a wide range of professional and academic specialties. You will be interacting with a distinguished and a well-connected faculty body that carries prestigious distinctions such as:

- 8 National Academy of Engineering members (including a past President of the University)
- 75 Fellow memberships in major Professional Societies
- 13 young researcher awards such as the National Science Foundation CAREER award, Office of Naval Research Young Investigator Program, and DARPA Young Faculty Awards.
- 3 faculty NSF PECASE Awards
- 11 editorships of premier mechanical engineering journals
- 30 Associate Editorships and/or leader positions in respective professional societies

You will have the chance to be a part of a vibrant and cutting-edge sponsored research program that continues to double every five years, and currently stands at \$19.1 million per year. In your research, you will be interacting with sponsors from industry and government, who support both basic and applied research in a wide variety of areas including:

- Bio-sensors that depend on nanotechnologies and MEMS
- Automation of modern manufacturing processes including additive manufacturing
- Micro-robotics and intelligent robots
- Intelligent systems in the era of machine learning and artificial intelligence
- Integrated and sustainable energy conversion systems
- Reliable and self-prognosticating electronic products and systems
- Probabilistic risk assessment.

You will be conducting your research in state-of-the-art laboratories and learning from a wide offering of modern technically relevant courses. You will find that our graduate program is designed to offer both a breadth of understanding, while also providing outstanding and comprehensive opportunities in your particular area of research.

In the 2019-2020 academic year, the Department of Mechanical Engineering has 257 actively enrolled graduate students. Of these, 47 are pursuing Master of Science degrees and 210 are pursuing Doctoral studies. Over the past two years the Department of Mechanical Engineering has granted 189 degrees, 76 Master of Science and 113 Doctor of Philosophy. Alumni of the Department of Mechanical Engineering's graduate program have gone on to enjoy distinguished and prestigious careers in academia, industry, and government. Nationally, we offer the third-highest salary for graduate researchers, and we provide an exciting collegial atmosphere, combining an intensive academic experience with a friendly, open and highly diverse department culture.

As a part of the largest department in the A. James Clark School of Engineering, you will be a part of a College that has consistently ranked in the top 25 in the U.S. News and World Report's Graduate School rankings since 1997, and prides itself on the production of highly educated and skilled graduates. Located just a few miles from Washington, D.C., the Clark School is at the center of a constellation of high-tech companies and federal laboratories, offering students and faculty access to unique professional development advanced opportunities with industry and government partners.

This booklet and our website are designed to provide prospective and current students with information regarding the program, its rules and regulations, the admission process and the pathway to the degrees that we grant. If you desire additional information, please do not hesitate to contact us at [megrad@umd.edu](mailto:megrad@umd.edu).

Abhijit Dasgupta  
Jeong H. Kim Professor  
Associate Chair for Academic Affairs  
Director of Graduate Studies

## II. DEPARTMENT INFORMATION

### II.1 Introduction

Graduate instruction and research are carried out in three divisions, grouped broadly by areas of specialization: Design and Systems Reliability (DSR); Mechanics, Materials, and Manufacturing (MMM) and Thermal, Fluids and Energy Sciences (TFES). The Department maintains two graduate programs. Mechanical Engineering (ENME) and Reliability Engineering (ENRE). Students enrolled in the graduate programs of the department pursue Master of Science (M.S.) and/or Doctor of Philosophy (Ph.D.) degrees.

#### **Design and Systems Reliability (DSR)**

This area of concentration includes the study of design, decision-making, data analytics, machine learning, and reliability science. It includes methods for analysis of reliability, maintainability, availability and safety. In the core courses, students learn about engineering design methods, engineering decision-making, engineering optimization, reliability, risk management, and their applications to advanced systems, including electronic and mechatronic products. Advanced courses are offered in prognostics, robotics, life-cycle cost analysis, accelerated testing, condition monitoring, and cybersecurity, for applications in critical technology domains, including health care, renewable energy, autonomous vehicle systems and microelectronics.

Examples of current research topics include:

- Predicting, measuring and tracking levels of reliability during systems' life cycles
- Prognostics and health management of engineering systems
- Systems risk assessment and management
- Life-cycle cost of ownership
- Understanding and mitigating the causes of component, system, and process failures
- Incorporating reliability, sustainment, and life-cycle considerations into design
- Microelectronic device and electronic system stress and reliability analysis
- Design and reliability of high temperature and high power electronic systems, electro-optics, sensors, and actuators
- Battery design, thermal management, and reliability
- Integrated product design and manufacturing
- Design formalisms
- Multi-criteria design decision making and optimization
- Statistical process control and improved manufacturing methods
- Human reliability analysis
- Cybersecurity
- Machine learning and data analytics

#### **The research is supported by dedicated laboratories in:**

- Design Assurance Techniques Laboratory
- Design Decision Support Laboratory
- Electronic Systems Cost Modeling Laboratory
- Environmental Conditioning and Accelerated Testing Laboratory
- Hybrid Systems Integration and Simulation Lab
- Product Innovation and Realization Laboratory Suite (PIRLS) and Design ME Suite
- Simulation-Based System Design Laboratory
- Systems Risk and Reliability Analysis Lab
- Test Services and Failure Analysis Laboratory

**Courses that support these research activities are:**

- ENME 600 – Engineering Design Methods
- ENME 607 – Engineering Decision Making
- ENME 610 – Engineering Optimization
- ENME 625 – Multidisciplinary Optimization
- ENME 690 – Mechanical Fundamentals of Electronic Systems
- ENME 695 – Design for Reliability
- ENME 722 – Equilibrium Modeling in Engineering
- ENME 725 – Probabilistic Optimization
- ENME 737 – Prognostics and Health Management
- ENME 741 – Operations Research Models in Engineering
- ENME 743 – Applied Machine Learning
- ENME 765 – Thermal Issues in Electronic Systems
- ENME 770 – Life Cycle Cost Analysis
- ENME 780 – Mechanical Design of High Temperature and High Power Electronics
- ENME 808A – Batteries: Operation, Modeling, and Reliability
- ENME 808N – Nanomechanics
- ENME 808Z – Fundamentals of Optics and Optical Systems for Engineers
- ENRE 600 – Fundamentals of Failure Mechanisms
- ENRE 602 – Reliability Analysis
- ENRE 640 – Collection and Analysis of Reliability Data
- ENRE 641 – Accelerated Testing
- ENRE 645 – Human Reliability Analysis
- ENRE 648 – Special Topics in Reliability Engineering
- ENRE 655 – Advanced Methods in Reliability Modeling
- ENRE 661 – Microelectronics Device Reliability
- ENRE 670 – Probabilistic Risk Assessment
- ENRE 671 – Risk Assessment in Engineering
- ENRE 684 – Information Security

**Mechanics, Materials, and Manufacturing (MMM)**

This division concentrates on fundamental studies of mechanics, materials, and manufacturing. Areas of specialization include: design, characterization, manufacturing and multi-scale modeling of materials; applied and theoretical mechanics; experimental mechanics; computational mechanics; additive manufacturing; micro-nano-bio systems.; sensor and actuator technologies; microelectromechanical systems (MEMS), structural dynamics; noise and vibration control; nonlinear dynamics; control systems; robotics; intelligent machines (including in health-care systems, medical devices and in autonomous systems); smart structures

Examples of current research topics include:

- Control systems in product development organization
- Applied artificial intelligence and machine learning to MMM areas
- Fiber optics and bio-mimetic multi-physics sensor systems.
- Metamaterials and Smart structures
- Vibration and acoustic control
- Vibro-acoustic heating and phonon transport
- Non-linear dynamics of milling of thin walled structures
- Control of crane-load oscillations
- Surgical robotics
- Sensor systems for healthcare
- Dynamic deformation and fracture studies, including fracture and fragmentation by explosives
- Crystal-scale creep-fatigue damage mechanics of high-temperature viscoplastic materials

- Micromechanics of advanced composite materials, including cellulose and wood-based composites
- Characterization and optimization of mechanical properties of materials
- Methods for non-destructive detection of damage in structural systems
- Mechanical characterization of Micro-Electro-Mechanical Systems (MEMS) materials
- Microfluidics, biochemical MEMS sensors, lab-on-a-chip
- Manufacturing systems
- Graphene and nano-tube based nanostructures
- Origami nano-structures
- Molecular modeling of energetic materials
- Additive manufacturing in micro-nano-bio systems

**Research is conducted in the following laboratories:**

- Advanced Manufacturing Laboratory
- Bioinspired Advanced Manufacturing Lab
- Computational Dynamics Laboratory
- Dynamics and Controls Laboratory
- Laboratory for Computational Research in Science and Technology
- Laboratory for Control and Information Systems
- Laboratory for MicroTechnologies
- Maryland MEMS and Microfluids Laboratory
- Medical Robotics and Equipment Lab
- Multiscale Measurements Laboratory
- Vibrations Laboratory

**Courses that support these research activities are:**

- ENME 605 – Advanced Systems Control
- ENME 611 – Fiber Optics
- ENME 662 – Linear Vibrations
- ENME 664 – Dynamics
- ENME 665 – Advanced Topics in Vibration
- ENME 670 – Continuum Mechanics
- ENME 672 – Composite Materials
- ENME 674 – Finite Element Methods
- ENME 680 – Experimental Mechanics
- ENME 684 – Modeling Material Behavior
- ENME 704 – Active Vibration Control
- ENME 711 – Vibration Damping
- ENME 740 – Lab-on-a-Chip Microsystems
- ENME 744 – Additive Manufacturing
- ENME 746 – Medical Robotics
- ENME 750 – Applied System Identification
- ENME 751 – Applied Nonlinear Control
- ENME 808E – Machine Learning: Theory and Applications
- ENME 808G – Flexible Macroelectronics
- ENME 808K – Microelectromechanical Systems (MEMS)
- ENME 808T – Network Control Systems

**Thermal, Fluid and Energy Sciences (TFES)**

This area of concentration encompasses three broad disciplines: thermal science, fluid mechanics, and energy science. Areas of specialization include heat transfer, combustion, energy systems analysis, hydrodynamics, turbulence, and computational fluid dynamics.

Examples of current research topics include:

- Application of three-dimensional vortex methods to turbulent flow prediction
- Experimental, numerical, and theoretical analysis of scalar pollutant dispersion in turbulent boundary layers
- Experimental studies of the near surface atmospheric boundary layer
- Large-eddy and direct numerical simulation of 3-D and non-equilibrium boundary layers
- Experimental measurement and analysis of particle/turbulence interaction within turbulent, multi-phase flows
- Fundamental research into pool and flow boiling heat transfer
- Experimental investigation of steady and unsteady breaking waves
- Fouling and particulate deposition on low temperature surfaces
- Performance of water foaming agents in fire protection applications
- Mixing of boron diluted water slugs and nuclear reactor reactivity excursions
- Thermal management and characterization of electronic equipment
- Transport phenomena in manufacturing
- Study of absorption heat pumps and chillers
- Heat transfer enhancement of environmentally safe refrigerants
- Investigation of performance potential for natural refrigerants
- Simulation, analysis, and experimentation in heat pump and refrigeration systems
- Annular and post-annular flow in microchannels
- Two-phase thermofluid enhancement through flow regime modification
- Monolithic and thin-film thermoelectric microcoolers

**The research is supported by the following dedicated laboratories:**

- Advanced Heat Exchangers Lab
- Combustion Engineering Laboratory
- Hydrodynamics Laboratory
- CEEE Energy Laboratory
- Heat Pump Laboratory
- Phase-Change Heat Transfer Laboratory
- Software Development Laboratory
- Small and Smart Thermal Systems Laboratory

**Courses that support these research activities are:**

- ENME 631 – Advanced Conduction and Radiation Heat Transfer
- ENME 632 – Advanced Convection Heat Transfer
- ENME 633 – Molecular Thermodynamics
- ENME 635 – Analysis of Energy Systems
- ENME 640 – Fundamentals of Fluid Mechanics
- ENME 641 – Viscous Flow
- ENME 642 – Hydrodynamics I
- ENME 646 – Computational Fluid Dynamics and Heat Transfer
- ENME 647 – Multiphase Flow and Heat Transfer
- ENME 656 – Physics of Turbulent Flow
- ENME 657 – Analysis of Turbulent Flow
- ENME 701 – Sustainable Energy Conversion and the Environment
- ENME 712 – Measurement, Instrumentation, and Data Analysis for Thermo-fluid Processes
- ENME 742 – Urban Microclimate and Energy
- ENME 745 – Numerical Methods in Engineering
- ENME 808I – Interfacial Fluid Mechanics
- ENME 808U – Modern Climate Control of Building Energy Design and Analysis

## **Reliability Engineering Graduate Program (ENRE)**

This program covers aspects of engineering related to reliability and risk assessment.

### **The primary areas of specialization include:**

- Microelectronics reliability
- Reliability analysis
- Risk analysis
- Software Reliability

### **Examples of current research topics include:**

- Measuring, tracking, and predicting levels of reliability during systems life cycle
- Understanding why and how components, systems, and processes fail
- Improvement of reliability by removing failure causes.
- Providing input to decision making on system design and operation
- Determining potential undesirable consequences of systems and processes
- Identifying how potential undesirable consequences of systems and processes happen
- Assessing the probability of frequency of consequences
- Providing input to decision makers on optimal strategies to reduce risk
- Human reliability analysis
- Microelectronic device reliability and stress analysis
- Software quality assurance
- Study of Information security and software safety
- Software testing

### **Courses that support these research activities are:**

- ENRE 600 – Fundamentals of Failure Mechanisms
- ENRE 602 – Reliability Analysis
- ENRE 607 – Reliability Engineering Seminar
- ENRE 620 – Mathematical Techniques of Reliability Engineering
- ENRE 640 – Collection and Analysis of Reliability Data
- ENRE 641 – Accelerated Testing
- ENRE 645 – Human Reliability Analysis
- ENRE 648 – Special Problems in Reliability Engineering
- ENRE 655 – Advanced Methods in Reliability Modeling
- ENRE-661 – Microelectronics Device Reliability
- ENRE 670 – Risk Assessment for Engineers I
- ENRE 671 - Risk Assessment for Engineers II
- ENRE 684 – Information Security

## II.2 CONTACT INFORMATION

### Mechanical Engineering (ME) Graduate Office

2168 Glenn L. Martin Hall  
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Department Chair

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### AY 2019-2020 Members of the Mechanical Engineering Graduate Committee

Professor Abhijit Dasgupta  
Professor Jeffrey Herrmann  
Professor Shapour Azarm  
Professor Peter Sandborn  
Professor Amr Baz  
Associate Professor Jin-Oh Hahn  
Associate Professor Johan Larsson  
Professor James Duncan

***Please see Appendix VII.5 for additional contact information***



### **III. DEGREE PROGRAMS**

The Mechanical Engineering Department offers programs of study leading to the Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) degrees in both Mechanical Engineering and Reliability Engineering. In addition, the Department offers a joint Bachelor of Science/Master of Science (B.S. /M.S.) program. Students also have the option of obtaining a Master of Engineering degree with a concentration in Mechanical Engineering or Reliability Engineering through the **Office of Advanced Engineering Education**. The requirements for each of the listed degree programs are described below in Section IV.

#### **III.1 Master of Science (M.S.) in Mechanical Engineering**

The Master of Science Degree in Mechanical Engineering is awarded for the successful completion of a unified, coherent program of coursework and research that is approved by the student's advisor and by the Director of Graduate Studies and meets the Graduate School requirements. A high level of academic achievement is expected in the coursework completed by the student. In addition, students are expected to carry out independent research, primarily in mechanical sciences and engineering, culminating in the preparation and defense of a thesis describing the research.

#### **III.2 Doctor of Philosophy (Ph.D.) in Mechanical Engineering**

The Doctor of Philosophy Degree is awarded in recognition of high level of scholarship, the ability to carry out independent research that makes fundamental contributions to the student's field of research, and the publication of such research in archival journals. A high level of academic achievement is expected in the coursework completed by the student. The program of study for the degree must consist of coursework, and independent research, primarily in mechanical sciences and engineering, culminating in the preparation and defense of a dissertation describing the research.

#### **III.3 Master of Science (M.S.) in Reliability Engineering**

The Master of Science Program in Reliability Engineering is awarded for the successful completion of a unified, coherent program of coursework and research that is approved by the student's advisor and by the Co-Director of Graduate Studies and meets the Graduate School requirements. A high level of academic achievement is expected in the coursework completed by the student. The Reliability Engineering Program offers both a thesis and non-thesis Master of Science degree.

#### **III.4 Doctor of Philosophy (Ph.D.) in Reliability Engineering**

The Doctor of Philosophy degree is awarded in recognition of high level of scholarship, the ability to carry out independent research, and the publication of such research in archival journals. A high level of academic achievement is expected in the coursework completed by the student. The program of study for the degree must consist of coursework, research and the preparation of a dissertation describing it, primarily in reliability and risk engineering.

#### **III.5 Joint Bachelor/Master Program B.S. /M.S. in Mechanical Engineering**

The combined Bachelor's/Master's Degree (B.S. /M.S.) Program is designed to allow highly capable undergraduates from the University of Maryland to accelerate their studies to obtain both degrees on a compressed and efficient schedule. The basic requirements for the individual degrees are similar to those from the more traditional path through these programs. However, in the combined program, the course requirements overlap so that the total number of courses is less for the combined program than for the traditional programs. Undergraduate students accepted to this program typically begin their graduate experience in their senior year by taking graduate level courses and participating in research activities.

#### **III.6 Master of Engineering & Graduate Certificate in Engineering Programs**

The Master of Engineering and Certificate Programs provide a professional degree and a certificate, respectively. While this program was initially designed for part-time students who want to continue their education while working full-time, the Master of Engineering welcomes full-time students. Both programs are application-oriented. Neither program provides financial support for graduate students. The Master of Engineering program does not require a thesis. Students interested in ultimately pursuing a Ph.D. are

recommended to enroll in the traditional M.S program or a BS/M.S. program, to establish a course-work and research background appropriate for continuing studies. For more information about the Master of Engineering or Certificate programs, students should consult the Office of Advanced Engineering Education's web page at <http://www.oaee.umd.edu> or call the **Office of Advanced Engineering Education office at 301-405-0362.**

## **IV. DEGREE REQUIREMENTS**

### **IV.1 M.S. Program in Mechanical Engineering**

#### **Course Requirements**

Students enrolled in the M.S. program must complete at least 30 credits for graduation. This includes 24 credits of approved coursework and 6 credits of M.S. Thesis Research. The M.S. Plan of Study sets forth the courses required to be taken by the student in partial fulfillment of the M.S. degree requirements. The coursework plan must be prepared in consultation with a faculty advisor in the student's technical area of interest and submitted to the ME Graduate Studies Office (2168 Glenn L. Martin Hall) for approval by the Director of Graduate Studies before the end of the first semester of study. Changes to the plan are permitted, but must be approved by the student's advisor and the Director of Graduate Studies prior to their implementation. A new Plan of Study reflecting the changes must be filed with the ME Graduate Studies Office every time changes are made.

The M.S. Plan of Study can include a maximum of six (6) approved transfer credits for graduate work undertaken at other accredited U.S. institutions. The Graduate School must approve the transfer of credits; approval is sought through the submission of a Transfer or Inclusion of Credit form to the Graduate School. Transfer of credits may be accepted on the following conditions. The coursework must: (a) be no more than seven years old at the time of graduation; (b) have been taken for graduate credit; and (c) have resulted in a grade of B- or better. If the coursework is taken at the University of Maryland College Park and meets criteria b and c above, then the period of validity may be extended from 5 years to 7 years, if the Director of Graduate Studies and the advisor certify to the Dean of the Graduate School that the coursework taken has been revalidated by the student's demonstration that the knowledge contained in the course(s) remains current. Separate justification has to be presented for each course that requires revalidation. Under no circumstances will any transfer credits be accepted that are more than seven years old at the time of graduation.

Courses taken as a Master of Professional Engineering student or as a B.S/M.S Mechanical Engineering student at the University of Maryland College Park must be transferred to the M.S. program by completing the Transfer or Inclusion of Credit form.

The Plan of Study must contain a minimum of 24 credits of graduate coursework (not including thesis credits). At least 18 credits (6 courses) must be from courses taken at the 600-level or above. At least five (5) of the eight courses must be taken in the Mechanical Engineering Department. The coursework must satisfy the following criteria:

<b>Required/Core Course:</b>	<b>minimum of 3 credits (1 course)</b>
<b>Mathematics Course:</b>	<b>minimum of 3 credits (1 course)</b>
<b>Electives:</b>	<b>the minimum number of elective is 18 credits or 6 courses (at least 5 courses must be in ENME) in addition to the required math and core course</b>
<b>Total Credits of Coursework:</b>	<b>24 credits (8 courses)</b>

A minimum of five courses must be completed in the Department of Mechanical Engineering.

The Core (breadth) requirement is fulfilled by completing one course that is outside of a student's research area from the following list:

### **Design and Systems Reliability**

- ENME 600: Engineering Design Methods
- ENME 607: Engineering Decision Making
- ENME 610: Engineering Optimization
- ENME 690: Mechanical Fundamentals of Electronic Systems
- ENME 695: Design for Reliability

### **Thermal, Fluids, and Energy Sciences**

- ENME 632: Advanced Convection Heat Transfer
- ENME 633: Molecular Thermodynamics
- ENME 640: Fundamentals of Fluid Mechanics

### **Mechanics, Materials, and Manufacturing**

- ENME 605: Advanced Systems Control
- ENME 662: Linear Vibrations
- ENME 664: Dynamics
- ENME 670: Continuum Mechanics

**The mathematics requirement can be fulfilled by completing at least one course from the following list:**

- CMSC 460: Computational Methods
- CMSC 467: Intro to Numerical Analysis II
- MATH 403: Intro to Abstract Algebra
- MATH 404: Field Theory
- MATH 405: Linear Algebra
- MATH 432: Intro to Point Set Topology
- MATH 436: Differential Geometry I
- MATH 437: Differential Geometry II
- MATH 452: Introduction to Dynamics and Chaos
- MATH 462: PDEs for Scientists and Engineers
- MATH 463: Complex Variables for Scientists and Engineers
- MATH 464: Transform Methods for Scientists and Engineers
- MATH 475: Combinatorics and Graph Theory
- STAT 410: Introduction to Probability Theory
- STAT 420: Introduction to Statistics
- STAT 440: Sampling Theory
- ENME 605: Advanced Systems Control
- ENME 610: Engineering Optimization
- ENME 625: Multidisciplinary Optimization
- ENME 700: Advanced Mechanical Engineering Analysis I
- ENME 725: Probabilistic Optimization
- ENME 745: Computational Methods in Science and Engineering
- ENRE 620: Mathematical Techniques of Reliability Engineering
- ENRE 655: Advanced Methods in Reliability Modeling
- Any MATH, STAT, or AMSC course at the 600 level or above.

For course descriptions, as well as a class schedule for the upcoming term, see <https://enme.umd.edu/course-schedule>

## Advisor

As early as possible, students should identify the faculty member whom they would like to serve as their coursework and research advisor. For research assistants, the faculty providing the financial support is also the advisor. A student's advisor will also serve as chairperson of the student's Thesis Committee (see below).

## Thesis Requirements

Students in the M.S. program must complete a minimum of six (6) credits of M.S. Thesis Research (799) while preparing the M.S. thesis. In order to register for 799, you must obtain permission from the Graduate Studies Office. Thesis research must be carried out under the guidance of an advisor who is a member of the Mechanical Engineering Graduate Faculty. The thesis must be presented formally and defended in an oral examination open to the public, which is conducted upon completion of the thesis.

The members of the thesis examining committee must be nominated at least six (6) weeks prior to the thesis defense. The Graduate School has further information on deadlines for submission of the Nomination of Thesis Committee form. This form must first be submitted to the ME Graduate Studies Office for approval and then forwarded to the Office of the Registrar in order to nominate the committee. Changes in a thesis committee can be made at any time, with the approval of the student's advisor, the Director of Graduate Studies and the Graduate School. In addition to the Graduate School's requirements for the composition of a thesis examining committee, the Department of Mechanical Engineering requires that mechanical and reliability engineering thesis committees be comprised of three full or associate faculty members of the Graduate Faculty (at least two of whom will be Full Members). The Chair of the Committee normally will be the student's advisor, who will be a Full or Associate Member of the Graduate Faculty. Additional members, beyond these three, can be appointed to the thesis committee, including the special nomination of research faculty or outside scientists. To nominate a Special or Associate Member to serve, the nominee's curriculum vitae must be submitted to the Graduate Office, at least eight weeks prior to the date of the thesis defense.

The M.S. thesis must be prepared according to the guidelines in the current edition of the University of Maryland Thesis Manual, which may be obtained online from:

[https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/DissertationThesis/etd\\_style\\_guide\\_201708.pdf](https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/DissertationThesis/etd_style_guide_201708.pdf)

A copy of the thesis, after the advisor has approved it, must be provided to each member of the examining committee at least two (2) weeks prior to the date of the examination. In addition, one week prior to the examination date, a notice that includes the thesis date, location, title, abstract, and committee members must be sent to the ME Graduate Studies Office ([megrad@umd.edu](mailto:megrad@umd.edu)) inviting faculty and students to the formal thesis presentation. The notice will be sent out via email to departmental listserv as well as posted on the [megrad.umd.edu](http://megrad.umd.edu) website.

A few days before the examination is scheduled to take place, the ME Graduate Studies Office will send the Report of the Examining Committee Form, Electronic Publication Form, the M.S Approved Program Form and the Middle States Accreditation Form to the student's advisor, who will bring these documents to the defense. Upon passing the examination, the forms are signed by the each member of the examining committee, the advisor, and the student and submitted to the ME Graduate Studies Office for final approval and are then forwarding to the Office of the Registrar. An electronic copy of the thesis must be submitted to the Graduate School (see below) and to the ME Graduate Studies Office. Students should also fill out the Department's Exit Information form found at: <http://megrad.umd.edu/graduate-student-exit-information-form/>

## Graduation Paperwork

The necessary forms will be completed by the Graduate Office with the assistance of the student and their advisor. The following forms must be completed and submitted prior to graduation:

1. Application for Graduation found online at [www.testudo.umd.edu](http://www.testudo.umd.edu)

2. If students have transferred from another program into the Mechanical Engineering M.S. program, they must submit a Transfer of Credit Form, available online at [https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/request\\_for\\_transfer\\_or\\_inclusion\\_of\\_credit\\_for\\_masters\\_degrees\\_0.pdf](https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/request_for_transfer_or_inclusion_of_credit_for_masters_degrees_0.pdf) in order to include previous coursework as part of the Mechanical Engineering Approved Program.
3. Nomination of Thesis or Dissertation Committee Form must be submitted to the Office of the Registrar, 1113 Lee Building after approval by the ME Graduate Studies Office. Copies of the form are available online at [https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/nomination\\_of\\_thesis\\_or\\_dissertation\\_committee\\_form.pdf](https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/nomination_of_thesis_or_dissertation_committee_form.pdf) and in the ME Graduate Studies Office.
4. Report of the Examining Committee Form is generated by the Office of the Registrar upon the approval of the Nomination of Thesis Committee form. The Report of the Examining Committee Form must be submitted to the Office of the Registrar, 1113 Mitchell Building after approval by the ME Graduate Studies Office.
5. An electronic copy of the thesis must be submitted to the Graduate School online. The paperwork and instructions regarding how to upload the document are found here: [https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/thesis\\_and\\_dissertation\\_electronic\\_publication\\_form.pdf](https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/thesis_and_dissertation_electronic_publication_form.pdf) An electronic copy of the approved thesis should also be submitted to the ME Graduate Studies Office, [megrad@umd.edu](mailto:megrad@umd.edu).

Deadlines for the above forms vary from semester to semester and are posted in on the Graduate School's website at <https://gradschool.umd.edu/calendar/deadlines>

Failure to submit the forms by the established deadlines results in postponement of the student's graduation to the following semester. During the final semester, students should verify with the Office of the Registrar, 1113 Mitchell Bldg. (301)314-8226, that they have met all the requirements for graduation.

### Summary of Requirements and Timeline

<b>First semester</b>	M.S. Plan of Study approved by Advisor and Director of Graduate Studies. Students should fill out their coursework plans electronically. For instructions on how to do this, please see <a href="http://megrad.umd.edu/plan-of-study/">http://megrad.umd.edu/plan-of-study/</a> Request for Inclusion or Transfer of Credits submitted (if transferring any credits into the M.S. program—these credits must be approved on your <i>M.S. Plan of Study</i> ).
<b>Semester Before Last</b>	Nomination of Thesis Committee Form submitted at least 6 weeks before Thesis defense.
<b>Last semester</b>	<ul style="list-style-type: none"> <li>• Register for a minimum of one credit (including summer)</li> <li>• Application for Graduation submitted by first week of semester</li> <li>• M.S. Thesis Defense</li> <li>• Report of Examining Committee Form submitted following the defense (form will be sent to the advisor)</li> <li>• Approved Program Form submitted to the ME Graduate Studies Office</li> <li>• Electronic Thesis Publication Form submitted to the ME Graduate Studies Office</li> <li>• Electronic copy of thesis submitted to the Graduate School via ETD website</li> <li>• Electronic copy of thesis submitted to the ME Graduate Studies Office</li> <li>• Exit Information Survey submitted to the ME Graduate Studies Office</li> </ul>

M.S. students must complete all requirements for their degrees within five (5) years. Students may apply for an exception for a maximum of two additional years if all classes were taken at the University of Maryland College Park. Final approvals are made by the Graduate School.

## Continuation toward the Ph.D. Program

Students enrolled in the M.S. program with a GPA of 3.5 or above and at least 24 graduate credits have the option to take the Ph.D. qualifying exam (see Section IV.3) during the following semester. This option must be exercised no later than the fourth semester of study, or the semester following the accumulation of 24 or more credits, whichever occurs first.

Qualified M.S. students who wish to take the Ph.D. qualifying examination must notify the ME Graduate Studies Office of their intention prior to the start of the semester in which they plan to take the exam. Students who pass the Ph.D. qualifying examination and meet the admission requirements of the Mechanical Engineering Department will be recommended for direct admission into the Ph.D. program. Such students will qualify to earn an M.S. degree without thesis, upon their advancement to candidacy. Students who anticipate qualifying for subsequent entry into the Ph.D. program should note that M.S. thesis credits (ENME 799) do not count toward the Ph.D. coursework requirement. Students wishing to switch from the M.S. Degree program to the Ph.D. program must in all cases reapply to the Graduate School for admission into the Ph.D. program. Students who are unable to pass the Ph.D. qualifying examination will not be considered for admission into the Ph.D. program, as discussed further in Section IV.3 below.

## IV.2 M.S. Program in Reliability Engineering

Two options exist to earn the M.S. degree in Reliability Engineering:

### Non-thesis Option:

1. Complete 30 credit hours with at least 18 at the 600 level or above.
2. Complete the required six (6) credit hours of core courses (see below).
3. Maintain an average grade of B or better.
4. Submit at least one scholarly paper for approval by two faculty members, addressing reliability within his/her field of engineering. The topic must be selected and an advisor located by the second semester of study. The paper can be completed by registering for ENRE648, a special topics independent study with selected advisor and approved through the Graduate Committee
5. Complete a set of approved technical elective courses to satisfy the balance of the course requirements (a minimum of 24 credit hours).

### Thesis option:

1. Complete 24 credit hours with at least 18 at the 600 level or above. This does not include thesis research credits (ENRE 799)
2. Complete the required six (6) credit hours of core courses (see below).
3. Maintain an average grade of B or better.
4. Take an additional six (6) credit hours of ENRE 799 (thesis research).
5. Write a satisfactory thesis and defend it in an oral examination.
6. Complete a set of approved technical elective courses to satisfy the balance of the course requirements (a minimum of 18 credit hours).

## Course Requirements

All students seeking graduate degrees in Reliability Engineering must complete the following courses:

1. ENRE 600 Fundamentals of Failure Mechanisms
2. ENRE 602 Reliability Analysis

Non-Thesis students must also complete:

3. ENRE 648 Special Problems in Reliability Engineering

Students may not register for more than a total of six (6) credits of ENRE 648: Special Problems in Reliability Engineering and no more than three credits in a single semester. For each registration of ENRE648, an approved scholarly paper must be submitted to the Graduate Office. Research completed for ENRE648 may not overlap with a student's thesis or dissertation topic. Furthermore, under no circumstances will students be permitted after the completion of the semester in which the credits were

taken to convert ENRE648 credit to thesis (ENRE799) or dissertation (ENRE899) credits. In addition, a syllabus (outline of the course of study, the name(s) of text(s) that will be used, and a description of how the grade will be determined) must be written up for this independent study by one (or both) of the faculty. This syllabus needs to be submitted to the ME Graduate Studies Office and be approved by the Graduate Committee.

## **Other Requirements**

The thesis requirements, the Graduation Paperwork and timeline for the M.S. Degree in Reliability Engineering are the same as those for the M.S. Degree in Mechanical Engineering. Please see Section IV.1.

## **IV.3 Ph.D. Program**

### **Advisor**

As early as possible, students should identify the faculty member whom they would like to serve as their coursework and research advisor. For research assistants, the faculty providing the financial support is also the advisor. A student's advisor will also serve as chairperson of the student's Dissertation Committee (see below).

### **Qualifying Exam**

All students entering the doctoral program are required to take the qualifying exam. The objectives of the exam are the following: (1) to determine the student's aptitude and ability to do original and independent research at the doctoral level; and (2) to assess the student's mastery of fundamental knowledge in his or her technical area and identify deficiencies. This exam is administered in an oral format.

### **Mechanical Engineering Qualification Examination**

Mechanical Engineering Doctoral students who matriculate into the program with an M.S. degree must take the qualifying examination no later than their second semester of study at the University of Maryland. Those who matriculate with a B.S. degree must take it no later than their fourth semester of study at the University of Maryland, or the semester following the semester in which they have accumulated 24 credits or more, whichever occurs first.

Mechanical Engineering students who do not pass the qualifying examination during their first attempt may, upon the recommendation of their examining committee and review of the Director of Graduate Studies, be allowed to repeat the examination during the same semester. Under no circumstances will a student be permitted to repeat the qualifying examination more than once. Students who have exhausted their opportunities to pass the doctoral qualifying examination will not be allowed to continue in the doctoral program. Such students will be permitted to remain in the program for one additional semester, after which their graduate admission will be terminated. Under no circumstances will such students be considered for readmission into the doctoral program.

For Mechanical Engineering graduate students, the examining committee for the qualifying exam will be formed by three (3) faculty members from the Department of Mechanical Engineering. All committees will be comprised of the student's advisor, a chair, and a third member. The chair of this committee will be selected by the Director of Graduate Studies and the Chair of the Department and must be a full-time, regular faculty member. The second member will be the student's advisor. The third member will be chosen by the Technical Division Leader in consultation with the Director of Graduate Studies. Up to one (1) Professional-Track-Faculty (PTK) member may serve on the qualifying exam committee, subject to the following constraints: The Professional Track-Faculty member cannot chair the qualifying exam committee, cannot serve on a committee with their supervisor, and must be a member of graduate faculty. The names of the members of the examining committee will be sent to the student via e-mail by the ME Graduate Studies Office. Each student must contact their examining committee as soon as possible to schedule the exam during the department's approved dates. Students who fail on their first attempt will

be given a second opportunity to take the qualifying exam with a different committee of three faculty members, selected by the Director of Graduate Studies.

The format of the Mechanical Engineering qualifying exam is as follows:

1. **Goals of the Exam:** The qualifying exam will be an oral exam conducted in English. The goals of the exam include the following: i) determine the student's ability to understand and apply fundamental concepts in their technical area, ii) determine the student's aptitude and ability to conduct original and independent research at the doctoral level, iii) assess the student's ability to critically review previous work from the literature, and iv) identify areas in the student's background that need strengthening as the student makes progress in their doctoral studies.

2. **When to take the Exam:** Mechanical Engineering Doctoral students who matriculate into the program with an M.S. degree must take the qualifying examination no later than their second semester of study at the University of Maryland. Those who matriculate with a B.S. degree must take it no later than their fourth semester of study at the University of Maryland, or during the semester following the accumulation of 24 or more credits, whichever occurs first. Under special circumstances (e.g., non-traditional background, health related issues), the student's advisor may petition the Director of Graduate Studies to defer the exam. It is recommended that these petitions be submitted during the beginning of a semester. Along with the Graduate Committee, the Director of Graduate Studies will review each submitted petition and communicate the decision on the petition to the student's advisor.

3. **Exam Schedule:** The first round of the exams will be typically scheduled during February of the spring semester and September of the fall semester. The second round of exams will be typically scheduled during April of the spring semester and October of the fall semester.

4. **Exam Preliminaries and Procedures:**

**Exam Subject Areas:** In consultation with their advisor and the ME Graduate Studies Office, the student (examinee) will choose at least two and at most three independent, broad exam subject areas that reflect the student's background knowledge and key dissertation fields. Students- will be asked to make this choice at the time they sign up for the exam.

**Exam Committee Composition:** The composition of the exam committee will be determined by the subject areas chosen by the examinee. The exam committee will consist of three faculty members who are mainly from the Department of Mechanical Engineering of the University of Maryland. When appropriate for the examinee's choice of subject areas, a full-time tenure-track and/or tenured faculty member from outside the Department may be selected by the ME Graduate Studies Office to serve as one of the three members of the examining committee.

**Exam Committee Selection:** Each exam committee for the first attempt will be composed of the following persons: the student's advisor, a chair, and a third member. Co-advisors will be allowed to participate as silent observers during the first attempt. The members of this committee will be selected by the Director of Graduate Studies and the Chair of the Department in consultation with the student's advisor and the Technical Division Leader. For the second exam administered to students who fail on their first attempt, the Director of Graduate Studies and the Chair of the Department in consultation with the student's advisor and the Technical Division Leader will form an entire new committee of three faculty members.

**Exam Venue and Date:** The student and the committee chair are responsible for scheduling the exam date and venue in consultation with the committee and the ME Graduate Studies Office, and for notifying the committee in a timely manner. In the event an exam cannot be administered as originally scheduled, due to extenuating circumstances(subject to approval by the Graduate Director and Chair of the exam committee), the student will provide copies of their presentation to the committee as per the originally scheduled date and time. The exam will then be rescheduled for the earliest available date, preferably the next business day, but no more than two business days after the originally scheduled date. Should a time not be agreed upon for the exam to be held within two business days, the whole examination process will be reinitiated with a new topic assigned to the student.

**Student's Background:** Each student must contact the chair of their examining committee no later than two weeks before the Monday of the week that the qualifying examination is to be held, to make the necessary arrangements. The student should also provide the chair of the examining committee a folder that contains the following: i) transcripts of undergraduate and graduate course work, ii) M.S. thesis research topic if applicable, and iii) Ph.D. proposal topic if known.

**Research Topic:** Ten (10) calendar days before the date that the qualifying examination is to be held, each student will be assigned a research topic and one to two references related to some aspect of one or more of the subject areas selected by the student. The topic will be selected by the chair of the examination committee in consultation with both the student's advisor and the third committee member. This topic cannot be from the student's M.S. research area, but it can be from an area that the student might address later during their doctoral dissertation research. A different exam topic must be selected for each student.

**Written Summary Report:** The student should study the assigned and other pertinent literature on the assigned topic in order to be able to formulate research questions within the topic, suitable for doctoral-level investigation. The student should be able to outline their approach for carrying out such an investigation. The results of this study are to be summarized on one page, formatted as follows: single-spaced, 12-point type, and one-inch margins all around. The summary must consist of the following three paragraphs: (i) a paragraph reviewing the pertinent literature on the assigned topic, (ii) a paragraph identifying a research issue related to the assigned topic area, that the student feels is worthy of doctoral-level research, and (iii) a paragraph describing a suitable research approach (experimental, numerical, and/or analytical) to address the research issue proposed by the student. The summary is to be submitted to each member of the examining committee by noon, three days prior to the scheduled examination.

**Oral Exam:** The student will prepare a brief presentation (using appropriate media) describing their literature review, statement of appropriate research problem and proposed approach for addressing the stated research problem. The exam will begin with a 15 to 20 minute presentation by the student, and this will be the starting point for the oral exam discussion. The presentation may lead to questions (based on the student's chosen exam subject areas and potentially broader than the assigned exam topic) related to the goals of the exam. In general, the exam should take approximately one hour.

5. **Exam Outcome:** The examining committee will confer immediately after the exam, carry out deliberations about the exam outcome, reach a decision, and convey this decision through the Examination Committee Chair to the Graduate Office. The student will be notified of the outcome of the exam in writing, by the ME Graduate Studies Office. This notification may include conditions that a student would need to fulfill before attaining candidacy. Examples of these conditions include courses to be taken in a certain area. The committee may also provide other constructive feedback to the student on areas or skills that need to be strengthened. This is a possible outcome for students who are found to be qualified to conduct doctoral-level research but who do not fare well on some aspect(s) of the exam, for reasons that can be remedied.

*The student taking the exam is considered to have passed the exam only if the committee decides unanimously in favor of the student.*

## **Reliability Engineering Qualification Examination**

Reliability Engineering Doctoral students are eligible to take the qualifying exam after the completion of the equivalent of 24 credits of graduate course work including the completion of the reliability core course requirement with a GPA of 3.5 or better. The following core courses must be completed within a doctoral student's first four semesters.

1. ENRE 600 Fundamentals of Failure Mechanisms
2. ENRE 602 Reliability Analysis

Reliability Engineering students who do not pass the qualifying examination during their first attempt may repeat the examination during the following semester. Under no circumstances will a student be permitted to repeat the qualifying examination more than once. Students who have exhausted their opportunities to

pass the doctoral qualifying examination will not be allowed to continue in the doctoral program. Such students will be permitted to remain in the program for one additional semester, after which their graduate admission will be terminated. Under no circumstances will such students be considered for readmission into the doctoral program.

Reliability Engineering graduate students will have an examining committee formed by three faculty members, two of whom must be from the Reliability Engineering program. All committees will be comprised of: the student's advisor, a chair, and a third member. The chair of this committee will be selected by the Co-Director of Graduate Studies for Reliability and the Chair of the Department and must be a full-time, regular faculty member. The third member will be chosen by the Technical Division Leader in consultation with the Co-Director of Graduate Studies for Reliability. One professional track faculty member may serve on student's committee, but cannot be the chair, cannot serve on a committee with their supervisor, and must be a member of graduate faculty. The names of the members of the examining committees will be sent by email to the student. For the second exam given to students who fail on their first attempt, an entirely new committee of three faculty members will be selected. Each student must contact their examining committee as soon as possible to schedule the exam during the department's approved dates.

The format for the Reliability Engineering qualifying examination is as follows:

1. The purpose of the test is to evaluate the student's ability to conduct independent research. The student will be given a topic not necessarily familiar to them, but in the general field of reliability engineering. Performance in the exam will be evaluated based on the following criteria
  - a. Familiarity and depth of understanding of the relevant literature
  - b. Originality of the ideas addressing the research issue
  - c. Clarity and quality of communicating ideas to the committee
2. Contact the Chair of your Ph.D. Qualifying Committee ten (10) days prior to the date of your exam to obtain the question
3. Make sure that you fully understand the research question(s) being asked. It is recommended that you discuss any clarification questions you might have about the topic with your committee Chair.
4. You are expected to spend ten (10) days performing this research and to prepare for presenting your approach to the committee.
5. The examination is approximately 1 hour in length.
6. Prepare a 30 minute presentation. That means a maximum of 20 slides in electronic form. A computer will be available for your use.
7. Prepare a one page written summary report. The student should study the assigned and other pertinent literature on the selected topic in order to be able to formulate research questions within the topic, suitable for doctoral-level investigation and to outline their approach for carrying out such investigation. The results of this study are to be summarized on one page, formatted as follows: single-spaced, 12-point type, and one-inch margins all around. The summary must consist of the following three paragraphs: (i) a paragraph reviewing the pertinent literature on the assigned topic, (ii) a paragraph identifying a research issue related to the topic that the student feels worthy of doctoral-level research, and (iii) a paragraph describing a suitable research approach (experimental, numerical, and/or analytical) to address the research issues proposed by the student. The summary is to be submitted to each member of the committee by noon three days prior to the scheduled exam.
8. Your presentation will be followed by questions by the committee. The committee may also ask questions during your presentation.
9. Do not request review of your presentation by the committee members prior to the examination

The examining committee will confer immediately after the exam, carry out deliberations about the exam, reach a decision, and convey this decision through the Examination Committee Chair to the ME Graduate Studies Office. The student will be notified of the outcome of the exam by the Graduate Office, in writing.

*The student taking the exam is considered to have passed the exam only if the committee decides unanimously in favor of the student.*

## Coursework Requirements

The Ph.D. Plan of Study sets forth the entire program of study that will be undertaken to satisfy the course requirements for the doctoral degree. The Plan of Study must be compiled in consultation with the student's advisor, who must approve the coursework plan. The plan should then be submitted to the Graduate Office of the Department of Mechanical Engineering for approval by the Director of Graduate Studies in the first semester of study. In exceptional circumstances plan of study may need to be approved by the Graduate Committee as well. Should this be the case, the Graduate Committee will receive the plan by email and will make a collective decision regarding the outcome.

Changes to the plan are permitted but must be approved by the student's advisor, the Director of Graduate Studies, and for any special exceptions, the Graduate Committee prior to their implementation. A new plan reflecting the changes must be filed with the Graduate Office of the Department of Mechanical Engineering every time a change is made.

## Mechanical Engineering

The Ph.D. Plan of Study for Mechanical Engineering must contain a minimum of 36 credits of graduate coursework. A minimum of 12 credits of coursework must be taken at the University of Maryland as a Ph.D. student. Students with graduate coursework from another accredited institution may, upon approval of the student's advisor and the Director of Graduate Studies, transfer and include up to 24 credits of graduate coursework into their Plan of Study. Plans that include graduate work completed at other academic institutions must be accompanied by appropriate documentation (transcripts/course description) to verify the level of work and to confirm that the work will not be duplicated by the courses that will be taken at the University of Maryland. All credits must be derived from courses taken at the 600-level or above. In rare circumstances, 400-level courses may be allowed as a graduate course by prior approval, only if taken in accordance with the advisor's recommendation when no graduate equivalents exist. Coursework plans that include such 400-level courses must be accompanied by a statement from the advisor justifying the recommendation and a statement from the instructor that the course was taken at the graduate level. No ENME or ENRE 400-level course can be part of the graduate Plan of Study. Requests for exemptions for 400-level courses from other interdisciplinary programs (outside of ENME/ENRE) may be given consideration, if no graduate equivalent exists, provided the request is accompanied by: (i) a statement from the advisor justifying the recommendation; and (ii) a statement from the instructor that the course was taken at the graduate level.

The coursework plan should contain a minimum of 6 credits in mathematics. Courses that satisfy this requirement are:

1. MATH, STAT or AMSC 600-level and higher.
2. Any one of the following:
  - a. ENME 605: Advanced Systems Control
  - b. ENME 610: Engineering Optimization
  - c. ENME 625: Multidisciplinary Optimization
  - d. ENME 700: Advanced Mechanical Engineering Analysis I
  - e. ENME 725: Probabilistic Optimization
  - f. ENME 745: Numerical Methods in Engineering
  - g. ENRE 620: Mathematical Techniques of Reliability Engineering
  - h. ENRE 655: Advanced Methods in Reliability Modeling

## Reliability Engineering

The Ph.D. plan of study for Reliability Engineering must contain a minimum 36 semester credit hours of 600 level or above courses, which includes ENRE 600 and ENRE 602. At least 6 of the courses in a student's coursework plan must be in ENRE. These 36 semester hours of courses may not include any doctoral research credits (ENRE 899). Students with graduate coursework from another accredited institution may, upon approval of the student's advisor and the Director of Reliability Engineering Graduate Program, transfer and include up to 24 credits of graduate coursework into their Plan of Study. Plans that include graduate work completed at other academic institutions must be accompanied by appropriate documentation (transcripts/course description) to verify the level of work and to confirm that the work will not be duplicated by the courses that will be taken at the University of Maryland. All credits

must be derived from courses taken at the 600-level or above. The Plan of Study must contain the following Reliability Engineering core courses:

Reliability Engineering core courses:

- 1 ENRE 600 Fundamentals of Failure Mechanisms
- 2 ENRE 602 Reliability Analysis

Students may not register for more than a total of six credits of ENRE 648: Special Problems in Reliability Engineering and no more than three credits in a single semester. For each registration of ENRE648 an approved scholarly paper must be submitted to the Graduate Office. Research completed for ENRE648 may not overlap with a student's thesis or dissertation topic. Furthermore, under no circumstances will students be permitted after the completion of the semester in which the credits were taken to convert ENRE648 credit to thesis (ENRE799) or dissertation (ENRE899) credits.

The Plans of Study should be submitted electronically here: <http://megrad.umd.edu/plan-of-study/>

Course descriptions, and a class schedule for the current semester is online at <https://enme.umd.edu/course-schedule>.

### **Seminar Requirement for Satisfactory Progress**

In addition to coursework, all on-campus full-time Ph.D. students are required to attend a minimum of eight (8) seminars in each of the fall and spring semesters. The list of seminars attended by the student must be approved by the advisor at the end of the semester, and that approval will be necessary in addition to other metrics for satisfactory progress in the program. Off-campus and part-time doctoral students are encouraged to attend seminars, whenever possible, and share this information with their respective doctoral advisors.

### **Dissertation Committee**

Functions of the Dissertation Committee include conducting the dissertation-proposal review, conducting the final review of the dissertation, advising and aiding students in completing the program of study, advising the student in the research activity as necessary, and evaluating the student's progress. The Dissertation Committee is formally nominated through the completion of the Nomination of Thesis or Dissertation Committee Form, available online at [https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/nomination\\_of\\_thesis\\_or\\_dissertation\\_committee\\_form.pdf](https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/nomination_of_thesis_or_dissertation_committee_form.pdf)

### **The Doctoral Defense Committee:**

The Committee must consist of a minimum of five members, at least three of whom must be Full Members of the University of Maryland College Park Graduate Faculty who are on tenured or tenure-track appointments. Each Dissertation Examining Committee will have a chair, who must be a Full Member of Graduate Faculty, or, by special permission, has been appointed by the Dean of the Graduate School. Each Dissertation Examining Committee must also have appointed to it a representative of the Dean of the Graduate School. The Dean's Representative should have some background or interest related to the student's research; be from a department other than the students'; must have a tenure home that is different from that of the Chair of the Committee, the student's advisor, and the student; and must be a tenured Member of the Graduate Faculty.

Each member of the Committee must be a member of the Graduate Faculty of University of Maryland College Park (UMCP). Upon nomination by the Director of Graduate Studies and approval by the Dean of the Graduate School, individuals serve in addition to the three required Full Regular Members. To nominate a Special or Associate Member to serve, submit the nominee's curriculum vitae to the Graduate Office.

Graduate Faculty who terminate employment at UMCP (and who do not have emeritus status) retain their status as members of the Graduate Faculty for twelve months, and during that time may serve as members and chairs of Dissertation Examining Committees, but not as the Dean's Representative. If

granted Special Member Status, however, they may serve as co-chairs. Professors Emeriti and Emeritae may serve on the Dissertation Examining Committees if they have retained their membership in the Graduate Faculty.

In addition to the University requirements for composition of a dissertation committee, the Department of Mechanical Engineering requires that all dissertation committees for mechanical and reliability engineering doctoral students contain five Full or Associate members of graduate faculty at the University of Maryland. Research faculty and outside scientists, who are appointed as Special Members of the Graduate Faculty, are permitted to sit on dissertation committees only in addition to the five members of the graduate faculty.

### **Graduate Faculty Categories:**

In general, Full Members are faculty who are tenured or on tenure-track appointments. Associate Members include the many scholars on campus in research appointments; as visiting, adjunct or affiliated professors who may appropriately serve on thesis or dissertation committees. The Special membership category recognizes outstanding scholars, including many at government agencies in the area, who may not have any official affiliation with the campus but whom UMCP welcomes to participate on thesis and dissertation committees. Special members are given a renewable five-year appointment to serve on committees. To nominate an individual to serve as an Associate or Special Member, the student's advisor needs to submit to the Graduate Office the nominee's curriculum vitae prior to the proposal presentation.

Mechanical and Reliability Engineering students are expected to appoint their Dissertation Committee before their dissertation proposal is presented. To nominate the examining committee, the student must complete the Nomination of Thesis or Dissertation Committee Form and return it to the Graduate Office for approval and forwarding to the Office of the Registrar. Changes to a dissertation committee due to unavoidable circumstances can be made at any time, with the approval of the student's advisor, the Director of Graduate Studies, and the Office of the Registrar.

The advisor and student are notified in writing by the Office of the Registrar regarding approval of the nominated doctoral Dissertation Examination Committee and the Report of the Examining Committee Form is generated. Until the time of the student's dissertation defense, the Report of the Examining Committee form is kept in the student's file in the ME Graduate Studies Office.

## **Dissertation Proposal and Proposal Presentation**

The doctoral dissertation proposal is a formal presentation of the research the student plans to undertake as the basis for the Ph.D. dissertation. The dissertation proposal must be prepared in written form under the guidance of the student's prospective dissertation advisor, and presented for approval by the student's prospective dissertation committee. The purpose of the proposal presentation is for the dissertation examining committee to review the proposed research plan and provide feedback and advice to refine it.

A dissertation proposal will be considered to have been approved when signed by all committee members after the proposal presentation and submitted to the Graduate Office for inclusion in the student's file. The student's research should not be complete at this time, and the proposal presentation should not be treated as preparation for the final Ph.D. defense.

### **Proposal Format**

- Proposals need to be submitted to the committee members at least a week before the proposal presentation.
- Proposal format should follow the dissertation format of the Graduate School and it is preferable to have the material presented in single space with 12 point font.
- It is left open to the committee members to accept an electronic copy of the proposal.
- The program presentation should not be public, but the committee can extend invitations to outside parties of their choosing.
- The proposal presentation should last between 20 and 30 minutes and the total time of the proposal presentation meeting should be between 1 and 1.5 hours.
- The recommended format for the presentation is as follows:
  - Motivation

- Literature survey
- Problem statement
- Proposed research
- Roadmap and timeline for completion of dissertation
- How to make the work more broadly useful: plans for publishing, data sharing, and software sharing.

As a general guideline, students should be able to average one refereed publication per year that they are in the program. However, the dissertation committee shall decide the appropriate number and type of publications that the student is expected to complete, prior to the final dissertation defense. To enable the dissertation committee to make this decision, the student will present to the committee a list of “accepted/in-press”, “published”, “submitted”, and “to be submitted” publications at the time they defend their dissertation proposal. The decision of the committee needs to be unanimous in terms of the refereed publications requirement prior to the student defending their Ph.D. dissertation. The above decision of the dissertation committee can be changed at a later date (with unanimous approval of the dissertation committee) to fewer refereed publications than those originally committed at the dissertation proposal presentation.

Mechanical Engineering students who matriculate into the doctoral program with an M.S. degree must present their doctoral dissertation proposals no later than the end of the fourth semester following their entry into this program. In the event the proposal is not approved, the student will be given until the end of the fifth semester to gain the approval of a proposed dissertation topic.

Mechanical Engineering students who matriculate into the doctoral program with a B.S. degree, or whose admission status is changed from the M.S. program to the doctoral program, must present their doctoral dissertation proposals later than the end of the sixth semester following their entry into the doctoral program, or the M.S. program, whichever occurs first. In the event the proposal is not approved, the student will be given until the end of the seventh semester to gain the approval of a proposed dissertation topic.

Reliability Engineering students must present their doctoral dissertation proposals no later than two semesters following their completion of the Qualifying Examination. In the event the proposal is not approved, the student will be given until the end of the seventh semester to gain the approval of a proposed dissertation topic.

Students who are unable to secure the approval of a proposed dissertation topic within the time limits set forth above will not be allowed to continue in the doctoral program. Such students will be permitted to remain in the program for one additional semester, after which their graduate admission will be terminated. Under no circumstances will such students be considered for readmission into the doctoral program.

### **Admission to Candidacy**

Once a student has passed his or her doctoral qualifying examination, completed the coursework in the doctoral program of study, and has obtained approval for his or her doctoral dissertation proposal, the student is considered to have completed the preliminary training and demonstrated his or her potential to successfully complete the Ph.D. degree. This is formally confirmed by the Office of the Registrar by recognizing the student as a Ph.D. Candidate. The student must submit the Application for Admission to Candidacy Form to the Office of the Registrar. This form must be approved by the Director of the Graduate Program and by the Office of the Registrar. Students must be admitted to candidacy at least 6 months prior to the date on which the degree will be conferred.

It is the responsibility of the student to submit an Application for Admission to Candidacy Form when all the requirements for candidacy have been fulfilled. The application form is available online at <http://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/admission-to-candidacy-form.pdf>

This form may also be obtained from the ME Graduate Studies Office, 2168 Martin Hall. Applications must be received by the Office of the Registrar prior to the 25th of the month, in order for the advancement to be effective the first day of the following month.

Doctoral students who do not hold an M.S. degree in Mechanical Engineering, or Reliability Engineering may be awarded a non-thesis M.S. degree upon advancement to candidacy. Mechanical Engineering Students who wish to apply for this degree must have completed a minimum of 30 credits of graduate coursework. At least 24 credits must have been taken at the University of Maryland and at least 21 credits must have been derived from courses taken at the 600-level or above. Reliability Engineering Students who wish to apply for this degree must have completed a minimum of 30 credits of graduate coursework. At least 24 credits at the University of Maryland and at least 18 credits at the 600 level or above and completion of 6 credits of core courses. In such cases, the doctoral dissertation proposal fulfills the research paper requirement of the non-thesis option and the doctoral proposal presentation serves as the department comprehensive examination. In addition, students must file the following forms:

1. Request for Inclusion or Transfer of Credits (if transferring credits not used for a previous graduate degree from another institution).
2. Approved Program Form, available online at <http://sph.umd.edu/sites/default/files/files/UMApproved%20Program.pdf>
3. Application for Graduation for M.S. non-thesis available online at <http://www.testudo.umd.edu/apps/candapp/>

## Ph.D. Dissertation

The doctoral dissertation must be prepared in consultation with the current edition of the University of Maryland Electronic Thesis and Dissertation Style Guide, which may be obtained at [https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/DissertationThesis/etd\\_style\\_guide\\_201708.pdf](https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/DissertationThesis/etd_style_guide_201708.pdf)

A copy of the dissertation, after the student's advisor has approved it, must be provided to each member of the examining committee at least two weeks prior to the date of the examination.

Each doctoral candidate is required to defend his or her doctoral dissertation orally in English. The defense consists of a formal presentation of the dissertation followed by a closed session where the examining committee reviews the student's work. The dissertation defense cannot be held until the Graduate School approves the composition of the nominated dissertation examining committee.

In addition, a notice must be posted by the Department of Mechanical Engineering Graduate Office inviting faculty and students to the formal dissertation presentation. A copy of this invitation which must include the day, time, location, title, abstract, and committee membership should be sent by email to the Graduate Office ([megrad@umd.edu](mailto:megrad@umd.edu)), who will post it on the ME graduate student listserv and the website.

A few days before the examination is scheduled to take place, the Graduate Office will send the Report of the Examining Committee Form, Electronic Publication Form, and the Middle States Accreditation Form to the student's advisor, who will take these documents to the defense. Upon passing the examination, the forms are signed by each member of the examining committee, the advisor, and the student and submitted to the ME Graduate Studies Office for final approval then forwarding to the Office of the Registrar. An electronic copy of the thesis must be submitted to the Graduate School (see below) and to the ME Graduate Studies Office. Students should also fill out the Department's Exit Information form found at: <http://megrad.umd.edu/graduate-student-exit-information-form/>

## Graduation Paperwork

The following forms must be completed and submitted prior to graduation:

- 1 Application for Graduation may be completed online at <http://www.testudo.umd.edu/apps/candapp/>
- 2 Report of Examining Committee. This form must be filed with Office of the Registrar, 1113 Mitchell Bldg. after approval from the ME Graduate Studies Office, which is generated upon the approval of the Nomination of Thesis Committee Form.
- 3 An electronic copy of the thesis must be submitted online to the Graduate School <https://www.etsadmin.com/main/home?siteId=76>

The deadlines for the above forms are posted in the Schedule of Classes and online at <https://www.gradschool.umd.edu/calendar/deadlines>

Failure to submit the above listed forms by the established deadlines will result in postponement of the student's graduation to the following semester. In the semester prior to graduation, students should verify with the ME Graduate Studies Office, that they have met all the requirements for graduation.

## Summary of Requirements and Timeline for Mechanical and Reliability Engineering Students

Admission to candidacy must be obtained within five years from entrance into the Ph.D. program. All remaining degree requirements must be completed within four years following admission to candidacy.

<b>1<sup>st</sup>. Sem.</b>	<ul style="list-style-type: none"> <li>▪ Ph.D. Plan of Study Approved by Advisor, Graduate Director</li> <li>▪ Ph.D. Qualifying Exam (preferred) if admitted with an M.S.</li> </ul>
<b>2<sup>nd</sup>. Sem.</b>	<ul style="list-style-type: none"> <li>▪ Ph.D. Qualifying Exam (mandatory if not taken previous semester)</li> </ul>
<b>3<sup>rd</sup>/4<sup>th</sup> Sem.</b>	<ul style="list-style-type: none"> <li>• Nomination of Dissertation Committee Form submitted at beginning of semester (prior to proposal presentation) (<a href="https://www.gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/nomination_of_thesis_or_dissertation_committee_form.pdf">https://www.gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/nomination_of_thesis_or_dissertation_committee_form.pdf</a>)</li> <li>• Present Ph.D. proposal and submit signed copy</li> <li>• Application for Admission to Candidacy Form submitted after successful proposal presentation and completion of coursework on approved Ph.D. Coursework Plan Admission to Candidacy must be granted 6 months before dissertation defense (<a href="http://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/admission-to-candidacy-form.pdf">http://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/admission-to-candidacy-form.pdf</a>) <ul style="list-style-type: none"> <li>▪ If student entered Ph.D. program with only B.S. then following admission to Candidacy they may apply for an M.S. without Thesis.</li> <li>▪ Request for Inclusion or Transfer of Credits (if transferring any credits not used towards a previous graduate degree into the M.S. program—these credits must be approved on your Ph.D. Coursework Plan) (<a href="https://www.gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/request_for_transfer_or_inclusion_of_credit_for_masters_degrees.pdf">https://www.gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/request_for_transfer_or_inclusion_of_credit_for_masters_degrees.pdf</a>)</li> <li>▪ Approved Program Form submitted (<a href="http://sph.umd.edu/sites/default/files/files/UMApproved%20Program.pdf">http://sph.umd.edu/sites/default/files/files/UMApproved%20Program.pdf</a>)</li> </ul> </li> </ul>

	<ul style="list-style-type: none"> <li>▪ Application for Graduation for M.S. non-thesis submitted by first week of semester that M.S. without thesis degree will be awarded (<a href="http://www.testudo.umd.edu/apps/candapp/">http://www.testudo.umd.edu/apps/candapp/</a>)</li> </ul>
<b>Final Sem.</b>	<ul style="list-style-type: none"> <li>• Registration for a minimum of one credit (including summer)</li> <li>• Application for Graduation (Ph.D.) submitted by first week of semester (<a href="http://www.testudo.umd.edu/apps/candapp/">http://www.testudo.umd.edu/apps/candapp/</a>)</li> <li>• Ph.D. Dissertation Defense (no less than 6 months after admission to candidacy)</li> <li>• Report of Examining Committee Form submitted following defense (sent by email to the advisor)</li> <li>• Electronic copy of dissertation submitted to the Graduate School at: <a href="https://www.etsadmin.com/main/home?siteId=76">https://www.etsadmin.com/main/home?siteId=76</a></li> <li>• Electronic pdf copy of dissertation submitted to ME Graduate Studies Office <a href="mailto:megrad@umd.edu">megrad@umd.edu</a></li> <li>• Complete Department Exit Information Form</li> <li>• Upload and Submit the ISSS Exit plan through the following link (international students only) <a href="https://globalmaryland.umd.edu/sites/default/files/ies/ExitPlanForm.pdf">https://globalmaryland.umd.edu/sites/default/files/ies/ExitPlanForm.pdf</a></li> <li>• Complete the Graduate School Surveys <a href="https://gradschool.umd.edu/students/academic-progress/doctoral-student-surveys">https://gradschool.umd.edu/students/academic-progress/doctoral-student-surveys</a></li> </ul>

#### IV.4 General Information and Procedures for M.S. & Ph.D. Programs.

##### Grade-Point Average

Students seeking a graduate degree must maintain an average grade of “B” (3.0) in all courses that have been taken for graduate credit since enrollment in the degree program. Ph.D. students enrolled in the Reliability Engineering program must complete the core courses with a minimal GPA of 3.5 in order to qualify for the Ph.D. Qualifying Exam.

##### Time Limitation and Transfer of Credits

With the exception of the six semester-hours of graduate-level course credits applicable for possible transfer to the master’s degree program, all requirements for the Master’s degree must be completed within a five-year period. When extraordinary conditions arise, this limitation can sometimes be extended to seven years by submitting a waiver request. This time limit applies to all coursework, including transfer credits from other institutions.

Admission to candidacy must be accomplished within five calendar years after admission into the doctoral program. All remaining requirements for the degree must be completed within four years of the admission to candidacy.

##### Program Advising

Prior to registering for any courses, students should consult with their advisor. The ME Graduate Studies Office can advise and assist students in locating an advisor. It is the student’s responsibility to develop an approved coursework plan before the end of the first semester of study in consultation with their advisor. Courses that are not on an approved Plan of Study will not be counted toward the degree.

## Minimum Registration Requirements

Graduate students are required to register every fall and spring semester during the duration of their graduate studies. In addition, students must be registered for at least one credit during the semester they graduate (including summer semesters).

Upon achieving doctoral candidacy, the Department of Mechanical Engineering additionally requires that doctoral candidates be registered for a minimum of six credit hours of ENME 899 per semester until the twelve-credit minimum has been reached and until the student graduates.

## Official Status

Official status (either full-time or part-time) for academic purposes is determined on the basis of a student's registration at the end of the Schedule-Adjustment Period (the first ten days of classes). Students receiving a fellowship/scholarship must maintain full-time status throughout the semester in order to keep their scholarship/fellowship, unless otherwise stipulated by the donor in writing. International students on F1 and J1 student visas must also maintain full-time status throughout each semester according to Federal regulations governing F1 and J1 students. Students should contact an advisor in the International Students and Scholars Services Office if they have any questions concerning full-time status.

To be certified as a full-time, a graduate student must be officially registered for a combination of courses equivalent to 48 units per semester. Graduate assistants holding full-time teaching or research appointments are considered full-time students if they are registered for at least 24 units. Courses taken for Audit do not generate graduate units and cannot be used in calculating full-time or part-time status. The list below gives the number of units per credit hour for each course level.

Course Number	Graduate Units
000-399	2 units per credit hour
400-499	4 units per credit hour
500-599	5 units per credit hour
600-798	6 units per credit hour
800-897	6 units per credit hour
799	12 units per credit hour
898	18 units per credit hour
899	18 units per credit hour
UMEI 005	6 units per credit hour
UMEI 006	2 units per credit hour
UMEI 007	4 units per credit hour
UMEI 008	2 units per credit hour

## IV.5 Joint B.S./M.S. Program

### Admission Requirements

The combined Bachelor's/Master's Degree (B.S. /M.S.) Program is available only to current University of Maryland undergraduate students. The minimum requirements for acceptance into the Combined B.S. /M.S. program are:

1. At least a 3.70 G.P.A.
2. No more than 30 credits of ENME courses remaining for B.S.
3. No more than 6 credits of CORE requirements remaining for B.S.
4. Submit the Combined Bachelor's/Master's Degree form to the Graduate School

[https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/combined\\_bachelors\\_masters\\_form.pdf](https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/combined_bachelors_masters_form.pdf)

Students wishing to apply to this program should contact the Mechanical Engineering Graduate Office or submit an interest form found here: [https://umd.formstack.com/forms/combined\\_bs\\_ms\\_program](https://umd.formstack.com/forms/combined_bs_ms_program)

## **Other Requirements**

The requirements for the combined B.S./M.S. program are the same as those for the Master of Science program. For the specific requirements of the M.S. program, refer to section VI.1.

## **VI.6 Master of Engineering and Graduate Certificate in Engineering Programs.**

For more information about the Master of Engineering or Graduate Certificate Programs., please consult their website at <https://advancedengineering.umd.edu/>.

## **V. APPENDICES**

### **V.1 Appendix I: 2019 - 2020 Academic Calendar**

Visit: <https://www.provost.umd.edu/calendar/>

#### August 2019

- 23 Last day to add or drop classes without financial penalty
- 26 First day of classes - Fall 2019 semester

#### September 2019

- 2 Campus Closed - Labor Day Holiday
- 9 Grad Students - Last day to add classes for fall 2019

#### November 2019

- 4 Last Day to adjust schedule for the fall semester (drop, credit change, grading method change)
- 27-29 Thanksgiving Break — University closed

#### December 2019

- 9 Last Day of Classes, fall 2019
- 10 Exam Study Day
- 11-17 Final Exams.
- 17 Main Winter Commencement Ceremony
- 18 College Commencement Ceremonies

#### January 2020

- 2 First day of winter term classes
- 20 Martin Luther King Holiday – University Closed
- 22 Winter-term classes end
- 24 Last day to add or drop spring 2020 classes without financial penalty
- 27 First Day of classes – spring 2020

#### February 2020

- 7 Last Day to adjust schedule for the spring semester (drop, credit change, grading method change)

#### March 2020

- 15-22 Spring Break

#### April 2020

- 10 Last Day to adjust schedule for the fall semester (drop, credit change, grading method change)

#### May 2020

- 12 Last Day of classes for spring 2016
- 14-18 Final Exams.
- 21-23 College Commencement Ceremonies
- 22 Main Commencement Ceremony

## V.2 Appendix II: Graduate Forms

### Department of Mechanical and Reliability Engineering Forms

1. Ph.D. Coursework Plan and M.S. Coursework Plan [megrad.umd.edu/plan-of-study](http://megrad.umd.edu/plan-of-study)

### Graduate School Forms.

All Graduate School forms may be obtained from the Graduate School, 2123 Lee Building. Some additional electronic versions of the Graduate School forms that are not listed here may also be accessed at <https://gradschool.umd.edu/forms>

Request for Transfer or Inclusion of Credit for the Master's Degree:

[https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/request\\_for\\_transfer\\_or\\_inclusion\\_of\\_credit\\_for\\_masters\\_degrees\\_0.pdf](https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/request_for_transfer_or_inclusion_of_credit_for_masters_degrees_0.pdf)

Nomination of Thesis or Dissertation Committee:

[https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/nomination\\_of\\_thesis\\_or\\_dissertation\\_committee\\_form.pdf](https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/nomination_of_thesis_or_dissertation_committee_form.pdf)

Application for Admission to Candidacy:

[https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/application\\_for\\_admission\\_to\\_candidacy.pdf](https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/application_for_admission_to_candidacy.pdf)

Master's Degree Approved Program Form:

[https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/approved\\_program\\_form.pdf](https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/approved_program_form.pdf)

Petition for Waiver of Regulation:

[https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/petition\\_for\\_waiver\\_of\\_regulation.pdf](https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/petition_for_waiver_of_regulation.pdf)

Request for the Time Extension for Completion of Graduate Degree:

[https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/request\\_for\\_time\\_extension.pdf](https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/request_for_time_extension.pdf)

## V.3 Appendix III: Faculty Information

### List of Faculty, Division, and Research Information

**Anand, Dave K.            DSR**

Professor Emeritus  
3120 Glenn L. Martin Hall  
301-405-5294  
[dkanand@umd.edu](mailto:dkanand@umd.edu)  
Control systems; automation; manufacturing and energy

**Azarm, Shapour            DSR**

Professor  
2155 Glenn L. Martin Hall  
301-405-5250  
[azarm@umd.edu](mailto:azarm@umd.edu)  
Multi-objective; multi-disciplinary design optimization; and multi-attribute design decision making for product and process design

**Balachandran, Balakumar            MMM**

Professor and Chair  
2181 Glenn L. Martin Hall  
301-405-5309  
[balab@umd.edu](mailto:balab@umd.edu)  
Nonlinear dynamics; vibration and acoustics control; signal analyses; system identification

**Bar-Cohen, Avram            DSR**

Distinguished University Professor  
2106B Glenn L. Martin Hall  
301-405-3173  
[abc@umd.edu](mailto:abc@umd.edu)  
Thermal design and optimization of micro- and nano- systems, thermofluid modeling and analysis of boiling and two-phase flow; thermal manufacturing processes; technology foresight and management

**Baz, Amr            MMM**

Professor  
2137 Glenn L. Martin Hall  
301-405-5216  
[baz@umd.edu](mailto:baz@umd.edu)  
Active and passive control of vibration and noise; control of intelligent structures and continuous systems

**Bigio, David            DSR**

Associate Professor  
3129 Glenn L. Martin Hall  
301-405-5258  
[dbigio@umd.edu](mailto:dbigio@umd.edu)  
Polymer processing and manufacturing; special interest in mixing of fluid systems and chaos theory on mixing; controls of polymer processes; special applications to extrusion, electronic packaging, and injection molding

**Bruck, Hugh            MMM**

Professor and Associate Dean  
2110 Glenn L. Martin Hall  
301-405-8711  
[bruck@umd.edu](mailto:bruck@umd.edu)  
Processing, characterization, and modeling for the design of functionally graded, multifunctional, and nanostructured materials; experimental methods for dynamic and static materials characterization at the microscale and nanoscale

**Chopra, Nikhil MMM**

Associate Professor  
2149 Glenn L. Martin Hall  
301-405-7011  
[nchopra@umd.edu](mailto:nchopra@umd.edu)

Cyber-robotic systems, cooperative control of multiagent systems, telerobotics

**Christou, Aris DSR**

Professor  
2141 Chemical and Nuclear Engineering Building  
301-405-5208  
[christou@umd.edu](mailto:christou@umd.edu)

Electronic packaging materials; thin film semiconductors; reliability of electronic systems

**Chung, Peter MMM**

Associate Professor  
2135 Glenn L. Martin Hall  
301-405-4543  
[pchung15@umd.edu](mailto:pchung15@umd.edu)

Computational focus in fields of mechanics, materials, physics, and chemistry; multiscale modeling and simulation; classical and quantum modeling of atomic scale solids; computational methods; high performance computing; mesoscale and microstructure effects on materials

**Cukier, Michel DSR**

Associate Professor  
3419 A.V. Williams Building  
301-314-2804  
[mcukier@umd.edu](mailto:mcukier@umd.edu)

Reliability engineering, security evaluation, intrusion tolerance, distributed system evaluation

**Das, Siddhartha TFES**

Assistant Professor  
3163 Glenn L. Martin Hall  
301-405-6633  
[sidd@umd.edu](mailto:sidd@umd.edu)

Soft Capillarity and Wetting; Soft Electrokinetics; Micro-nanoscale transport; Drops and Bubbles; Energy applications; Asphaltene; 3-D Printing; Water-2-D Material Interactions; Water transport in trees

**Dasgupta, Abhijit DSR**

Professor and Graduate Director  
2174 Glenn L. Martin Hall  
301-405-5251  
[dasgupta@umd.edu](mailto:dasgupta@umd.edu)

Analysis and experimental characterization of fiber-reinforced composite materials; damage mechanics of heterogeneous materials; thermomechanical and vibrational fatigue damage in micro-electronic components

**DeVoe, Don MMM**

Professor  
3125 Glenn L. Martin Hall  
301-405-8125  
[ddev@eng.umd.edu](mailto:ddev@eng.umd.edu)

Micro-electromechanical Systems (MEMS); micro-fluidics for bio-molecular analysis; biosensors.

**Diaz-Mercado, Yancy MMM**

Assistant Professor  
2104A Glenn L. Martin Hall  
301-405-6506

[yancy@umd.edu](mailto:yancy@umd.edu)

Control and coordination of multi-agent systems using control theory, optimization, and graph theory. In particular, he is interested in developing theoretically-sound, scalable control solutions that enable effective control of large networked systems, and applying these to facilitate robot swarm manipulation.

**diMarzo, Marino TFES**

Professor

3104E J. M. Patterson Building

301-405-5257

[marino@umd.edu](mailto:marino@umd.edu)

Fire protection agents Fire sprinklers Large-scale test instrumentation and data analysis Nuclear reactor safety thermal hydraulics

**Duncan, James TFES**

Professor

3118 Glenn L. Martin Hall

301-405-5260

[duncan@umd.edu](mailto:duncan@umd.edu)

Fluid mechanics: breaking waves, bubble dynamics and solid/fluid interactions.

**Fathy, Hosam**

Professor

[hfathy@umd.edu](mailto:hfathy@umd.edu)

**Fuge, Mark DSR**

Assistant Professor

2172 Glenn L. Martin Hall

301-405-2558

[fuge@umd.edu](mailto:fuge@umd.edu)

Developing machine learning algorithms that learn from and subsequently aid human design and creativity; a mixture of topics that he calls Design Informatics. This involves using a combination of artificial intelligence, machine learning, computational linguistics, ethnography, human-computer interaction, social science, and crowdsourcing techniques to analyze and build web-based software tools for designers on top of scalable machine learning systems.

**Gabriel, Steven DSR**

Professor

0151D Glenn L. Martin Hall

301-405-3242

[sgabriel@umd.edu](mailto:sgabriel@umd.edu)

Optimization and equilibrium modeling in energy and the environment Algorithm development for solving complementarity and two-level problems in engineering-economic applications

**Groth, Katrina DSR**

Assistant Professor

0151C Glenn L. Martin Hall

301-405-5215

[kgroth@umd.edu](mailto:kgroth@umd.edu)

Risk analysis, system safety, failure analysis, Human Reliability Analysis, human-machine interaction, decision making under uncertainty, Bayesian Networks, Bayesian methods, complex systems.

Applications in: nuclear power plants, hydrogen fueling stations, oil and gas, energy, transportation, and infrastructure

**Gupta, Ashwani TFES**

Distinguished University Professor

2159 Glenn L. Martin Hall

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Swirl flows; combustion in micro-engines, gas turbines and furnaces; high temperature air Combustion; fuel sprays; fuels; air pollution; flowfield modeling and laser diagnostics; alternative fuels; thermal destruction of solid and liquid wastes

**Hahn, Jin-Oh MMM**

Associate Professor  
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Mathematical Modeling, System Identification, Closed-Loop Control, Health Monitoring, Fault Diagnostics and Accommodation in Dynamic Systems with Emphasis on Challenges in Health and Medicine; Physiological Monitoring and Closed-Loop Control; Medical Cyber-Physical Systems

**Han, Bongtae DSR**

Professor  
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Experimental stress analysis; nanomechanics; mechanical design of micro-electronic devices; mechanics of composite materials; optical methods

**Herrmann, Jeffrey DSR**

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Design, decision-making, and control systems in product development organizations and manufacturing systems

**Kiger, Kenneth TFES**

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Fluid mechanics; turbulence and multi-phase flows; experimental instrumentation

**Kim, Jungcho TFES**

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Phase change heat transfer; microgravity; electronic cooling; MEMS; heat transfer in turbomachinery

**Krieger, Axel MMM**

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Development of novel tools, image guidance, and robot control techniques for medical robotics. Specifically, Professor Krieger investigates methodologies that increase the intelligence and autonomy of medical robots to perform previously impossible tasks and improve both efficiency and patient outcomes.

**Larsson, Johan TFES**

Associate Professor  
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Enabling large eddy simulation to be applied at realistic (high) Reynolds numbers through approximate wall-modeling; developing grid-adaptation techniques for turbulence simulations; developing models for transcritical combustion; and developing physics-based uncertainty quantification approaches for complex multi-physics systems.

**Li, Teng MMM**

Professor

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Mechanics of sustainable materials; mechanics of energy storage materials; mechanics of soft and active materials; mechanics of nanoelectronics; mechanics of low-dimensional nanomaterials; mechanics of flexible electronics

**McCluskey, F. Patrick DSR**

Professor

2125 Glenn L. Martin Hall

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Electronics packaging for extreme temperature environments; power electronics packaging; computer-aided risk assessment of micro-electronic devices; electronic materials and semiconductor manufacturing

**Modarres, Mohammad DSR**

Professor

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Nuclear engineering, reliability engineering, expert system applications in reliability and safety; probabilistic risk assessment

**Mote Jr., Clayton Daniel MMM**

Professor and Former President of the University of Maryland

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Dynamic systems; vibration; biomechanics

**Ohadi, Michael TFES**

Professor

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Heat and mass transfer; smart heat exchangers; micro and nano thermal systems

**Pecht, Michael DSR**

Professor

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Reliability assessment of electronic products; electronic product design and manufacture; supply chain management

**Pertmer, Gary TFES**

Associate Professor and Co-Director of Undergraduate Programs

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Nuclear reactor systems design and analysis; reactor safety; and thermalhydraulics (heat transfer and fluid mechanics)

**Radermacher, Reinhard**      **TFES**

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Energy conversion; combined cooling heating and power systems; refrigeration and air-conditioning; alternative refrigerants; thermal system optimization

**Riaz, Amir**      **TFES**

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Numerical methods for multiphase flow Multiscale modeling and simulation of multiphase flow in porous media, microchannels and heat exchangers Multiphase transport of mixtures in porous media Perturbation analysis of interfacial instability Carbon dioxide sequestration Enhanced oil recovery

**Sandborn, Peter**      **DSR**

Professor  
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Inter-disciplinary technology tradeoff analysis; computer aided design and virtual prototyping tools; design-to-cost for system assembly substrate fabrication and die preparation; known good die and design-for-environment.

**Schmidt, Linda**      **DSR**

Professor  
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301-405-0417  
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System and product design theory and methodology Developing designer assistance tools for system and product design Engineering student team training Preservation of proprietary design knowledge conceptual design processes

**Smela, Elisabeth**      **MMM**

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Micro-electro-mechanical systems (MEMS); combining organic materials with silicon to make new devices; conjugated polymer micro-actuators

**Sochol, Ryan**      **MMM**

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Micro/Nanoscale 3D printing; advanced manufacturing; cell mechanobiology & physcobiology; soft robotics; integrated microfluidic circuitry; 3D microelectronics; energetics

**Srebric, Jelena**      **TFES**

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Multi-scale Modeling of Urban Neighborhoods Computational Fluid Dynamics and Energy Simulations Simulations and Measurements of Indoor and Outdoor Environments Ventilation Indoor Air Quality (IAQ) and Building Energy Analysis Sustainable Buildings and Climate Change

**Vaughn-Cooke, Monifa DSR**

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Human factors Systems engineering Healthcare system and medical device design Design decision making Psychometric tool development Bio-behavioral risk assessment Decision support systems

**Yang, Bao TFES**

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Micro/nanoscale thermal transport and energy conversion; thermal science and its applications in electrical engineering and material science; micro/nano devices; MEMS and nanotechnology.

**Yu, Miao MM**

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optical sensors, sensor mechanics and material behavior at multiple spatial scales, micro-scale and nano-scale sensor systems, sensors for civil, mechanical, electrical, biochemical, biomechanics, biology, medical, and environmental applications, and sensor networks; adaptive optics, wavefront sensing and control, imaging through turbulence; smart materials and structures; and theoretical and experimental mechanics.

## V.4 Appendix IV: Graduate Course Descriptions

SOME COURSES MAY NOT BE OFFERED EVERY SEMESTER, PLEASE CHECK WITH THE GRADUATE OFFICE. CALL: (301) 314-7058

Graduate courses are offered in the four research divisions (Design, Risk Assessment and Manufacturing; Electronic Products and Systems; Mechanics and Materials; Thermal, Fluid and Energy Sciences) as well as part of the Reliability Engineering Program. Graduate courses that are common to more than one research Division are grouped under "Special Topics."

### Design and Systems Reliability (DSR)

#### **ENME 600 - ENGINEERING DESIGN METHODS (3)**

Prerequisites: Graduate standing or permission of instructor. This is an introductory graduate level course in critical thinking about formal methods for design in mechanical engineering. Course participants gain background in these methods and the creative potential each offers to designers. Participants will formulate, present, and discuss their own opinions on the value and appropriate use of design materials for mechanical engineering.

#### **ENME 607 - ENGINEERING DECISION-MAKING (3)**

Prerequisite: Graduate standing or permission of instructor. In the course of engineering design, project management, and other functions, engineers have to make decisions, almost always under time and budget constraints. This course covers material on individual decision-making, group decision-making, and organizations of decision-makers. The course will present techniques for making better decisions and for understanding how decisions are related to each other. Specific topics include the role of models, decision-making heuristics, decision analysis, sequential decision-making, decision processes, search, decomposition, project management, decision-making systems and product development organizations.

#### **ENME 610 - ENGINEERING OPTIMIZATION (3)**

Prerequisite: Graduate standing or permission of instructor. Overview of applied single- and multi-objective optimization and decision-making concepts and techniques with applications in engineering design and/or manufacturing problems. Topics include formulation examples, concepts, optimality conditions, unconstrained/constrained methods, and post-optimality sensitivity analysis. Students are expected to work on a semester-long real-world multi-objective engineering project.

#### **ENME 625 - MULTIDISCIPLINARY OPTIMIZATION (3)**

Prerequisite: Graduate standing or permission of instructor. Overview of single- and multi-level design optimization concepts and techniques with emphasis on multidisciplinary engineering design problems. Topics include single- and multi-level optimality conditions, hierarchic and non-hierarchic modes, and multi-level post optimality sensitivity analysis. Students are expected to work on a semester-long project.

#### **ENME 690 - MECHANICAL FUNDAMENTALS OF ELECTRONIC SYSTEMS (3)**

Prerequisites: None. This course will provide the student with an understanding of the fundamental mechanical principles used in the design of electronic devices and their integration into electronic systems. It will focus on the effect of materials compatibility, thermal stress, mechanical stress, and environmental exposure on product performance, durability, and cost. Both electronic devices and package assemblies will be considered. Analysis of package assemblies to understand thermal and mechanical stress effects will be emphasized through student projects.

#### **ENME 695 – DESIGN FOR RELIABILITY (3)**

Prerequisites: None. This course will present classical reliability concepts and definitions based on statistical analysis of observed failure distributions. Techniques to improve reliability, based on the study of root-cause failure mechanisms, will be presented; based on knowledge of the life-cycle load profile, product architecture and material properties. Techniques to prevent operational failures through robust design and manufacturing practices will be discussed. Students will gain the fundamentals and skills in the field of reliability as it directly pertains to the design and the manufacture of electrical, mechanical, and electromechanical products.

#### **ENME 722 – EQUILIBRIUM MODELING IN ENGINEERING (3)**

Prerequisites: None. Provide motivation and introduction to equilibrium models involving economics and engineering. We will concentrate on models involving markets (Nash-Cournot, etc.) those wherein the

activities are spatially diverse, those involving energy activities or traffic flow, as well as selected other examples in mechanical engineering. Areas that will be covered include: Review of relevant optimization theory, presentation of the mixed complementarity problem (MCP) and variational inequality problem (VIP) formats to solve equilibrium problems as well as introduction to existence and uniqueness results, relevant game theory notions, presentation of specific models for engineering-economic applications, presentation for algorithms to solve these equilibrium problems.

### **ENME725 – PROBABILISTIC OPTIMIZATION (3)**

Prerequisites: An advanced undergraduate course in probability and a graduate course in optimization or permission of the instructor. Provide an introduction to optimization under uncertainty. Chance-constrained programming, reliability programming, value of information, two stage problems with recourse, decomposition methods, nonlinear programming theory, probability theory. The objectives of this course are to provide understanding for studying problems that involve optimization under uncertainty, learn about various stochastic programming formulations (chance constrained programs, two stage methods with recourse, etc.) relevant to engineering and economic settings, present theory for solutions to such problems, and present algorithms to solve these problems.

### **ENME 737 – PROGNOSTICS AND HEALTH MANAGEMENT (3)**

Prerequisites: None. Prognostics and health management (PHM) is an enabling discipline consisting of technologies and methods to assess the reliability of a product in its actual life cycle conditions to determine the advent of failure and mitigate system risk. PHM permits the reliability of a system to be evaluated and predicted in its actual application conditions. In recent years, prognostics and health management (PHM) has emerged as a key enabling technology to provide an early warning of failure; to forecast maintenance as needed; to reduce maintenance cycles; to assess the potential for life extensions; and to improve future designs and qualification methods. In future, PHM will enable systems to assess their own real-time performance (self-cognizant health management and diagnostics) under actual usage conditions and adaptively enhance life cycle sustainment with risk-mitigation actions that will virtually eliminate unplanned failures.

### **ENME 741 – OPERATION RESEARCH MODELS IN ENGINEERING (3)**

Prerequisites: ENCE 302 OR ENME 271 and ENME 392, and Math 140, MATH 240, or permission of the instructor. A survey of the fundamentals of operations research models and methods in engineering including: optimization using linear programming, nonlinear programming, integer programming, as well as equilibrium/game theory via mixed complementarity problems. Examples of specialized course items include: specifics of optimizing power and gas networks, discussion of other network optimization problems, resource-constrained problems, two-level optimization as an example of mixed integer nonlinear programming (MINLP) programming problems as well as algorithms to solve the above types of problems.

### **ENME 743 – APPLIED MACHINE LEARNING FOR ENGINEERING AND DESIGN (3)**

Prerequisites: ENME 392 or equivalent, or permission of the instructor. Learn how to apply techniques from Artificial Intelligence and Machine Learning to solve engineering problems and design new products or systems. Design and build a personal or research project that demonstrates how computational learning algorithms can solve difficult tasks in areas you are interested in. Master how to interpret and transfer state-of-the-art techniques from computer science to practical engineering situations and make smart implementation decisions.

### **ENME 765 - THERMAL ISSUES IN ELECTRONIC SYSTEMS (3)**

Prerequisites: Thermodynamics, fluid mechanics, transfer processes (undergraduate level). Corequisite: ENME 473 (or equivalent). This course addresses a range of thermal issues associated with electronic products life cycle. Topics include: Passive, active, and hybrid thermal management techniques for electronic devices and systems. Computational modeling approaches for various levels of system hierarchy. Advanced thermal management concepts, including single phase and phase change liquid immersion, heat pipes, and thermoelectrics.

### **ENME 770 - LIFE CYCLE COST ANALYSIS (3)**

Prerequisites: None. This course melds elements of traditional engineering economics with manufacturing process modeling and life cycle cost management concepts to form a practical foundation for predicting the cost of commercial products. Methodologies for calculating the cost of systems will be

presented. Product life cycle costs associated with scheduling, design, reliability, design for environment (life cycle assessment), and end-of-life scenarios will be discussed. In addition, various manufacturing cost analysis methods will be presented, including: process-flow, parametric, cost of ownership, and activity based costing. The effects of learning curves, data uncertainty, test and rework processes, and defects will be considered. This course will use real life design scenarios from integrated circuit fabrication, electronic systems assembly, and substrate fabrication, as examples of the application of the methods mentioned above.

### **ENME 780 - MECHANICAL DESIGN OF HIGH TEMPERATURE AND HIGH POWER ELECTRONICS (3)**

Prerequisites: ENME 220, ENME 382, ENME 473 or ENME 690. This course will discuss issues related to silicon power device selection (IGBT, MCT, GTO, etc.), the characteristics of silicon device operation at temperatures greater than 125C, and the advantages of devices based on SOI and SiC. It will also discuss passive component and packaging materials selection for distributing and controlling power, focusing on the critical limitations to the use of many passive components and packaging materials at elevated temperatures. In addition it will cover packaging techniques and analysis to minimize the temperature elevation caused by power dissipation. Finally, models for failure mechanisms in high temperature and high power electronics will be presented together with a discussion of design options to mitigate their occurrence.

### **ENME 808A – BATTERIES: OPERATION, MODELING, AND RELIABILITY (3)**

Prerequisites: None. Knowledge of battery operation, degradation, safety and testing are becoming expected knowledge for all engineers and this new graduate level class will provide the necessary background and advanced coverage on the topics. This is an interdisciplinary course, and students in all science and engineering disciplines are welcome. Students will get the opportunity to learn the basic scientific foundations that enhance battery reliability and safety in field applications. Guest lecturers from industry, academia, and government will supplement the lectures in their specialized fields of applications.

### **ENME 808N – NANOMECHANICS (3)**

Prerequisite: None. The success of nanotechnology depends on unexpected material behavior due to nanoscale phenomena, many of which cannot be explained by conventional continuum mechanics. This course examines the mechanics of nanoscale phenomena, the applicability of conventional continuum mechanics, and the alternate techniques available for addressing nanomechanics. Examples of alternate modeling techniques include discrete models based on molecular dynamics, as well as enriched continuum models (based on strain-gradient effects, non-local effects, surface effects, dipole mechanics, and micro-continuum mechanics). This is an advanced graduate course and assumes some familiarity with conventional continuum mechanics.

### **ENME 808Z – FUNDAMENTALS OF OPTICS AND OPTICAL SYSTEMS FOR ENGINEERS (3)**

Prerequisites: None. To familiarize students with the optical principles and applications, and to help them learn the method details and develop skills for research investigations.

## **Mechanics, Materials, and Manufacturing**

### **ENME 605 - ADVANCED SYSTEMS CONTROL: LINEAR SYSTEMS (3)**

Prerequisite: ENME 403 or permission of instructor. Modern control theory for both continuous and discrete systems. State space representation is reviewed and the concepts of controllability and observability are discussed. Design methods of deterministic observers are presented and optimal control theory is formulated. Control techniques for modifying system characteristics are discussed.

### **ENME 611 – FIBER OPTICS (3)**

Prerequisites: None. Introduces students to fiber optics, provides a background including fiber optic components and terminology, and equip students with ability to understand and evaluate various kinds of fiber optic sensors for a wide range of applications along with a detailed understanding of relevant signal processing and analysis techniques.

### **ENME 662 - LINEAR VIBRATIONS (3)**

Prerequisite: ENME 360 or equivalent or permission of instructor. Development of equations governing small oscillations of discrete and spatially continuous systems. Newton's equations, Hamilton's principle, and Lagrange's equations. Free and forced vibrations of mechanical systems. Modal analysis. Finite element discretization and reductions of continuous systems. Numerical methods. Random vibrations.

### **ENME 664 - DYNAMICS (3)**

Prerequisite: ENES 221 or equivalent or permission of instructor. Kinematics in plane and space; dynamics of particles, system of particles, and rigid bodies. Holonomic and non-holonomic constraints. Newton's equations, D'Alembert's principle, Hamilton's principle, and equations of Lagrange. Impact and collisions. Stability of equilibria.

### **ENME 665 - ADVANCED TOPICS IN VIBRATIONS (3)**

Prerequisite: ENME 662 or permission of instructor. Nonlinear oscillations and dynamics of mechanical and structural systems. Classical methods, geometrical, computational, and analytical methods. Bifurcations of equilibrium and periodic solutions; chaos.

### **ENME 670 - CONTINUUM MECHANICS (3)**

Prerequisite: None. Mechanics of deformable bodies, finite deformation and strain measures, kinematics of continua and global and local balance laws. Thermodynamics of continua, first and second laws. Introduction to constitutive theory for elastic solids, viscous fluids and memory dependent materials. Examples of exact solutions for linear and hyper elastic solids and Stokesian fluids.

### **ENME 672 - COMPOSITE MATERIALS (3)**

Prerequisite: None. Micro mechanics of advanced composites with passive and active reinforcements, mathematical models and engineering implications, effective properties, damage mechanics, and recent advances in "adaptive" or "smart" composites.

### **ENME 674 - FINITE ELEMENT METHODS (3)**

Prerequisites: None. Theory and application of finite element methods for mechanical engineering problems such as stress analysis, thermal and fluid flow analysis, electro-magnetic field analysis and coupled boundary-value problems for "smart" or "adaptive" structure applications, and stochastic finite element methods.

### **ENME 680 - EXPERIMENTAL MECHANICS (3)**

Prerequisite: Undergraduate course in instrumentation or equivalent. Advanced methods of measurement in solid and fluid mechanics. Topics covered include scientific photography, moire, photoelasticity, strain gages, interferometry, holography, speckle, NDT techniques, shock and vibration, and laser anemometry.

### **ENME 684 - MODELING MATERIAL BEHAVIOR (3)**

Prerequisite: ENME 670 or permission of instructor. Constitutive equations for the response of solids to loads, heat, etc. based on the balance laws, frame invariance, and the application of thermodynamics to solids. Non-linear elasticity with heat conduction and dissipation. Linear and non-linear non-isothermal viscoelasticity with the elastic-viscoelastic correspondence principle. Classical plasticity and current viscoplasticity using internal state variables. Maxwell equal areas rule, phase change, and metastability and stability of equilibrium states. Boundary value problems. Introduction to current research areas.

### **ENME 704 - ACTIVE VIBRATION CONTROL (3)**

Prerequisite: ENME 602, ENME 662 or equivalent. This course aims at introducing the basic principles of the finite element method and applying it to plain beams and beams treated with piezoelectric actuators and sensors. The basic concepts of structural parameter identification are presented with emphasis on Eigensystem Realization Algorithm (ERA) and Auto-regression models (AR). Different active control algorithms are then applied to beams/piezo-actuator systems. Among these algorithms are: direct velocity feedback, impedance matching control, modal control methods and sliding mode controllers. Particular focus is given to feed forward Least Mean Square (LMS) algorithms and filtered-X LMS. Optimal placement strategies of sensors and actuators are then introduced and applied to beam/piezo-actuator systems.

### **ENME 711 - VIBRATION DAMPING (3)**

Prerequisite: ENME 662 or equivalent. This course aims at introducing the different damping models that describe the behavior of viscoelastic materials. Emphasis will be placed on modeling the dynamics of simple structures (beams, plates and shells) with Passive Constrained Layer Damping (PCLD). Consideration will also be given to other types of surface treatments such as Magnetic Constrained Layer

Damping (MCLD), Shunted Network Constrained Layer Damping (SNCLD), Active Constrained Layer Damping (ACLD) and Electrorheological Constrained Layer Damping (ECLD). Energy dissipation characteristics of the damping treatments will be presented analytically and by using the modal strain energy approach as applied to finite element models of vibrating structure.

### **ENME 740 – Lab-on-a-Chip Microsystems (3)**

Fundamentals and application of lab-on-a-chip and microfluidic technologies. A broad view of the field of microfluidics, knowledge of relevant fabrication methods and analysis techniques, and an understanding of the couple multi-domain phenomena that dominate the physics in these systems.

### **ENME 744 – Additive Manufacturing (3)**

Develop a comprehensive understanding of fundamental additive manufacturing-alternatively, “three-dimensional (3D) printing-approaches, including extrusion-based deposition, stereolithography, powder bed-based melting, and inkjet-based deposition. Cultivate a “design-for additive manufacturing” skill set for combining computer-aided design (CAD) and computer-aided manufacturing (CAM) methodologies to produce successful 3D prints. Fabricate 3D mechanical objects using a variety of 3D printing technologies on campus. Execute a design project that demonstrates how additive manufacturing technologies can overcome critical limitations of traditional manufacturing processes.

### **ENME 746 – Medical Robotics (3)**

The evolution of robotics in surgery is a new and exciting development. Surgical robotics brings together many disparate areas of research such as development and modeling of robotic systems, design, control, safety in medical robotics, haptics (sense of touch), ergonomics in minimally invasive procedures, and last but not the least, surgery. The primary goal of this course is to acquaint the students with fundamentals of robot design and control the different areas of research that lead to the development of medical robotic systems. As a result, the course will cover basic robot kinematics such as forward and inverse kinematics as well as velocity and acceleration analysis. We will also cover additional topics specific to medial robotics such as medical image guidance. The course will include a project, where students will learn to develop, build, and control a medical robot.

### **ENME 750 – Applied System Identification (3)**

An introductory graduate level course on system identification, which concerns various methods and techniques for data-driven modeling and estimation of dynamical systems.

### **ENME 751 – Applied Nonlinear Control (3)**

An introductory graduate level course on nonlinear control design, which concerns various methods and techniques for the analysis and synthesis of nonlinear control systems.

### **ENME 808E – Machine Learning: Theory and Applications (3)**

This introductory course will cover theory, algorithms, and applications of machine learning. Topics covered include the learning problem, theory of generalization, VC dimension, regularization, neural networks, support vector machines.

### **ENME 808N: Nanomechanics (3)**

This course will cover the fundamental theory behind basic methods of multi-scale simulation in mechanical engineering, beginning with an overview of the discrete methodologies (including quantum mechanics, molecular dynamics, and Montecarlo simulation) and ending with basic problems involving their integration into continuum equations of motion for the simulation of nanodevices, and nanometrology tools. A brief overview of the theoretical treatment of polymers, surfaces, and interfaces will also be provided. The fundamental concepts will be illustrated with current nonomechanics applications, such as nonomanipulation and scanning probe microscopy.

### **ENME 808K – MEMS AND MICROFABRICATION TECHNOLOGIES I (3)**

Prerequisite: None. This course presents a broad overview of Micro-ElectroMechanical Systems (MEMS) and micro-fabrication technologies. Both traditional and emerging micro-fabrication techniques for micro-sensors, micro-actuator, and nanotechnology will be introduced. Both silicon and non-silicon micro-fabrication will be covered.

### **ENME 808T – Dynamics and Control of Robotic Systems (3)**

This course is intended as the basic course in the control of robotic systems. The predominant focus of the course is on control of robotic manipulators, although a brief introduction to control techniques for mobile robots is also discussed. In this course students are made aware of the Lagrangian or Hamiltonian nature of the robot dynamics and their resultant fundamental structural properties. Starting with the basic linear control techniques based on PD, PID for tracking and disturbance rejection, the fundamental properties of the nonlinear robot dynamics are utilized to develop nonlinear adaptive and robust controllers for robotic systems. Robot force control is introduced for contact control, and finally a primer to control of nonholonomic systems using geometric nonlinear control techniques is also discussed.

## **Thermal, Fluids, and Energy Sciences**

### **ENME 631 - ADVANCED CONDUCTION AND RADIATION HEAT TRANSFER (3)**

Prerequisites: ENME 315, 321 and 700 (at least concurrent) or equivalent or permission of instructor. Theory of conduction and radiation. Diffused and directional poly- and mono-chromatic sources. Quantitative optics. Radiation in enclosures. Participating media. Integro-differential equations. Multi-dimensional, transient and steady state conduction. Phase change. Coordinate system transformations.

### **ENME 632 - ADVANCED CONVECTION HEAT TRANSFER (3)**

Prerequisites: ENME 315, 321, 342, 343, and 700 or equivalent or permission of instructor. Statement of conservation of mass, momentum and energy. Laminar and turbulent heat transfer in ducts, separated flows, and natural convection. Heat and mass transfer in laminar boundary layers. Nucleate boiling, film boiling, Leidenfrost transition, and critical heat flux. Interfacial phase change processes; evaporation, condensation, industrial applications such as cooling towers, condensers. Heat exchanger design.

### **ENME 633 - Molecular THERMODYNAMICS (3)**

Prerequisite: permission of department. Also offered as ENNU 625. An examination of the interactions between molecules, which govern thermodynamics relevant to engineering, will be conducted. We will investigate both classical and statistical approaches to thermodynamics for understanding topics such as phase change, wetting of surfaces, chemical reactions, adsorption, and electrochemical processes. Statistical approaches and molecular simulation tools will be studied to understand how molecular analysis can be translated to macroscopic phenomena.

### **ENME 635 - ANALYSIS OF ENERGY SYSTEMS (3)**

Prerequisite: ENME 633 or equivalent or permission of instructor. Rankine cycles with non-azeotropic working fluid mixtures, two-, multi- and variable-stage absorption cycles and vapor compression cycles with solution circuits. Power generation cycles with working fluid mixtures. Development of rules for finding all possible cycles suiting a given application or the selection of the best alternative.

### **ENME 640 - FUNDAMENTALS OF FLUID MECHANICS (3)**

Prerequisite: ENME 700 or equivalent or permission of instructor. Equations governing the conservation of mass, momentum, vorticity and energy in fluid flows. Equations are illustrated by analyzing a number of simple flows. Emphasis on physical understanding facilitating the study of advanced topics in fluid mechanics.

### **ENME 641 - VISCOUS FLOW (3)**

Prerequisite: ENME 640 or equivalent or permission of instructor. Fluid flows where viscous effects play a significant role. Examples of steady and unsteady flows with exact solutions to the Navier-Stokes equations. Boundary layer theory. Stability of laminar flows and their transition to turbulence.

### **ENME 642 - HYDRODYNAMICS I (3)**

Prerequisite: ENME 640 or equivalent or permission of instructor. Exposition of classical and current methods used in analysis of inviscid, incompressible flows.

### **ENME 646 - COMPUTATIONAL FLUID DYNAMICS AND HEAT TRANSFER II (3)**

Prerequisites: ENME 632, 640 and 700 or equivalent or permission of instructor. Numerical solution of inviscid and viscous flow problems. Solutions of potential flow problems Euler equations, boundary layer equations and Navier-Stokes equations. Applications to turbulent flows.

### **ENME 647 - MULTIPHASE FLOW AND HEAT TRANSFER (3)**

Prerequisites: ENME 321 and 342 or equivalent or permission of instructor. Boiling and condensation in stationary systems, phase change heat transfer phenomenology, analysis and correlations. Fundamentals of two-phase flow, natural circulation in thermal hydraulic multi-loop systems with applications to nuclear reactors safety. Multiphase flow fundamentals. Critical flow rates. Convective boiling and condensation. Multiphase flow and heat transfer applications in power and process industries.

### **ENME 656 - PHYSICS OF TURBULENT FLOW (3)**

Prerequisites: ENME 640 and 641 or equivalent or permission of instructor. Definition of turbulence and its physical manifestations. Statistical methods and the transport equations of turbulence quantities. Laboratory measurement and computer simulation methods. Isotropic turbulence. Physics of turbulent shear flows.

### **ENME 657 - ANALYSIS OF TURBULENT FLOW (3)**

Prerequisites: ENME 640 and 641 or equivalent or permission of instructor. Mathematical representation of turbulent transport, production and dissipation. Closure schemes for predicting flows. Recent advances in direct and large-eddy numerical simulation techniques.

### **ENME 700 - ADVANCED MECHANICAL ENGINEERING ANALYSIS I (3)**

Prerequisite: None. This course is aimed at graduate students who aspire to become mathematically self-sufficient in engineering research. The intent is to instill mathematical literacy across a relatively wide front under the constraint of a one-semester treatment. After taking this course, students should be able to function reasonably well in pursuing more advanced and specialized mathematical topics. The application of mathematical concepts to solving physical problems encountered in Mechanical Engineering will be stressed. Students will be required to explore the capabilities of Mathematica, Math CAD or equivalent in solving differential equations analytically and numerically. Topics covered are: 1) Partial differential equations (classification of second order PDEs, classical solution techniques for second order linear PDEs, hyperbolic equations, Green's functions, variational methods, perturbations and singular perturbation methods, 2) geometric theory of Differential Equations, 3) Tensor Analysis with Applications to continuum Mechanics.

### **ENME 701 – Sustainable Energy Conversion and the Environment (3)**

Discussion of the major sources and end-users of energy in our society with particular emphasis on renewable energy production and utilization. Introduces a range innovative technologies and discusses them in the context of the current energy infrastructure. Renewable sources such as wind and solar are discussed in detail. Particular attention is paid to the environmental impact of the various forms of energy.

### **ENME 712 - MEASUREMENT, INSTRUMENTATION, AND DATA ANALYSIS FOR THERMO-FLUID PROCESSES (3)**

Prerequisites: (none). This course is designed to offer systematic coverage of the methodologies for measurement and data analysis of thermal and fluid processes at the graduate level. The course materials will cover three broad categories: (1) Fundamentals of thermal and fluid processes in single phase and multi phase flows as related to this course; (2) Measurement/Instrumentation techniques for measurement of basic quantities such as pressure, temperature, flow rate, heat flux, etc.; and (3) Experimental design and planning, sources of errors in measurements, and uncertainty analysis. and engineering of measurement. The environmental impact and industrial use of nanoparticles. an industry design concept. Smaller assignments will allow the student to use the theoretical tools that are taught along with the individual technology topics to analyze a problem related to the specific technology (i.e., PEM fuel cells, DI diesels, etc.) random signals, which are used to describe the attributes of physical systems. Several of these techniques are implemented by student teams through laboratory activities. Software is employed to support these activities and to supplement the classroom material.

### **ENME 742 – Urban Microclimate and Energy (3)**

Examines urban microclimate from the perspective of transient heat and mass transfer using building energy simulations for building clusters. The focus is on understanding building energy consumption and environmental impacts from the individual building scale to a neighborhood scale. Emerging morphological properties of building clusters modulate transient convective and radiative heat transfer resulting in different local microclimatic conditions. At the neighborhood scale, these conditions are analyzed using heat and mass transfer simulations in building clusters to provide boundary conditions for

transient building energy simulations. At the individual building scale, besides the energy consumption, this course examines connection between indoor and outdoor environments.

### **ENME 745 – Numerical Methods in Engineering (3)**

Fundamental aspects of how to apply analytical mathematical concepts to discrete data. The course is aimed at graduate students in any area of engineering, and treats the materials in a general manner that is not specific to any application or field of specialization.

### **ENME 808I – Interfacial Fluid Mechanics (3)**

Provides basic understanding on several fluid mechanics phenomena that are driven by surface tension. Such examples range from describing the equilibrium of harmless drop sitting on your coffee table to the more complication dynamics of wine drops on your wine glass. Understanding these phenomena can be vitally important to multitude of disciplines in Mechanical Engineering, Chemical Engineering, Material Science and Engineering, Bioengineering, Civil Engineering, Physics, and Chemistry.

### **ENME 808U – Modern Climate Control and Building Energy Design/Analysis (3)**

Fundamentals and design calculations of heat and moisture transfer in buildings; evaluation of cooling heating and power requirements of buildings; building energy consumption simulations, use of alternative energy and energy conservation measures in buildings; fundamentals of fans/pumps and air/water distribution in buildings; introduction to refrigeration and energy systems for data centers and other mission-critical facilities.

## **Reliability Engineering**

### **ENRE 600 - FUNDAMENTALS OF FAILURE MECHANISMS (3)**

Introduces the student to some basic principles of reliability engineering and reliability physics. The approach is to provide a general tool set by which engineers can understand how to consider reliability in all phases of the design and manufacture of a product. The emphasis is on integrating statistics and probability with understanding the fundamental physics of processes that lead to failures.

### **ENRE 602 - RELIABILITY ANALYSIS (3)**

Principal methods of reliability analysis, including fault tree and reliability block diagrams; Failure Mode and Effects Analysis (FMEA); event tree construction and evaluation; reliability data collection and analysis; methods of modeling systems for reliability analysis. Focus on problems related to process industries, fossil-fueled power plant availability, and other systems of concern to engineers.

### **ENRE 620 - MATHEMATICAL TECHNIQUES OF RELIABILITY ENGINEERING (3)**

Prerequisites: MATH 246 or permission of department. Basic probability and statistics  
Application of selected mathematical techniques to the analysis and solution of reliability engineering problems. Applications of matrices, vectors, tensors, differential equations, integral transforms, and probability methods to a wide range of reliability-related problems.

### **ENRE 640 - COLLECTION AND ANALYSIS OF RELIABILITY DATA (3)**

Prerequisites: ENRE 620 and ENRE 602. Basic life model concepts. Probabilistic life models, for components with both time independent and time dependent loads. Data analysis, parametric and nonparametric estimation of basic time-to-failure distributions. Data analysis for systems. Accelerated life models. Repairable systems modeling.

### **ENRE 641 – Probabilistic Physics of Failure and Accelerated Testing (3)**

Models for life testing at constant stress. Graphical and analytical methods. Test plans for accelerated testing. Competing failure modes and size effects. Models and data analyses for step and time varying stresses. Optimizing of test plans.

### **ENRE 645 - HUMAN RELIABILITY ANALYSIS (3)**

Prerequisites: ENRE 600 and ENRE 602; or permission of department. Credit will be granted for only one of the following: ENRE 645, or ENSE 606. Methods of solving practical human reliability problems, the THERP, SLIM, OAT, and SHARP methods, performance shaping factors, human machine systems analysis, distribution of human performance, and uncertainty bounds, skill levels, source of human error probability data, examples and case studies.

**ENRE 648 - SPECIAL PROBLEMS IN RELIABILITY ENGINEERING (1-6)**

Repeatable to 6 credits if content differs. For students who have definite plans for individual study of faculty-approved problems. Credit given according to extent of work.

**ENRE 655 - ADVANCED METHODS IN RELIABILITY MODELING (3)**

Prerequisites: None. Bayesian methods and applications, estimation of rare event frequencies, uncertainty analysis and propagation methods, reliability analysis of dynamic systems, analysis of dependent failures, reliability of repairable systems, human reliability analysis methods, and theory of logic diagrams and application to systems reliability.

**ENRE 670 - RISK ASSESSMENT FOR ENGINEERS I (3)**

Prerequisite: ENRE 602. Why study risk, sources of risk, probabilistic risk assessment procedure, factors affecting risk acceptance, statistical risk acceptance analysis, psychometric risk acceptance, perception of risk, comparison of risks, consequence analysis, risk benefit assessment. Risk analysis performed for light water reactors, chemical industry, and dams. Class projects on risk management concepts.

**ENRE 671 - RISK ASSESSMENT FOR ENGINEERS II (3)**

Prerequisite: ENRE 670. The course covers advanced techniques for performing quantitative risk assessment. The fundamental theory of systems risk modeling, methods for vulnerability identification, risk scenario development, and probability assessment are presented. Also covered are methods for risk results presentation, and several example applications.

**ENRE 684 - INFORMATION SECURITY (3)**

Prerequisites: None. This course is divided into three major components: overview, detailed concepts, and implementation techniques. The topics to be covered are: general security concerns and concepts from both a technical and management point of view, principles of security, architectures, access control and multi-level security, trojan horses, covert channels, trap doors, hardware security mechanisms, security models, security kernels, formal specifications and verification, networks and distribution systems and risk analysis.

## V.5 Appendix V: Contact Information

Resource	Contact Person	Telephone	Office
Chair's Office	Dr. B. Balchandran, Chair and Minta Martin Professor Kimberley Frye, Assistant to the Chair	301-405-3031 balab@umd.edu kfrye@umd.edu	2181B Martin Hall
Office of Graduate Studies	Dr. Abhijit Dasgupta, Director Dr. Jeffrey Herrmann, Co-Director Kerri Popper James, Associate Director Megan Petry, Graduate Studies Coordinator Marta Manzano, Academic Program Specialist	301-314-7058 megrad@umd.edu	2168 Martin Hall
Conference Room Reservation	<a href="https://clarknet.eng.umd.edu/room-scheduling">https://clarknet.eng.umd.edu/room-scheduling</a>		
Keys & Key Cards	Nicholas Thompson, Administrative Assistant	301-405-2410 nthomps3@umd.edu	2181 Martin Hall
Travel	Lita Brown, Business Manager	301-405-5303 ibrown@umd.edu	2181E Martin Hall
Payroll and Human Resources	Tammie Garstecki, Manager Jameel Khan, HR Services Coordinator Gina Speaks, Account Clerk	mehr@umd.edu	2181 Martin Hall
Graduate School	Graduate Student Services	301-405-3466	2123 Lee Bldg.
International Student and Scholar Services	International Student Services	301-314-0342	1126 H.J. Patterson Hall
Parking Permits	Kimberly Frye, Assistant to the Chair	301-405-3031	2181 Martin Hall
Registration	Office of the Registrar	301-314-8240	Mitchell Bldg., Ground Floor
University ID Card	Office of the Registrar	301-314-8218	Mitchell Bldg., Ground Floor
Financial Aid/ Student Accounts	Office of the Bursar	301-314-9000	1135 Lee Bldg