Department of Mechanical Engineering

Graduate Handbook

2015-2016

Department of Mechanical Engineering
A. James Clark School of Engineering
University of Maryland
2081 Glenn L. Martin Hall
College Park, Maryland, 20742

Phone: (301) 405-4216
Fax: (301) 314-9477

www.enme.ume.edu
# TABLE OF CONTENTS

I. MESSAGE FROM THE GRADUATE DIRECTOR ......................................................... 3

II. DEPARTMENT INFORMATION ............................................................................. 4

   II.1 INTRODUCTION .............................................................................................. 4
       *Design and Reliability of Systems* ................................................................. 4
       *Electronic Products and Systems* ................................................................. 5
       *Mechanics and Materials* .............................................................................. 6
       *Thermal, Fluid and Energy Sciences* ............................................................ 7
       *Reliability Engineering Graduate Program* .................................................. 8

   II.2 CONTACT INFORMATION ............................................................................ 10

III. DEGREE PROGRAMS ...................................................................................... 11

   III.1 MASTER OF SCIENCE (M.S.) IN MECHANICAL ENGINEERING .............. 11
   III.2 DOCTOR OF PHILOSOPHY (PH.D.) IN MECHANICAL ENGINEERING ...... 11
   III.3 MASTER OF SCIENCE (M.S.) AND DOCTOR OF PHILOSOPHY (PH.D.) IN RELIABILITY ENGINEERING .......................................................... 11
   III.4 JOINT BACHELOR/MASTER PROGRAM B.S./M.S. ................................. 11
   III.4 PROFESSIONAL MASTER OF ENGINEERING (ENPM) & GRADUATE CERTIFICATE IN ENGINEERING (GCEN) PROGRAMS ................................................. 11

IV. DEGREE REQUIREMENTS ............................................................................... 12

   IV.1 M.S. PROGRAM IN MECHANICAL ENGINEERING .................................. 12
       *Course Requirements* ................................................................................... 12
       *Thesis Requirements* ................................................................................... 13
       *Graduation Paperwork* ................................................................................ 13
       *Summary of Requirements and Timeline* ................................................... 14
       *Transfer into the Ph.D. Program* ................................................................... 14
       *Continuation towards the Ph.D. Degree* ...................................................... 15
   IV.2 M.S. PROGRAM IN RELIABILITY ENGINEERING .................................... 15
       *Course Requirements* ................................................................................... 15
       *Other Requirements* .................................................................................... 16
   IV.3 PH.D. PROGRAM ........................................................................................ 16
       *Advisor* .......................................................................................................... 16
       *Qualifying Exam* .......................................................................................... 16
       *Coursework Requirements* ........................................................................... 19
       *Thesis and Dissertation Committee* ............................................................. 20
       *Dissertation Proposal and Proposal Defense* ............................................. 21
       *Admission to Candidacy* ............................................................................... 22
       *Ph.D. Dissertation* ....................................................................................... 23
       *Graduation Paperwork* ............................................................................... 24
       *Summary of Requirements and Timeline for Mechanical Engineering Students* .......................................................................................................................... 24
   IV.4 GENERAL INFORMATION AND PROCEDURES FOR M.S. & PH.D. PROGRAMS ................................................................................................................. 25
       *Grade-Point Average* .................................................................................... 25
       *Time Limitation and Transfer of Credits* ...................................................... 25
       *Program Advising* ........................................................................................ 26
       *Minimum Registration Requirements* ......................................................... 26
Distance Program Requirements ................................................................. 26
Official Status ......................................................................................... 26

IV.5  JOINT B.S./M.S. PROGRAM .............................................................. 27
Admission Requirements ........................................................................ 27
Other Requirements .............................................................................. 27

VI.6  ENPM AND GCEN PROGRAMS ...................................................... 27

V.  APPENDICES ....................................................................................... 28

V.1  APPENDIX I: 2015-2016 ACADEMIC CALENDAR ......................... 28

V.2  APPENDIX II: GRADUATE FORMS .................................................. 29
Department of Mechanical and Reliability Engineering Forms ............ 29
Graduate School Forms ......................................................................... 29

V.3  APPENDIX III: FACULTY INFORMATION ....................................... 30
List of Faculty, Division, and Research Information ............................ 30

V.4  APPENDIX IV: GRADUATE COURSE DESCRIPTIONS .................... 34
Design, Risk Assessment and Manufacturing ....................................... 34
Electronic Products and Systems .............................................................. 35
Mechanics & Materials ......................................................................... 38
Thermal-Fluid Sciences .......................................................................... 41
Reliability Engineering .......................................................................... 43

V.5  APPENDIX V: CONTACT INFORMATION ........................................ 47
I. MESSAGE FROM THE GRADUATE DIRECTOR

There has never been a more exciting time to perform research in the Department of Mechanical Engineering at the University of Maryland. Our department is ranked in the Top 25 by U.S. News and World Report and is supported by the following faculty resources:

- 47 active faculty members
- 8 National Academy of Engineering members (including the University President)
- 75 professional society Fellow memberships
- 13 National Science Foundation (NSF) CAREER, Office of Naval Research YIP, and DARPA Young Faculty Awards
- 3 faculty NSF PECASE Awards
- 11 editors of premier journals
- 30 faculty members serve as Associate Editors and/or serve as officers of their respective professional societies

Sponsored research continues to double every five years, and stands today at $26.6 million per year. Funding is provided by a mixture of industrial government sponsors, who support both basic and applied research in a wide variety of areas including bio-MEMS, manufacturing automation, micro-robotics, integrated energy conversion systems, electronic products and systems reliability and prognostics, and probabilistic risk assessment. Our research activities are supported by state-of-the-art laboratories and a wide offering of modern, technically relevant courses. Nationally, we offer the third-highest salary for graduate researchers, and we provide an exciting atmosphere combining intensive research with a friendly and open department culture. In the 2010-2011 academic year, the Department of Mechanical Engineering has 293 active graduate students enrolled. Of these, 72 are Master of Science and 221 are Doctoral students.

Hugh Bruck
Professor
Director of Graduate Studies

Graduate education and research is an essential mission of the Mechanical Engineering Department; the most critical component of our research program is the students who carry out the theoretical and experimental studies under the guidance of our faculty. Without the dedication and outstanding work of our highly accomplished graduate students much of the valuable and challenging research carried out in the Department of Mechanical Engineering’s diverse laboratories could not take place. The A. James Clark School of Engineering, which has ranked in the top 20 in the U.S. News and World Report’s Graduate School rankings since 1997, prides itself on the production of highly educated and skilled graduates. Our graduate coursework is designed to offer both a breadth of understanding, while also providing an outstanding and comprehensive education in a student’s particular area of research interest. Alumni of the Department of Mechanical Engineering’s graduate program have gone on to enjoy distinguished and extremely well-respected careers in both academia and industry. Over the past five years the Department of Mechanical Engineering’s graduate program has granted 289 degrees, 149 Master of Science and 140 Doctor of Philosophy.

This booklet and our web site 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 enmegrad@umd.edu.
II. DEPARTMENT INFORMATION

II.1 Introduction

Graduate instruction and research are carried out in four divisions, roughly corresponding to areas of specialization: Design, Risk Assessment and Manufacturing (DRS); Mechanics and Materials (MM); Thermal, Fluid and Energy Sciences (TFES); Electronic Products and Systems (EPS). The Department maintains two graduate programs: Mechanical Engineering (ME) and Reliability Engineering (RE). Students enrolled in the graduate program of the department pursue Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) degrees.

Design and Reliability of Systems

The focus of this Division is the study of:
- Product and process design and decision making
- Manufacturing system modeling and automation
- Manufacturing process modeling and control
- Reliability and failure modes associated with specific semiconductor devices
- Structural reliability – design of structures to specific failure probability criteria
- Reliable design of electronic printed wiring boards
- Manufacturing technology designed specifically to meet high standards for yield and quality
- Reliability test methods for various electronic or mechanical devices
- Test screening of parts or systems to eliminate latent defects
- Reliability and safety assessment tools for complex aerospace, nuclear, or chemical process systems

Examples of current research topics include:
- Integration of product development and manufacturing
- Design formalisms
- Multi-criteria design decision making
- Root Cause Failure
- Probabilistic Risk
- Common Cause Failure
- Structured software
- Microelectronic Devices
- Information Storage
- Statistical Process Control
- Improved Manufacturing Methods
- Operator Advisory Systems
- Software

The research is supported by dedicated laboratories in:
- Advanced Manufacturing Laboratory
- Computer-Integrated Manufacturing Laboratory
- Designer Assistance Tool Laboratory
- Decision Support Laboratory
- Intelligent Control Engineering Laboratory
- Polymer Processing Laboratory

Courses that support these research activities are:
- ENME 600 – Engineering design methods
- ENME 601 – Manufacturing systems design and control
- ENME 606 – Nonlinear systems
- ENME 610 – Engineering optimization
- ENME 611 – Geometric modeling by CAD/CAM applications
- ENME 614 – Advanced production control techniques
- ENME 616 – Computer aided manufacturing
- ENME 620 – Design for manufacture
The research interests of this Division are the fundamental methods to attain more cost-effective and reliable electronic packaging.

Areas of specialization include:
- Electronic packaging
- Materials characterization
- Accelerated testing
- Condition monitoring
- Prognostics
- Computer aided life cycle engineering (CALCE)

Examples of current research topics include:
- Development of physics-of-failure of electronic equipment
- Experimental validation of electronic packaging designs
- New material combinations
- Incorporating reliability, productivity, supportability, and life-cycle parameters into integrated product design and manufacturing
- Plastic encapsulated microcircuits
- Thermal management
- Connectors and contacts
- Electro-optics
- High temperature electronics

The research is supported by the following dedicated laboratories:
- Electromagnetic Propagation and Compatibility Laboratory
- Electronic Systems Cost Modeling Laboratory
- Environmental Conditional and Acceleration Testing Laboratory
- Failure Analysis and Materials Characterization Laboratory
- Permanent Interconnects and Acceleration Testing Laboratory

- ENME 623 – Analysis of machining systems
- ENME 625 – Multidisciplinary optimization
- ENME 627 – Manufacturing with polymers
- ENME 808B – Emerging manufacturing processes: 21st century manufacturing
- ENME 808N – Active Polymer Materials
- ENME 808X – Engineering decision-making
- ENRE 600 – Fundamentals of Failure Mechanisms
- ENRE 602 – Reliability Analysis
- ENRE 607 – Reliability Engineering Seminar
- ENRE 625 – Materials Selection and Mechanical Reliability
- 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 653 – Advanced Reliability Engineering
- ENRE 655 – Advanced Methods in Reliability Modeling
- ENRE 657 – Telecommunication Systems Reliability
- ENRE 661 – Microelectronics Device Reliability
- ENRE 662 – Reliability and Quality in Microcircuit Manufacturing
- ENRE 664 – Electronic Packaging Materials
- ENRE 670 – Risk Assessment for Engineers I
- ENRE 671 – Risk Assessment for Engineers II
- ENRE 681 – Software Quality Assurance
- ENRE 682 – Software Reliability and Integrity
- ENRE 683 – Software Safety
- ENRE 684 – Information Security
Courses that support these research activities are:

- ENME 660 – Microelectronic components engineering
- ENME 690 – Mechanical Fundamentals of electronic systems
- ENME 693 – High-density electronic assemblies and interconnects
- ENME 695 – Failure mechanisms and reliability
- ENME 760 – Mechanics of photonic systems
- ENME 765 – Thermal issues in electronic systems
- ENME 770 – Life cycle cost analysis
- ENME 775 – Manufacturing technologies for electronic systems
- ENME 780 – Mechanical design of high temperature and high power electronics
- ENME 785 – Experimental characterization of micro- and nano-scale structures
- ENME 808J – Advanced packaging MEMS, sensors, 3-D multi-chip modules
- ENME 808U – Principles for electronic enclosure design and manufacturing
- ENME 808Z – Design in Electronic Product Development

In addition, research is supported in the following centers:

- Center for Energetic Concepts Development
- Center for Environmental Energy Engineering
- Computer Aided Life Cycle Engineering (CALCE) Electronic Products and Systems Center
- Small Smart Systems Center

Mechanics and Materials

This Division concentrates on the studies analytical and experimental fundamentals of mechanics and materials.

Areas of specialization include:

- Computational modeling;
- Conjugated polymer micro-actuators
- Control systems
- Processing and characterization of materials
- Experimental mechanics
- Fracture mechanics
- Linear and nonlinear mechanics
- Micro-nano-bio systems
- Noise and vibration control
- Nonlinear dynamics
- Robotics and intelligent machines
- Smart and multifunctional structures
- Microscale and nanoscale materials characterization
- Thin film and nanostructured materials

Examples of current research topics include:

- Control systems in product development organization
- Dynamic deformation and fracture studies, including fracture and fragmentation by explosives
- Fiber optics
- Smart structures
- Vibration and acoustic control
- Nonlinear dynamics of milling of thin walled structures
- Control of crane-load oscillations
- Development of creep-fatigue damage models for viscoplastic materials such as solder
- Micromechanics of advanced composite materials
- Characterization and optimization of mechanical properties of materials
- Processing and composition for alloy property optimization
- Theory and application of finite element methods for active materials
- Modal testing methods for non-destructive detection of damage in structural systems
- Mechanical characterization of MEMS materials
- Manufacturing systems MEMS (Micro-Electro-Mechanical Systems)
- Design and fabrication of functionally graded, multifunctional and nanostructured materials
Research is conducted in the following laboratories:

- Dynamics Effects Laboratory
- Mechanical Behavior Laboratory
- Multiscale Measurements Laboratory
- Maryland MEMS Laboratory
- Micro Technologies Laboratory
- Photomechanics Laboratory
- Vibration Laboratory
- Vibration and Noise Control Laboratory
  - Virtual Reality Laboratory

Courses that support these research activities are:

- ENME 602 – MEMS Device Physics and Design
- ENME 605 – Advanced Systems Control: Linear Systems
- ENME 621 – Advanced Topics in Control Systems: Robust and Adaptive Linear Control
- ENME 644 – Fundamentals of Acoustics
- ENME 661 – Dynamic Behavior of Materials and Structures
  - ENME 662 – Linear Vibrations
- The Maryland MEMS
  - ENME 664 – Dynamics
- ENME 665 – Advanced Topics in Vibration
- ENME 666 – Modal Analysis and Testing
- ENME 670 – Continuum Mechanics
- ENME 672 – Composite Materials
- ENME 673 – Energy and Variational Methods in Applied Mechanics
- ENME 674 – Finite Element Methods
- ENME 677 – Elasticity of Advanced Materials and Structures
- ENME 678 – Fracture Mechanics
- ENME 680 – Experimental Mechanics
- ENME 684 – Modeling Material Behavior
- ENME 704 – Active Vibration Control
- ENME 710 – Applied Finite Elements
- ENME 711 – Vibration Damping
- ENME 808E – Nanomechanics
- ENME 808P – Random Vibration of Structural Systems
- ENME 808C – System-level MEMS design and simulation
- ENME 808K – Microelectromechanical Systems (MEMS)
- ENME 808R – Explosives

Thermal, Fluid and Energy Sciences

This Division encompasses two broad disciplines: thermal science and fluid mechanics.

Areas of specialization include:

- Heat transfer
- Combustion
- Energy systems analysis
- Hydrodynamics
- Turbulence
- Computational fluid dynamics (CFD)

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 high-temperature and supercritical turbulent flows with applications to nuclear reactor heat transfer problems.
- 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

• 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 refrigerant
• Simulation, analysis, and experimentation in heat pump and refrigeration systems

The research is supported by the following dedicated laboratories:

• Combustion Diagnostics and Environmental Measurements Laboratory
• Combustion Engineering Laboratory
• Hydrodynamics Laboratory
• Energy Laboratory
• Heat Pump Laboratory
• Nanoscale Heat Transfer and Energy Conversion Laboratory
• Phase-Change Heat Transfer Laboratory
• Refrigeration Laboratory
• Turbulence Experimental and Computational Research 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 705 – Non-Newtonian fluid dynamics
• ENME 706 – Impact of energy conversion on the environment
• ENME 707 – Combustion and reacting flow
• ENME 712 – Measurement, instrumentation, and data analysis for thermo-fluid processes
• ENME 808A – Phase change heat transfer

Reliability Engineering Graduate Program

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

The primary areas of specialization include:

• Microelectronic 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 624 – Failure Mechanisms and Effects Laboratory
• ENRE 625 – Material Selection and Mechanical Reliability
• ENRE 640 – Collection and Analysis of Reliability Data
• ENRE 641 – Accelerated Testing
• ENRE 642 – Reliability Engineering Management
• ENRE 643 – Advanced Product Assurance
• ENRE 644 – Bayesian Reliability Analysis
• ENRE 645 – Human Reliability Analysis
• ENRE 646 – Maintainability Engineering
• ENRE 648 – Special Problems in Reliability Engineering
• ENRE 653 – Advanced Reliability and Maintainability Engineering
• ENRE 655 – Advanced Methods in Reliability Modeling
• ENRE 657 – Telecommunications Systems Reliability
• ENRE-661 – Microelectronics Device Reliability
• ENRE 662 – Reliability and Quality In Microcircuit Manufacturing
• ENRE 664 – Electronics Packaging Materials
• ENRE 670 – Risk Assessment for Engineers I
• ENRE 671 - Risk Assessment for Engineers II
• ENRE 681 – Software Quality Assurance
• ENRE 682 – Software Reliability and Integrity
• ENRE 683 – Software Safety
• ENRE 684 – Information Security
II.2 CONTACT INFORMATION

Department of Mechanical Engineering
A. James Clark School of Engineering
University of Maryland
2081 Glenn L. Martin Hall
College Park, Maryland, 20742
Phone: (301) 405-4216
Fax: (301) 314-9477
www.enme.ume.edu

Prof. Hugh A. Bruck
Martin Hall 2154
Voice: (301) 405-8711
Fax: (301) 314-9477
Email: bruck@umd.edu

Director of Graduate Studies

Prof. Mohammad Modarres
Martin Hall 0151C
Voice: (301) 405-5226
Fax: (301) 314-9601
Email: modarres@eng.umd.edu

Associate Director of Graduate Studies, Reliability Program

Kerri Popper James
Martin Hall 2178
Voice: (301) 405-8601
Fax: (301) 314-9477
Email: kjames3@umd.edu

Associate Director of Graduate Studies

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 Mechanical Engineering. Students may also pursue a M.S. or Ph.D. in Reliability and Risk 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 through the Professional Master's Program.

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 Graduate Director and meets 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 it.

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, 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 mechanical sciences and engineering.

III.3 Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) in Reliability Engineering

The Reliability Engineering Program offers both Masters (M.S.) and Ph.D. degrees with the elected certification in Risk and Reliability Engineering (RRE). 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 Graduate Director and meets 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. 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.

These degrees are available on a full-time or part-time basis for both degree seeking and non-degree seeking students. These courses are usually offered in the late afternoon or evening and are also available as distance-delivered courses to non-resident students.

III.4 Joint Bachelor/Master Program B.S. /M.S.

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 time-efficient schedule. The basic requirements for the individual degrees are unchanged from the more traditional path through these programs; in the combined program, however, 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.4 Professional Master of Engineering (ENPM) & Graduate Certificate in Engineering (GCEN) Programs

The ENPM & GCEN Programs provide a professional degree and a certificate, respectively, designed for part-time students who want to continue their education while working full-time. Both programs are application-oriented. Most students in the ENPM & GCEN programs work full-time for employers that support their continuing education. Neither program provides financial support for graduate students. The
ENPM program does not require a thesis. Students interested in ultimately pursuing a Ph.D. should enroll in the traditional M.S. program to establish a background appropriate for a research degree. For more information about the ENPM or GCEN programs, consult the ENPM web page at http://www.enpm.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. Coursework Plan 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 Graduate Office (2180 Glenn L. Martin Hall) for approval by the Director of Graduate Studies at the beginning 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 coursework plan reflecting the changes must be filed with the ME Graduate Office every time changes are made.

The M.S. Coursework Plan can include a maximum of 6 approved transfer credits for graduate work undertaken at other accredited U.S. institutions. These transfer credits must be approved by Graduate School; approval is sought through the submission of a Transfer or Inclusion of Credit form to Graduate School. Transfer of credits may be accepted on the following conditions: (a) The coursework must be no more than seven years old at the time of graduation; and (b) the Graduate Director and the advisor must indicate 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. Each course for which revalidation is requested must be justified separately. Under no circumstances will any transfer credits be accepted that are more than seven years old at the time of graduation.

The plan must contain a minimum of 24 credits of graduate coursework (not including thesis credits). At least 15 credits must be from courses taken at the 600-level or above. At least five of the eight courses must be taken in the Department of Mechanical Engineering. The coursework must satisfy the following criteria:

- **Required/Core course:** a minimum of 3 credits
- **Mathematics course:** a minimum of 3 credits
- **Electives:** the minimum number of elective credits is 24 minus the total of the required courses including mathematics.

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

The core course requirement can be fulfilled by completing one course from the following list that is outside of a student’s research area.

Design, Risk Assessment and Manufacturing:

- Engineering Design Methods (formerly known as Advanced Mechanical Design)
  - Advanced System Control
  - Computer-Aided Manufacturing
- Thermal, Fluid and Energy Sciences
  - Advanced Convection Heat Transfer
  - Advanced Classical Thermodynamics
  - Fundamentals of Fluid Mechanics
- Mechanics and Materials
  - Linear Vibrations
  - Dynamics
  - Continuum Mechanics
Electronic Packaging Systems

- Mechanical Fundamentals of Electronic Systems
- Failure Mechanisms and Reliability

For course descriptions, as well as class schedules for the current and next three semesters, see
http://www.enme.umd.edu/grad/course-list

Thesis Requirements

M.S. students in the M.S. Program must complete a minimum of 6 credits of M.S. Thesis Research (ENME 799) while preparing the M.S. thesis. 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 eight weeks prior to the thesis defense. 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 Office for approval and then forwarded to the Graduate School 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 Graduate Director and 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 regular faculty members (tenure or tenure-track faculty). Additional members beyond these three can be made, including the special nomination of research faculty or outside scientists.

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/etd_style_guide_2014.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 weeks prior to the date of the examination. In addition, one week prior to the examination date, a notice must be posted on the bulletin board outside the ME Graduate Office inviting faculty and students to the formal thesis presentation. A copy of this notice should be emailed to the Graduate Coordinator at enmegrad@deans.umd.edu; the Graduate Coordinator will then post the notice on the ME graduate student listserv.

After the Office of the Registrar approves the Thesis Committee, the Report of the Examining Committee Form is mailed to the ME Graduate Office. A few days before the examination is scheduled to take place, the student should verify with the ME Graduate office that the report is in his or her file. The student’s advisor then obtains the Report of the Examining Committee Form and takes it to the defense. Upon passing the examination, this form is signed by each member of the examining committee and submitted to the ME Graduate Office for forwarding to the Registrar’s Office. At least one unbound copy of the thesis on regular paper is to be submitted to the ME Graduate Office. Students are encouraged to provide their advisor with an additional bound copy of the thesis (binding is available through the ME Graduate Office). An electronic copy of the thesis must be submitted to the Registrar’s Office (see below).

Graduation Paperwork

The necessary forms will be completed by the Graduate Office with the assistance of the student and his or her advisor. The following forms must be completed and submitted prior to graduation:
1. Application for Diploma, may be completed and submitted online:
   http://www.testudo.umd.edu/apps/candapp

2. Approved Program Form (this is not the same document as the department’s M.S. Coursework Plan) must be submitted to the Registrar’s Office, 1113 Mitchell Building after approval by the ME Graduate Office. Copies of the form are available online at http://sph.umd.edu/sites/default/files/files/UMApproved%20Program.pdf and in the ME Graduate Office. (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
3. Nomination of Thesis or Dissertation Committee Form must be submitted to the Registrar’s Office, 1113 Lee Building after approval by the ME Graduate office. Copies of the form are available online at https://www.gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/nomination_of_thesis_or_dissertation_committee_form.pdf and in the ME Graduate Office.

4. Report of the Examining Committee Form is generated by the Graduate School upon the approval of the Nomination of Thesis Committee form. The Report of the Examining Committee Form must be submitted to the Registrar’s Office, 1113 Mitchell Building after approval by the ME graduate Office.

5. An electronic copy of the thesis must be submitted to the Graduate School online at http://dissertations.umi.com/umd/ One copy of the approved thesis should be submitted to the ME Graduate Office, 2180 Glenn L. Martin Hall.

Deadlines for the above forms vary from semester to semester and are posted in the Schedule of Classes and online at: http://www.gradschool.umd.edu/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 Registrar’s Office, 1113 Mitchell Bldg, (301)314-8226, that they have met all the requirements for graduation.

Summary of Requirements and Timeline

<table>
<thead>
<tr>
<th>First semester</th>
<th>M.S. Coursework Plan approved by Advisor and Graduate Director. Students should fill out their coursework plans electronically. For instructions on how to do this, please see <a href="http://www.enme.umd.edu/sites/default/files/documents/instructions-for-coursework-plan-ms.pdf">http://www.enme.umd.edu/sites/default/files/documents/instructions-for-coursework-plan-ms.pdf</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 MS Coursework Plan).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semester Before Last</td>
<td>Nomination of Thesis Committee Form submitted at least 8 weeks before Thesis defense.</td>
</tr>
</tbody>
</table>

M.S. students must complete all requirements for their degrees within five years; this includes any credit transferred from other institutions.

Transfer into 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 VI.2) during the following semester. This option must be exercised no later than during the fourth semester of study, or during the semester following the semester in which the student has accumulated 24 credits or more, whichever occurs first.
Qualified M.S. students who would like to avail themselves of the opportunity to take the Ph.D. qualifying examination must notify the ME Graduate 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 also have an opportunity to earn an M.S. degree without thesis upon their advancement to candidacy. Students who anticipate qualifying for transfer or 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 who are unable to pass the Ph.D. qualifying examination will not be considered for admission into the Ph.D. program. Students wishing to switch from the M.S. Degree program to the Ph.D. must in all cases reapply to the Graduate School for admission into the Ph.D. program.

Continuation towards the Ph.D. Degree

Students who graduate from the M.S. program in good standing may reapply to the Graduate School for admission into the Ph.D. program. Such students must satisfy the Admission requirements for the Ph.D. program and will need to take the Ph.D. qualifying exam in their first semester of the Ph.D. program as described in Section VI.3.

IV.2 M.S. Program in Reliability Engineering

Two options exist to earn the MS degree in Reliability Engineering:

Non thesis option:
1. Complete 31 semester hours with at least 18 at the 600 level or above.
2. Complete the required 16 semester 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 Graduate Committee
5. Complete a set of approved technical elective courses to satisfy the balance of the course requirements (a minimum of 15 semester hours).

Thesis option:
1. Complete 25 semester hours with at least 12 at the 600 level or above.
2. Complete the required 16 semester hours of core courses (see below).
3. Maintain an average grade of B or better.
4. Take an additional 6 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 9 semester 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 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 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 VI.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 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 which follows the semester in which they have accumulated 24 credits or more, whichever occurs first.

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

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. 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.

For Mechanical Engineering graduate students the examining committee for the qualifying exam will be formed by three full-time faculty members from the Department of Mechanical Engineering. Reliability Engineering graduate students will have an examining committee formed by three-fulltime faculty members, two of which must be from the Reliability Engineering program. All committee’s 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. The third member will be chosen by the Technical Division Leader in consultation with the Director of Graduate Studies. For the second exam given to students who fail on their first attempt, a different committee of three full-time faculty members will be selected. The names of the members of the examining committees will be posted
on the Graduate Office bulletin board located near 2180 Martin Hall. Students taking the exam will also be notified by email. Each student must contact the chair of his or her examining committee no later than two weeks before the Monday of the week that the oral examinations are to be held to make the necessary arrangements.

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

**Mechanical Engineering Qualification Examination**

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 student’s ability to understand and apply fundamental concepts in his/her technical area, ii) determine student’s aptitude and ability to do original and independent research at the doctoral level, iii) assess the student’s ability to review previous work from the literature, and iv) identify areas in the student’s background that need strengthening as the student makes progress in his/her 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 which follows the semester in which they have accumulated 24 credits or more, 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 his/her advisor (or faculty sponsor) and the Graduate 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. The student 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. It is recommended that this committee be chosen from tenure-track and/or tenured faculty members who will later serve on the student’s proposal and defense committees. The exam committee will consist of three full-time tenure-track and/or tenured faculty members who are mainly from the Department of Mechanical Engineering of the University of Maryland. Depending on the examinee’s choice of subject areas, a full-time tenure-track and/or tenured faculty member from outside the Department may be allowed by the Graduate Office to serve as one of the three members of the examining committee.

   - **Exam Committee Selection:** For the first attempt, each committee will be comprised of the following persons: the student’s advisor (or faculty sponsor), 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/or the Chair of the Department in consultation with the student’s advisor (or faculty sponsor) and the Division Leader. For the second exam administered to students who fail on their first attempt, a different committee of three full-time faculty members will be formed by the Director of Graduate Studies and/or the Chair of the Department in consultation with the student’s advisor and the Division Leader.

   - **Exam Venue and Date:** The committee chair is responsible for scheduling the exam date and venue in consultation with the committee and the Graduate Office, and for notifying the student in a timely manner. In the event of extenuating circumstances (subject to approval by the Graduate Director and Chair of the exam committee) prevent an exam from being administered as originally scheduled, the student will provide copies of their presentation to the committee as per the
originally scheduled date and time. The exam will be rescheduled for the earliest available date, preferably the next business day, but no more than two business days after the exam was originally scheduled. Should a time not be agreed upon for the exam to be held within two business days, the student will be considered as not having a topic assigned, and 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 his/her examining committee no later than two weeks before the Monday of the week that the qualifying examinations are 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 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 in some aspect to 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 (or faculty sponsor) and the third committee member. The topic may be one that is relevant to the student’s future doctoral work but will be different for each student. This topic cannot be from the student’s M.S. research area but can be from an area which the student might address later during his/her doctoral dissertation research.

- **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 his/her 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 topic 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 transparencies or other appropriate media) describing his or her literature review, problem statement and proposed approach. 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 chosen subject areas and sometimes unrelated to the assigned topic and of a broader nature) related to the goals of the exam.

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 Graduate Office of the Department. 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 preferred for students who are considered to be qualified to conduct doctoral-level research but who do not fair well on the exam for reasons that can be remedied.

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

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

1. The purpose of the test is to evaluate your ability to do independent research. You will be given a topic not necessarily familiar to you, but in the general field of reliability engineering. Your performance will be evaluated based on the following criteria:
   a. Familiarity and depth of understanding of the relevant literature
   b. Originality of your ideas addressing the research issue
2. Contact the Chair of your Ph.D. Qualifying Committee one week 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 one week to perform 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 viewgraphs in electronic form and/or hard copy. Both a computer and an overhead projector are available for your use.
7. Your presentation will be followed by questions by the committee. The committee may also ask questions during your presentation.
8. Do not request review of your presentation by the committee members prior to the examination.
9. You will be informed of the results by the Graduate Program Office approximately 2 weeks after your exam.

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 Graduate Office. The student will be notified of the outcome of the exam in writing.

Coursework Requirements

The Ph.D. Coursework Plan sets forth the entire program of study that will be undertaken to satisfy the course requirements for the doctoral degree. The program 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 Department Graduate Committee and the Director of Graduate Studies in the first semester of study. The Graduate Committee generally approves coursework plans only once a semester during the first meeting of the semester. Changes to the plan are permitted but must be approved by the student’s advisor, the Director of Graduate Studies, and the Graduate Committee prior to their implementation. Most revisions will need to be re-approved by the Graduate Committee; since the Graduate Committee only reviews Ph.D. coursework plans once every semester, students should understand that most revisions are not immediately approved. 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.

The Ph.D. coursework plan 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. Students with a Master’s degree from another accredited institution may, upon approval of the student’s advisor and the Graduate Committee, transfer and include up to 24 credits of graduate coursework. Plans that include graduate work completed at other academic institutions must be accompanied by appropriate documentation 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; 400-level courses are allowed only if taken in accordance with the advisor’s recommendation and as graduate courses when no graduate equivalents exist. Coursework plans that include such 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 plan of study. Interdisciplinary programs will be given favorable consideration.

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: Linear Systems
   b. ENME 610: Engineering Optimization
   c. ENME 625: Multidisciplinary Optimization
   d. ENME 673: Energy and Variational Methods in Applied Mechanics
The Ph.D. coursework plan for Reliability Engineering must contain a minimum of 36 semester hours of courses with at least 30 semester hours at the 600 level or above, which includes all required courses for the M.S. plus 12 additional 600-level credits. At least six 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 entering into the program with an M.S. degree will be given credit for the courses taken in that program up to 24 credits with the approval of the student's advisor and the Department of Mechanical Engineering Graduate Committee. The coursework plan 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.

Coursework plans should be submitted electronically using the MEGS database. For instructions on how to complete a Ph.D. coursework plan electronically, see http://www.enme.umd.edu/sites/default/files/documents/phd-coursework-plan.pdf

Course descriptions, as well as class schedules for the current and next three semesters are online at http://www.enme.umd.edu/grad/course-list. Hard copies of course descriptions are also available in the Graduate Office of the Department of Mechanical Engineering (2180 Martin Hall).

Seminar Requirement for Satisfactory Progress

In addition to coursework, all on-campus Ph.D. students are required to attend a minimum of eight 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.

Thesis and 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://www.gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/nomination_of_thesis_or_dissertation_committee_form.pdf

The Master's Thesis Examination Committee:
The Committee must consist of a minimum of three members, at least two of whom must be Regular Members of the UMCP Graduate Faculty, who are on tenured or tenure-track appointments. The Chair of the Committee is the student’s advisor, who must be a Regular or Adjunct Member of the Graduate Faculty, or, by special permission, has been appointed by the Dean of the Graduate School. Each member of the Committee must be a member of the Graduate Faculty of UMCP. Upon nomination by the Director of the Graduate Program and approval by the Dean of Graduate School, individuals who have been approved for Special membership in the Graduate Faculty may serve on Thesis Examining
Committees. These individuals serve in addition to the two required Regular Members. To nominate a Special Member to serve, submit the nominee’s curriculum vitae, a nomination form, and a letter of support from the Director of the Graduate Program. 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 Thesis Examining Committees. If granted Special Member status, however, they may serve as co-chair. Professors Emeriti and Emeritae may serve on Thesis Examination Committees if they have retained their membership in the Graduate Faculty.

The Doctoral Defense Committee:
The Committee must consist of a minimum of five members, at least three of whom must be Regular Members of the UMCP Graduate Faculty who are on tenured or tenure-track appointments. Each Dissertation Examining Committee will have a chair, who must be a Regular 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 student’s; and must be a tenured Member of the Graduate Faculty. Each member of the Committee must be a member of the Graduate Faculty of UMCP. Upon nomination by the Director of the Graduate Program and approval by the Dean of the Graduate School, individuals serve in addition to the three required Regular Members. To nominate a Special Member to serve, submit the nominee’s curriculum vitae, a nomination form, and a letter of support from the Director of Graduate Studies. 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.

Graduate Faculty Categories:
In general, Regular Members are faculty who are tenured or on tenure-track appointments. Adjunct Faculty includes 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 a Special Member, the student’s advisor needs to submit to the Graduate Director the nominee’s curriculum vitae, a nomination form, and a letter of support. Specific instructions regarding the process and forms for nomination of an individual to the graduate faculty are online at: [http://www.enme.umd.edu/sites/default/files/documents/nomination-for-membership-to-grad-fac.pdf](http://www.enme.umd.edu/sites/default/files/documents/nomination-for-membership-to-grad-fac.pdf)

Mechanical 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 Registrar’s Office. 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 Registrar’s Office.

The advisor and student are notified in writing by the Registrar’s Office regarding approval of the nominated doctoral dissertation 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 Office.

Dissertation Proposal and Proposal Defense
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. A dissertation proposal will be considered to have been approved when signed by all committee members after the proposal defense and submitted to the Graduate Office for inclusion in the student’s file.

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 regular (tenure or tenure-track) faculty members. Research faculty and outside scientists are permitted to sit on dissertation committees only in addition to the five regular faculty members.

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 a unanimous approval of the dissertation committee) to fewer refereed publications than those originally mandated at the dissertation proposal.

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 fourth 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 by no 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 by 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 Registrar Office by recognizing the student as a Ph.D. Candidate. The student must submit the Application for Admission to Candidacy Form to the Graduate Office. This form must be approved by the Graduate Director, and by the Registrar Office. 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 Office, 2180 Martin Hall. In order for the advancement to be effective the first day of the following month, applications must be received by the Registrar’s Office prior to the 25th of the month.

Mechanical Engineering Doctoral students who do not hold an M.S. degree in Mechanical Engineering, or Reliability Engineering Doctoral students who do not hold an M.S. degree in Reliability Engineering may be awarded a non-thesis M.S. degree at 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 31 credits of graduate coursework. At least 25 credits at the University of Maryland and at least 18 credits at the 600 level or above and completion of 16 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 defense 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. Certification of Master’s Degree Without Thesis Form. This form is available online at https://www.gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/certification_of_masters_degree_without_thesis.pdf or in the ME Graduate Office. The form must be filed with Registrar’s Office, 1113 Mitchell Building, after approval by the ME Graduate Office.


2. Application for Diploma (Graduation Candidate Application), 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 Thesis Manual, which may be obtained at https://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/etd_style_guide_2014.pdf A typed 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.

In addition, a notice must be posted by the student on the designated bulletin board near the Department of Mechanical Engineering Graduate Office inviting faculty and students to the formal dissertation presentation. A copy of this invitation should be sent by email to the Graduate Coordinator, who will post it on the ME graduate student list server.

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. About a week prior to the date the dissertation defense is scheduled to take place, the student is advised to verify that the Report of the Examining Committee is in his or her file in the Graduate Office of the Department of Mechanical Engineering. The student’s advisor will then pick it up just prior to the dissertation defense and bring it with him or her to the examination.

When the student has passed the examination, the Report of the Examining Committee is signed by all members of the committee and submitted to the department’s Graduate Office for forwarding to Registrar Office.
An unbound copy of the dissertation on regular paper is to be submitted to the department’s Graduate Office. Students are encouraged to provide their advisor with a bound copy of the dissertation (binding is available through the ME Graduate Office). An electronic copy of the dissertation must be submitted to the Registrar’s Office at [http://dissertations.umi.com/umd/](http://dissertations.umi.com/umd/)

**Graduation Paperwork**

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

1. Application for Diploma, also referred to as Graduation Candidate Application, may be completed online at [http://www.testudo.umd.edu/apps/candapp/](http://www.testudo.umd.edu/apps/candapp/)

2. Report of Examining Committee. This form must be filed with Registrar’s Office, 1113 Mitchell Bldg, after approval from ME Graduate Office, and is generated upon the approval of the Nomination of Thesis Committee Form.


One copy of the approved thesis should be submitted to the ME Graduate Office, 2180 Glenn L. Martin Hall.

The deadlines for the above forms are posted in the Schedule of Classes and online at [https://www.gradschool.umd.edu/calendar/deadlines](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 Registrar’s Office, 1113 Mitchell Building, (301) 314-8226, that they have met all the requirements for graduation.

**Summary of Requirements and Timeline for Mechanical Engineering Students**

<table>
<thead>
<tr>
<th>1st semester</th>
<th>Ph.D. Coursework Plan Approved by Advisor, Graduate Director, and Graduate Committee</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ph.D. Qualifying Exam (preferred)</td>
</tr>
<tr>
<td>2nd semester</td>
<td>Ph.D. Qualifying Exam (required if not taken previous semester)</td>
</tr>
</tbody>
</table>
| 3rd or 4th semester | 1 | Nomination of Dissertation Committee Form submitted at beginning of semester [Link](https://www.gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/nomination_of_thesis_or_dissertation_committee_form.pdf)  
• Present Ph.D. proposal and submit signed copy  
• Application for Admission to Candidacy Form submitted after successful proposal presentation and Coursework Plan  
• Admission to Candidacy must be granted 6 months before dissertation defense [Link](http://gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/admission-to-candidacy-form.pdf)  
• If student entered Ph.D. program with only B.S. then following Admission to Candidacy they may apply for Certification of Master's Degree Without Thesis Form submitted [Link](https://www.gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/certification_of_masters_degree_without_thesis_form.pdf)  
• Request for Inclusion or Transfer of Credits (if transferring any credits not used towards a previous degree these credits must be approved on your Ph.D. Coursework Plan) [Link](https://www.gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/request_for_transfer_or_inclusion_form.pdf)  
• Approved Program Form submitted [Link](http://sph.umd.edu/sites/default/files/files/UMApproved%20Program%20Form.pdf)  
• Application for Diploma (M.S.) submitted by first week of semester that M.S. without thesis degree will be awarded [Link](http://www.testudo.umd.edu/apps/candapp/)  |
| Last semester | 2 | Application for Diploma (Ph.D.) submitted by first week of semester [Link](http://www.testudo.umd.edu/apps/candapp/)  
• Ph.D. Dissertation Defense (no less than 6 months after admission to candidacy)  
• Report of Examining Committee Form submitted following defense (pick up form in ME Grad Office)  
• Electronic copy of dissertation submitted Registrar Office at: [Link](http://dissertations.umi.com/umd/)  
• 1 copy of Dissertation submitted to ME Graduate Office |

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.

### 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. Qualifier Oral 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 obtained 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 Office can advise and assist students in locating an advisor. It is the student's responsibility to develop an approved coursework plan at the beginning of the first semester of study in consultation with their advisor. Courses that are not on an approved coursework plan 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 graduated 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 three credit hours of ENME 899 per semester until the twelve-credit minimum has been reached. The section numbers associated with each faculty are online http://www.enme.umd.edu/grad/phd-mech. A hard copy is available in the ME Graduate Office.

Distance Program Requirements

All classes are recorded in CDs and are sent to the student for class use. The material on the CDs is copyrighted and may not be used for any other purpose than its original intent. In addition, distance students have web access to the streaming video of the course. Off-campus students usually contact their instructor by email and sometimes by telephone. In some courses, a Teaching Assistant is available to work with students when help is needed.

It is assumed that off-campus students will be approximately one week behind the on-campus students and all assignments given this one additional week before they are due. Likewise, exams for distance students will be held one week from the date of the on-campus exam. For students to participate in this distance education program, they must be able to arrange for a suitable proctor to oversee exams. It is usual for the Training Department of a company to provide proctoring of employees taking these exams. Distance exams unless otherwise specified by the instructor are to be completed in one session on the date of the exam. Students must make prior arrangements for the proctor to administer the exam on the exam date.

At the instructor's request, the Graduate Office will oversee the distribution of distance exams. Completed exams are to be faxed to the Graduate Office to Fitzgerald Walker's attention, 301-314-8015. The original should be sent by mail to Mechanical and Reliability Engineering Graduate Office, 2182 Martin Hall, University of Maryland, College Park, MD 20742.

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 private scholarship must maintain full-time status throughout the semester in order to keep their scholarship, 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. Please contact an advisor in IES at 301-314-7744 if you have any questions concerning full-time status.

To be certified as a full-time student 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.

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Graduate Units</th>
</tr>
</thead>
</table>

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. At least 3 letters of recommendation
5. An essay or statement of purpose

Students wishing to apply to this program should contact the Mechanical Engineering Graduate Office.

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 ENPM and GCEN Programs

For more information about the ENPM or GCEN programs, consult their ENPM web page at http://www.enpm.umd.edu or call the ENPM office at 301-405-0362.
V. APPENDICES

V.1 Appendix I: 2015 - 2016 Academic Calendar

Visit: https://www.gradschool.umd.edu/calendar/deadlines

August 2015
28  Last Day to Cancel Fall 2015 Registration
31  First Day of Classes - Fall 2015 semester

September 2015
1   Regular check-in begins for waitlist and holdfile
7   Campus Closed - Labor Day Holiday
15  Grad Students - Last Day to add classes for Fall 2015

October 2015
21  Begin Leave of Absence option

November 2015
9   Last Day to adjust schedule for the Fall semester (drop, credit change, grading method change)
26-29  Thanksgiving Break — University closed

December 2015
11  Last Day of Classes, Fall 2015
12  Exam Study Day
14-19 Final Exams
19   Main Winter Commencement Ceremony
20   College Commencement Ceremonies

January 2016
4   First day of Winter-term classes
18  Martin Luther King Holiday – University Closed
22  Winter-term classes end
25  First Day of classes – Spring 2016

March 2016
13-20 Spring Break

April 2016
27  Last Day for Doctoral students to submit electronic dissertation, original signed Report of Examining Committee Form for May Graduation

May 2016
10  Last Day of classes for Spring 2016
12-18 Final Exams
19  Main Commencement Ceremony (Thursday evening)
20  College Commencement Ceremonies (FridayS)
V.2  Appendix II: Graduate Forms

Department of Mechanical and Reliability Engineering Forms

1. Ph.D. Coursework Plan and MS Coursework Plan [https://apra.umd.edu/]

Graduate School Forms

All Graduate School forms may be obtained from Graduate School, 2123 Lee Building. Some additional electronic versions of Graduate School forms that are not listed here may also be accessed at [http://www.enme.umd.edu/grad/forms]

4  Request for Transfer or Inclusion of Credit for the Master’s Degree:  
[https://www.gradschool.umd.edu/sites/gradschool.umd.edu/files/uploads/request_for_transfer_or_inclusion_of_credit_for_masters_degrees.pdf]

5  Nomination of Thesis or Dissertation Committee:  

6  Approved Program for the Master of Science:  

7  Application for Admission to Candidacy:  

8  Certification of Master’s Degree Without Thesis:  

9  Petition for Waiver of Regulation:  

10 Request for the Time Extension for Completion of Graduate Degree:  
### V.3 Appendix III: Faculty Information

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

<table>
<thead>
<tr>
<th>Anand, Dave K.</th>
<th>DRS</th>
<th>Professor Emeritus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3120 Glenn L. Martin Hall</td>
</tr>
<tr>
<td></td>
<td></td>
<td>301-405-5294</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="mailto:dkanand@eng.umd.edu">dkanand@eng.umd.edu</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Control systems; automation; manufacturing and energy</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Azarm, Shapour</th>
<th>DRS</th>
<th>Professor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2155 Glenn L. Martin Hall</td>
</tr>
<tr>
<td></td>
<td></td>
<td>301-405-5250</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="mailto:azarm@eng.umd.edu">azarm@eng.umd.edu</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multi-objective; multi-disciplinary design optimization; and multi-attribute design decision making for product and process design</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Balachandran, Balakumar</th>
<th>MM</th>
<th>Professor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2133 Glenn L. Martin Hall</td>
</tr>
<tr>
<td></td>
<td></td>
<td>301-405-5309</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="mailto:balab@eng.umd.edu">balab@eng.umd.edu</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nonlinear dynamics; vibration and acoustics control; signal analyses; system identification</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bar-Cohen, Avram</th>
<th>TFES</th>
<th>Professor and Chair</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2181 Glenn L. Martin Hall</td>
</tr>
<tr>
<td></td>
<td></td>
<td>301-405-3173</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="mailto:abc@eng.umd.edu">abc@eng.umd.edu</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>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</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Barker, Donald</th>
<th>EPS, MM</th>
<th>Professor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2110B Glenn L. Martin Hall</td>
</tr>
<tr>
<td></td>
<td></td>
<td>301-405-5264</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="mailto:dbarker@eng.umd.edu">dbarker@eng.umd.edu</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Experimental stress analysis; fracture mechanics; high strain rate behavior of materials; thermo-mechanical and vibrational stress in printed circuit boards; engineering uses of microcomputers</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Baz, Amr</th>
<th>MM</th>
<th>Professor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2137 Glenn L. Martin Hall</td>
</tr>
<tr>
<td></td>
<td></td>
<td>301-405-5216</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="mailto:baz@eng.umd.edu">baz@eng.umd.edu</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Active and passive control of vibration and noise; control of intelligent structures and continuous systems</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bergbreiter, Sarah</th>
<th>MM</th>
<th>Assistant Professor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2170 Glenn L. Martin Hall</td>
</tr>
<tr>
<td></td>
<td></td>
<td>301-405-6506</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="mailto:sarahb@umd.edu">sarahb@umd.edu</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Microrobotics; Microactuators; MEMS fabrication; Networked multi-robot systems; Sensor Networks</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bernard, Peter</th>
<th>TFES</th>
<th>Professor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3116 Glenn L. Martin Hall</td>
</tr>
<tr>
<td></td>
<td></td>
<td>301-405-5272</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="mailto:bernard@eng.umd.edu">bernard@eng.umd.edu</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fluid mechanics; turbulence theory; calculation of turbulent flows</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bigio, David</th>
<th>DRS</th>
<th>Associate Professor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2184 Glenn L. Martin Hall</td>
</tr>
<tr>
<td></td>
<td></td>
<td>301-405-5258</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="mailto:bigio@eng.umd.edu">bigio@eng.umd.edu</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>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</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bruck, Hugh</th>
<th>MM</th>
<th>Professor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2153 Glenn L. Martin Hall</td>
</tr>
<tr>
<td></td>
<td></td>
<td>301-405-8711</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="mailto:bruck@eng.umd.edu">bruck@eng.umd.edu</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>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</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chopra, Nikhil</th>
<th>MM</th>
<th>Assistant Professor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2149 Glenn L. Martin Hall</td>
</tr>
<tr>
<td></td>
<td></td>
<td>301-405-5262</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="mailto:nchopra@umd.edu">nchopra@umd.edu</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cyber-robotic systems, cooperative control of multiagent systems, telerobotics</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Christou, Aris</th>
<th>MM</th>
<th>Professor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2141 Chemical and Nuclear Engineering Building</td>
</tr>
<tr>
<td></td>
<td></td>
<td>301-405-5208</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="mailto:gaas@eng.umd.edu">gaas@eng.umd.edu</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Electronic packaging materials; thin film semiconductors; reliability of electronic systems</td>
</tr>
</tbody>
</table>
Cukier, Michel  DRS, RE
Associate Professor
0151E Glenn L. Martin Hall
301-314-2804
mcukier@umd.edu
Reliability engineering, security evaluation, intrusion tolerance, distributed system evaluation

Dasgupta, Abhijit  MM
Professor
2110C Glenn L. Martin Hall
301-405-5251
dasgupta@eng.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

Desai, Jaydev  DRS
Associate Professor
0160 Glenn L. Martin Hall
jaydev@umd.edu
301-405-4427
Image-guided Robotics; Haptic (sense of touch) interfaces for Robot-assisted Surgery; Reality-based soft-tissue modeling for Surgical Simulation; Model-based teleoperation in Robot-assisted surgery; Cell manipulation

DeVoe, Don  MM
Professor
3125 Glenn L. Martin Hall
ddev@eng.umd.edu
301-405-8125
Micro-electromechanical Systems (MEMS); micro-fluidics for bio-molecular analysis; biosensors.

Dieter, George  DRS
Professor Emeritus
2145 Glenn L. Martin Hall
301-405-5248
gdieter@eng.umd.edu
Materials processing; engineering design; quality engineering; engineering education

Duncan, James  TFES
Professor
3118 Glenn L. Martin Hall
301-405-5260
duncan@eng.umd.edu
Fluid mechanics: breaking waves, bubble dynamics and solid/fluid interactions.

Fourney, William  MM
Professor
3164 Glenn L. Martin Hall
301-405-1129
four@eng.umd.edu
Dynamic fracture mechanics; rock fracture and fragmentation; experimental stress analysis

Gupta, Ashwani  TFES
Professor
2159 Glenn L. Martin Hall
301-405-5276
akgupta@eng.umd.edu
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

Gupta, Satyandra  DRS
Professor
3143 Glenn L. Martin Hall
301-405-5306
skgupta@eng.umd.edu
Integration of product design and manufacturing; geometric reasoning algorithms for computer aided design and manufacturing; manufacturing process simulation; and manufacturing automation.

Han, Bongtae  EPS
Professor
3147 Glenn L. Martin Hall
301-405-5255
bthan@eng.umd.edu
Experimental stress analysis; nanomechanics; mechanical design of micro-electronic devices; mechanics of composite materials; optical methods

Herrmann, Jeffrey  DRS
Associate Professor
0151B Glenn L. Martin Hall
301-405-5433
jwh2@eng.umd.edu
Design, decision-making, and control systems in product development organizations and manufacturing systems

Jackson, Gregory  TFES
Professor
4164 Glenn L. Martin Hall
301-405-2368
gsjackso@eng.umd.edu
Combustion and flame stability; liquid-fed combustion; catalytic combustion; fuel cells for automotive applications; fuel reforming

Kiger, Kenneth  TFES
Associate Professor
3129 Glenn L. Martin Hall
301-405-5245
kkiger@glue.umd.edu
Fluid mechanics; turbulence and multi-phase flows; experimental instrumentation

Kim, Jungho  TFES
Professor
2170 Glenn L. Martin Hall
301-405-5437
kimjh@eng.umd.edu
Phase change heat transfer; microgravity; electronic cooling; MEMS; heat transfer in turbomachinery

Li, Teng
Assistant Professor
2141 Glenn L. Martin Hall
301-405-0364
lit@umd.edu
Phase change heat transfer; microgravity; electronic cooling; MEMS; heat transfer in turbomachinery

McCluskey, F. Patrick  EPS
Associate Professor
3141 Glenn L. Martin Hall
301-405-0279
mcclupa@eng.umd.edu
Electronics packaging for extreme temperature environments; power electronics packaging; computer-aided risk assessment of micro-electronic devices; electronic materials and semiconductor manufacturing

Modarres, Mohammad  DRS, RE
Professor
0151F Glenn L. Martin Hall
301-405-5226
modarres@umd.edu
Nuclear engineering, reliability engineering, expert system applications in reliability and safety; probabilistic risk assessment

Mosleh, Ali  DRS, RE
Professor
2100 Marie Mount Hall
301-405-5215
mosleh@umd.edu
Nuclear engineering and reliability engineering, data analysis, common cause failure; expert knowledge assessment; probabilistic risk assessment

Mote Jr., Clayton Daniel  MM
Professor and President of the University of Maryland
1101 Main Administration Building
301-405-5803
dmote@deans.umd.edu
Dynamic systems; vibration; biomechanics

Ohadi, Michael  TFES
Professor
4164C Glenn L. Martin Hall
301-405-5263
ohadi@eng.umd.edu
Heat and mass transfer; smart heat exchangers; micro and nano thermal systems

Pecht, Michael  EPS
Professor
S1103 Engineering Lab Building
301-405-5323
pecht@eng.umd.edu
Reliability assessment of electronic products; electronic product design and manufacture; supply chain management

Radermacher, Reinhard  TFES
Professor
3137 Glenn L. Martin Hall
301-405-5286
rader@eng.umd.edu
Energy conversion; combined cooling heating and power systems; refrigeration and air-conditioning; alternative refrigerants; thermal system optimization

Sandborn, Peter  EPS
Associate Professor
3127 Glenn L. Martin Hall
301-405-3167
sandborn@calce.umd.edu
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  DRS
Associate Professor
0162 Glenn L. Martin Hall
301-405-0417
lschmidt@eng.umd.edu
Computational design and optimization; development of design formalisms

Shih, Tien-Mo  TFES
Associate Professor
3141 Glenn L. Martin Hall
301-405-5273
shih@eng.umd.edu
Computational fluid dynamics and heat transfer; computational engineering

Smela, Elisabeth  MM
Associate Professor
2176 Glenn L. Martin Hall
301-405-5265
smela@eng.umd.edu
Micro-electro-mechanical systems (MEMS); combining organic materials with silicon to make new devices; conjugated polymer micro-actuators
Solares, Santiago  MM
Assistant Professor
3331 Glenn L. Martin Hall
301-405-5035
ssolares@umd.edu
Multi-frequency atomic and chemical force microscopy simulation and experiment, surface reconstruction and functionalization, multi-scale simulation integrating atomistic and continuum scales

Wallace, James  TFES
Professor
0100K Glenn L. Martin Hall
301-405-5271
wallace@eng.umd.edu
Experimental turbulence; methods of turbulent flow drag reduction; social implications of science and technology

Yang, Bao  TFES
Associate Professor
4164D Martin Hall
301-405-6007
baoyang@umd.edu
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
Assistant Professor
2108 Glenn L. Martin Hall
301-405-3591
mmyu@eng.umd.edu
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.

Youn, Byeng  DRS
Assistant Professor
0158 Glenn L. Martin Hall
301-405-7004
bdyoun@umd.edu
Probabilistic risk analysis, risk-based design, energy harvesting innovations, prognostics and health management, resilience analysis and design

Zachariah, Michael  TFES
Professor
2125 Glenn L. Martin Hall
301-405-4311
mrz@umd.edu

Zhang, Guangming  DRS
Associate Professor
1131 Manufacturing Building
301-405-3565
zhang@eng.umd.edu
Manufacturing systems; dynamics of mechanical structures; control systems; engineering statistics; computer-aided engineering automation and machine learning
V.4  Appendix IV: Graduate Course Descriptions

SOME COURSES MAY NOT BE OFFERED EVERY SEMESTER, PLEASE CHECK WITH THE GRADUATE OFFICE. CALL: (301) 405-4216

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, Risk Assessment and Manufacturing

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 601 - MANUFACTURING SYSTEMS DESIGN AND CONTROL (3)
Prerequisites: None. Modeling and analysis techniques needed to design and control manufacturing systems. Deterministic and stochastic models, including discrete-event simulation and queuing systems. Applications of modeling and analysis.

ENME 602 - MEMS DEVICE PHYSICS AND DESIGN (3)
Prerequisite: N/A. Science, design, and device physics of micro-machined sensors and actuators. Transduction mechanisms, scaling laws, and micro-scale physics of MEMS components.

ENME 603 - ADVANCED MECHANISMS AND ROBOT MANIPULATORS (3)
Prerequisite: None. Analysis of spatial mechanisms and robot manipulators. The kinematics and dynamics of multi-degree-of-freedom mechanical systems are analyzed in detail. The main emphasis is on open-loop manipulators. Other mechanical systems such as closed-loop linkages, epicyclic gear drives, wrist mechanisms and tendon-driven robotic hands are covered.

ENME 604 - SYSTEMATIC DESIGN OF MECHANISMS (3)
Prerequisite: Undergraduate kinematics. Design of mechanisms from conceptual and dimensional points of view. Systematic methods of synthesis are introduced. The main emphasis is on planar mechanisms. A brief introduction to the kinematics of spatial mechanisms is also covered.

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 611 - GEOMETRIC MODELING BY CAD/CAM APPLICATIONS (3)
Prerequisites: None. This course introduces the underlying concepts behind three dimensional (3D) geometric modeling systems for curves, surfaces and solid bodies. It will cover: (1) geometric representation of three dimensional solid objects; (2) curve and surface representation; (3) geometric algorithms for curves, surfaces, and solids; and (4) real-world applications of geometric modeling. Advanced topics such as feature recognition, cutter path generation for numerical control machining, collision detection in robot path planning, and STEP standard for product data representation will also be introduced.

ENME 614 - ADVANCED PRODUCTION CONTROL TECHNIQUES (3)
Prerequisite: ENME 411 or consent of the instructor. Advanced techniques for quantitative and qualitative decision making in a modern manufacturing environment. A hierarchical architecture for the control and the performance evaluation of a manufacturing system serves as the framework for addressing various complex operational problems. Students are expected to analyze and solve a real industrial problem by collaborating with a local manufacturing company.
ENME 616 - COMPUTER AIDED MANUFACTURING (3)
Prerequisites: ENME 412 or permission of instructor. An introduction to the computer control of manufacturing processes. Topics include fundamentals of instrumentation, transducers and devices that lead to on-line process monitoring, control of machining processes, and automated material handling. Laboratory exercises include CNC machining and part verification on coordinate measuring machines.

ENME 620 - DESIGN FOR MANUFACTURE (3)
Prerequisite: ENME 808A (proposed no. ENME 600) or permission of instructor. Approaches and analysis methods for the concurrent design of quality products. Covers the following: axiomatic and systematic approaches to design and assembly, engineering properties of materials, manufacturing processes and their corresponding design rules, cost estimation, and factorial analysis and Taguchi's contributions.

ENME 623 - ANALYSIS OF MACHINING SYSTEMS (3)
Prerequisites: ENME 605 and ENME 662. Metal cutting principles, mathematical modeling of machining systems methods to perform dynamic analysis of machining systems and practical applications.

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 627 - MANUFACTURING WITH POLYMERS (3)
Prerequisites: ENME 412 or permission of instructor. The basic engineering approach for the processing of modern polymers and an introduction to the key properties of polymers for processing. Topics covered include morphology and structure of polymers, characterization of mixtures and mixing, elementary steps in polymer processing, screw extrusion and computer-aided engineering in injection molding.

ENME 808B - EMERGING MANUFACTURING PROCESSES: 21st CENTURY MANUFACTURING (3)
Prerequisite: Graduate standing or permission of instructor. This course will provide an introduction to several emerging and evolving modern manufacturing processes and their effect on the development of consumer products. The processes selected are solid free from fabrication and rapid prototyping, semiconductor manufacturing, micro electro-mechanical manufacturing techniques, electronic packaging, biotechnology, nanotechnology, and self-assembling materials. These processes will be presented in both their historical and economic contexts. In addition, their advantages, disadvantages, applications, limitations, competing technologies and future trends will be discussed. Future trends will include the effect of the customer selection of product features (e.g., mass customization via Internet ordering), on manufacturing process selection.

ENME 808X - 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.

Electronic Products and Systems

ENME 660 - MICROELECTRONIC COMPONENTS ENGINEERING (3)
Prerequisites: Graduate student standing or permission of instructor. The process of component selection lies at the heart of the design of electronic systems. This process includes application-independent considerations such as part manufacturer selection, manufacturer quality, part family quality, and integrity and distributor quality assessment; as well as application-specific considerations, including: determination of the life cycle environment, reliability assessment, performance assessment, assembly assessment, life cycle mismatch (obsolescence) assessment, legal liabilities, and risk management. This course will cover all the aspects of part selection and management and tie them in with the knowledge of electronic component materials, construction and manufacturing. It will present case studies, and involve students in projects and case studies with electronic equipment manufacturing companies.
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 693 - HIGH-DENSITY ELECTRONIC ASSEMBLIES AND INTERCONNECTS (3)
Prerequisites: None. This course presents the mechanical fundamentals needed to address reliability issues in high-density electronic assemblies. Potential failure sites and the potential failure mechanisms are discussed for electronic interconnects at all packaging levels from the die to electronic boxes, with special emphasis on thermo-mechanical durability issues in surface mount interconnects. Models are presented to relate interconnect degradation and aging to loss of electrical performance. Design methods to prevent failures within the life cycle are developed.

ENME 695 - FAILURE MECHANISMS AND 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 760 - MECHANICS OF PHOTONIC SYSTEMS (3)
Prerequisites: None. This course presents key principles for the design of photonic component packages to achieve reliable performance in high performance environments. Methods in thermal, mechanical, and optical analysis, and the impact of thermal, mechanical and chemical stresses are reviewed. General approaches using life-cycle engineering principles are also covered.

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 775 - MANUFACTURING TECHNOLOGIES FOR ELECTRONIC SYSTEMS (3)
Prerequisite: ENME 690 (Mechanical Fundamentals of Electronic Systems). This highly multi-disciplinary course presents the mechanical fundamentals of manufacturing processes used in electronics assemblies. The emphasis is on quantitative modeling of the intrinsic impact that processing has on structure, properties, performance and durability. Students will learn how to quantitatively model many of the key manufacturing steps from mechanistic first principles, so that sensitivity studies and process optimization can be performed in a precise manner. Processes considered include: wafer-level processes such as polishing, lithography, etching and dicing; packaging operations such as die attachment, wirebonding, flip chip bonding, and plastic encapsulation; multilevel high-density substrate fabrication processes; and assembly processes such as reflow and wave soldering of surface-mount components to electronic substrates.
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 125°C, 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 785 - EXPERIMENTAL CHARACTERIZATION OF MICRO- AND NANO-SCALE STRUCTURES (3)
Prerequisites: ENME 690 - Mechanical Fundamentals of Electronic Systems. This course teaches various methodologies for characterization of macro- to nano-scale structures. The specific areas include: (1) advanced failure analysis, (2) characterization of material properties and (3) quantitative stress analysis. The students will learn the basic principles of the methods and will develop skills for research investigations by participating in student projects.

ENME 808F - SENSORS AND MEMS PACKAGING (3).
Prerequisite: None. Advances in electronics can be measured by the benefits real products provide to customers. Many of the key benefits depend upon the ability of electronics to interface with the environment using electronic sensors. Examples of everyday electronic systems using sensors range from the mundane grocery store door opener to Doppler radar-based systems to complex weather satellites. For example, electronic sensors are now common in automobile anti-lock braking, airbag deployment, police radar, ignition control and emissions control systems. This course will provide a detailed overview of electronic sensor operation, selection, component packaging and mechanical and architectural integration into practical electronic systems. New advances in the MEMS or optical based sensor technologies need to pass the hurdle of economic and reliable packaging before their realization as viable products. These current challenges and future development potential in sensors will offer opportunities for engineers to work in innovative and exciting new applications.

ENME 808J - ADVANCED PACKAGING: MEMS, SENSORS, 3-D, MULTI CHIP MODULES (3)
Prerequisite: ENME 473 or equivalent graduate course. Concepts and technologies associated with the design and analysis of advanced packaging of electronic components and systems. Technologies treated include: hybrids, multichip modules, wafer scale integration, MEMS and 3D packaging. Concepts introduced in the course include mechanical reliability, system testability and design for testing, advanced electrical systems, and various design topics ranging from system partitioning and tradeoff analysis to layout and routing.

ENME 808U - PRINCIPLES FOR ELECTRONIC ENCLOSURE DESIGN AND MANUFACTURE (3)
Prerequisite: ENME 690 - Mechanical Fundamentals of Electronic Systems. This course examines the impact of enclosure and joint design on electromagnetic interference (EMI) in electrical systems. It reviews fundamental relationships between material properties and electrical behavior, in the context of EMI effects. Students will learn systematic strategies for design and evaluation of electronic enclosures, and analytical methods for testing and assessment. Methodologies will include computational solutions to Maxwell’s equations, as well as simple closed form approximations. Empirical and heuristic guidelines will also be presented.

ENME 808Z - DESIGN IN ELECTRONIC PRODUCT DEVELOPMENT (3)
Prerequisite: ENME 473 or equivalent graduate course. Merges technology, analysis, and design concepts into a single focused activity that results in the completed design of an electronic product. A set of product requirements are obtained from an industry partner, the students create a specification for the product, iterate the specification with the industry partner, then design and analyze the product. Students will get hands-on experience using real design implementation tools for requirements capture, tradeoff analysis, scheduling, physical design and verification. Issues associated with transferring of the design to manufacturing and selection of manufacturing facilities will also be addressed.
Mechanics & Materials

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 606 - NONLINEAR SYSTEMS (3)
Prerequisite: ENME 605 or permission of instructor. Analysis and synthesis of nonlinear dynamical systems. The stability problem and the synthesis of regulators for nonlinear processes are discussed using various approaches. Emphasis is placed on mechanical, electro-mechanical and aerospace applications.

ENME 621 - ADVANCED TOPICS IN CONTROL SYSTEMS: Robust and Adaptive Linear Control (3)
Prerequisite: ENME 605 or permission of instructor. Analysis and synthesis problems of systems with uncertain dynamics. Two approaches are examined: robust control of linear plants and adaptive control. The latest theoretical advancements in these areas are applied to several case studies of mechanical, electro-mechanical and aerospace systems.

ENME 608C - SYSTEM-LEVEL MEMS DESIGN AND SIMULATION (3)
Prerequisite: Graduate standing or permission of instructor. Hands-on utilization of MEMS computer aided design tools at the systems level. Students will perform design, simulation, and analysis projects using these software tools. Extended design projects involving commercial MEMS services, such as MUMPs and MOSIS foundry technologies, provide experience with design, layout, and simulation of devices for real-world applications. Applications to be covered include micro-sensors, micro-fluidics and bio-MEMS, and optical micro-systems.

ENME 644 - FUNDAMENTALS OF ACOUSTICS (3)
Prerequisite: ENME 360 or equivalent. This course covers the fundamental principles of acoustics allowing the students to go on to more advanced courses in acoustics, such as underwater sound propagation, active noise control, or radiation and scattering from elastic structures.

ENME 661 - DYNAMIC BEHAVIOR OF MATERIALS AND STRUCTURES (3)
Prerequisites: None. Response of materials and structures to dynamic loading events. Topics include: theory of wave propagation, plane waves, wave guides, dispersion relations, shock waves, equations of state, dynamic deformation mechanisms, adiabatic shear banding, dynamic fracture. Computational methods for modeling the dynamic response of structures will also be addressed.

ENME 662 - LINEAR VIBRATIONS (3)

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 666 - MODAL ANALYSIS AND TESTING (3)
Prerequisite: ENME 662 or permission of instructor. Development of linear discrete models of mechanical systems and structures, forced response using modal summation and state space models, digital signal processing, model testing techniques, modal parameters estimation, model refinement using modal test data.

ENME 670 - CONTINUUM MECHANICS (3)
Prerequisite: None. Mechanics of deformable bodies, finite deformation and strain measures, kinematics of continua 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 673 - ENERGY & VARIATIONAL METHODS IN APPLIED MECHANICS (3)**
Prerequisite: None. Application of variational principles to mechanics. Includes virtual work, potential energy, strain energy, Castigliano’s generalized complementary energy, and the principles of Hellinger-Reissner and Hamilton-Legendre transforms and the foundations of the calculus of variations. Singularities and stability in potential energy function. Applications to rigid, linear and non-linear elastic, and non-conservative examples. Approximation techniques such as Ritz, Petrov-Galerkin, least-squares, etc. Presents the basis for the finite element method.

**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 677 - ELASTICITY OF ADVANCED MATERIALS AND STRUCTURES (3)**
Prerequisite: MATH 462, ENME 670. Review of field equations and constitutive laws for linear elasticity, linearized boundary value problems; two-dimensional problems, biharmonic equation, Airy stress function, Neou’s method, plane stress and plane strain analysis, torsion and flexure, inverse and semi-inverse methods, Saint-Venant’s principle, thermoelastic problems; three-dimensional problems, Kelvin’s solution, the Boussinesq and Cerruti problems, Hertzian contact; energy methods; wave propagation; applications to advanced materials and structures (e.g., smart structures, multifunctional and functionally graded materials).

**ENME 678 - FRACTURE MECHANICS (3)**
Prerequisite: None. Advanced treatment of fracture mechanics covering the analysis concepts for determining the stress intensity factors for various types of cracks. Advanced experimental methods for evaluation of materials or structures for fracture toughness. Analysis of moving cracks and the statistical analysis of fracture strength. Illustrative fracture control plans are treated to show the engineering applications of fracture mechanics.

**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 710 - APPLIED FINITE ELEMENTS (3)
Prerequisites: ENME 331, ENME 332. Application of finite element methods to the solution of engineering problems - such as stress analysis, thermal conductivity, fluid flow analysis, electro-magnetic field analysis and coupled boundary value problems. Emphasis is on the application of the techniques to the solution of problems. Basic theory is covered at the beginning of the course.

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 infinite element models of vibrating structure.

ENME 808E – 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.

ENME808K – 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.

ENME808L – MEMS AND MICROFABRICATION TECHNOLOGIES II (3)
Prerequisite: ENME808K. This course is part 2 of a 2-semester course (part 1 is ENME808K), and it provides a classroom overview as well as a strong laboratory component. In the second semester, students microfabricate and test the devices that they designed during the first semester. Students have the opportunity to gain real-life research experience in the clean room. In addition, the course goes into greater depth in covering microsystems.

ENME808N – ACTIVE POLYMER MATERIALS (3)
Prerequisite: None. This course will cover active materials, including gels, conjugated polymers, IPMC, piezoelectrics, and electrostrictives. Actuation mechanisms will be reviewed (pH change, electric field, etc.) We will consider metrics for evaluating performance as well as their applications in MEMS, biomimetic devices, robotics, macro-structures, and optics. A substantial part of the course will be devoted to characterization techniques (stress, strain, SEM, TEM, AFM, x-ray diffraction, neutron diffraction, XPS, EDS, HPLC, FTIR, Auger, SIMS, TGA, UV-Vis-NIR, profilometry, ellipsometry, electrochemistry). Modeling and system identification for understanding the physical mechanisms of actuation will also be covered.

ENME808P – RANDOM VIBRATIONS OF STRUCTURAL SYSTEMS (3)
Prerequisites: ENME 361 and ENME 392; or the equivalent; and a working knowledge of MATLAB. Introduction to statistical concepts and mathematical methods used to model, analyze, and predict the response of mechanical, aeronautical, and civil structural systems to externally applied random excitations. These methods will be applied to the design and analysis of such systems to resist failures due to the effects of mechanical disturbances, wind and turbulence, earthquakes, transportation environments, and ocean wave loading.

ENME 808R - EXPLOSIVES I (3)
Prerequisite: None. This two-semester course provides a broad-based introduction to the whole field of explosive technology from basic research to production and demilitarization. The primary focus of the course is on explosive materials. The technology of research, development, and engineering is presented and then related to the behavior of energetic materials. The first semester emphasizes explosive sensitivity and safety, explosion effects, and the development and application of explosive compositions.
Thermal-Fluid Sciences

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

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)

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 702 - PARTIAL DIFFERENTIAL EQUATIONS FOR SCIENTISTS AND ENGINEERS (3)
Prerequisites: MATH 241 and MATH 246. Proposed description: Linear spaces and operators, orthogonality, Sturm-Liouville problems and eigenfunction expansions for ordinary differential equations, introduction to partial differential equations, including the heat equation, wave equation and Laplace’s equation, boundary value problems, initial value problems, and initial-boundary value problems.

ENME 705 - NON-NEWTONIAN FLUID DYNAMICS (3)
Prerequisites: ENME 342, ENME 640. This course offers the specific techniques and understanding necessary for being able to compute and understand issues associated with non-Newtonian fluid dynamics. Issues of rheology and analytic techniques are covered.

ENME 706 - IMPACT OF ENERGY CONVERSION ON THE ENVIRONMENT (3)
Prerequisite: Thermodynamics (graduate level) ENME 633. This course begins with a review of the energy flow diagram of the US and discusses the current status of energy production, transportation and consumption. This is followed by an introduction to environmental issues that are caused through energy conversion: Ozone depletion, global warming and air quality issues. Based on this background information, the students then develop, through classroom discussions, student presentations and lectures, alternative energy conversion concepts, assess their performance in design projects, and evaluate the potential environmental, infrastructure and cost impacts. The course focuses extensively and in considerable detail on the understanding and application of the latest energy conversion technologies.

ENME 707 - COMBUSTION AND REACTING FLOW (3)
Prerequisite: ENME 320 (Thermodynamics), ENME 331 (Fluid Mechanics), ENME 332 (Heat Transfer) or equivalent. This course covers thermochemistry and chemical kinetics of reacting flows in depth. In particular, we focus on the combustion of hydrocarbon fuels in both a phenomenological and mechanistic approach. The course covers the specifics of premixed and nonpremixed flame systems, as well as ignition and extinction. Combustion modeling with equilibrium and chemical kinetics methods will be addressed. Environmental impact and emissions minimization will be covered in detail. Finally, the course will cover available combustion diagnostic methods and their application in laboratory and real-world systems.

ENME 712 - MEASUREMENT, INSTRUMENTATION, AND DATA ANALYSIS FOR THERMO-FLOW 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 and multi phase flow 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.

ENME 799 - MASTER THESIS RESEARCH (1-6)

ENME 808 - ADVANCED TOPICS IN MECHANICAL ENGINEERING (2-3)
Prerequisite: Consent of instructor. Advanced topics of current interest in the various areas of mechanical engineering. May be taken for repeated credit.
ENME 808A - PHASE CHANGE HEAT TRANSFER (3)
Prerequisites: (none). Utilizing phase change during heat transfer can be very attractive since large amounts of heat can be removed with relatively small temperature differences. These processes can be important during the operation of high power devices, such as nuclear reactors, electronic cooling, and x-ray sources. The course will cover the fundamentals of phase change heat transfer and its application to numerous technologies. Topics include the basic thermodynamic relations, contact line mechanics, pool boiling, flow boiling, spray cooling, instrumentation, and experimental techniques.

ENME 808G – PHYSICAL GAS DYNAMICS (3)

ENME 808M - NANOPARTICLE AEROSOL DYNAMICS (3)
NanoParticle Aerosols (NA) (< 100 nm), and their science and technology play an important role in nature and industry. From air quality standards, nuclear reactor safety, inhalation therapy, workplace exposure, global climate change, to counterterrorism, aerosols play a central role in our environment. On the industrial side, NA plays an integral part of reinforcing fillers, pigments and catalysts, and the new emerging field of nanotechnology, they are the building blocks to new materials, which encompass, electronic, photonic and magnetic devices, and bio and chemical sensors. This graduate course will cover the basic science of nanoparticle formation, growth and transport. The science and engineering of measurement. The environmental impact and industrial use of nanoparticles.

ENME 808O - ANALYSIS OF INTERNAL COMBUSTION ENGINES AND FUEL CELLS
Prerequisite: None. This course will emphasize analysis of various power plant technologies being considered for the next generation of hybrid electric vehicles. The course will focus on the theory and design of power plants, including proton-exchange membrane fuel cells, direct injection diesel engines, and conventional spark ignition engines. A few weeks will also be set aside for looking at battery and electric motor technology being computational models for thermodynamic analysis and performance assessment of integrated hybrid vehicle power plants, both series and parallel configurations. Theoretical analysis will be presented in the context of outstanding problems related to hybrid electric vehicle power plant development and systems integration. Topics such as combustion cycle analysis and modeling of reacting flows will be presented in the context of specific technologies such as diesel engines or fuel cells. Students will perform an independent analysis on a hybrid system, which they will propose or extract from 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.)

ENME 808R - ADVANCED ENGINEERING STATISTICAL METHODS (3)
Prerequisite: Elementary statistics. The course introduces the statistical methodology used 1) for the analysis, control and improvement of processes, and 2) to quantify certain system characteristics in vibrations and turbulence. The fundamental techniques that form the basis of this methodology include: designed experimentation, which is employed to obtain the input/output relationships of a process and to determine appropriate input levels; statistical process control, which is used for monitoring process performance; reliability techniques, which are employed to minimize or eliminate premature failure; acceptance sampling, which supports quality assurance, and the statistical analysis of time-varying 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 898 – Ph.D. PRE-CANDIDACY RESEARCH CREDIT (1-12)
ENME 899 - PH.D. THESIS RESEARCH (1-12)

Reliability Engineering

ENRE 600 - FUNDAMENTALS OF FAILURE MECHANISMS (3)
Corequisite: ENRE 620. 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)
Corequisite: ENRE 620. 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 607 – RELIABILITY ENGINEERING SEMINAR (1)
Prerequisites: None. Topics of current interest, emphasizing the latest techniques and developments. Invited speakers will be selected to provide insights from the viewpoint of practitioners noted for their expertise in various facets of industry. Managers of reliability programs will be included along with those who are responsible for setting national policies and requirements. In-depth reviews will be provided, describing current research work underway across the nation.

ENRE 620 - MATHEMATICAL TECHNIQUES OF RELIABILITY ENGINEERING (3)
Prerequisites: MATH 246 or permission of department. Basic probability and statistics (required for ENRE 600 and ENRE 602). 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 624 - FAILURE MECHANISMS AND EFFECTS LABORATORY (3)
Prerequisite: ENRE 600 or permission of instructor. Techniques for studying failure analysis, corrosion and corrosion protection, statistical process control, mechanical failure mode analysis, failure reporting and corrective action systems, and environmental stress screening.

ENRE 625 - MATERIAL SELECTION AND MECHANICAL RELIABILITY (3)
Prerequisites: None. Topics include: microstructure development, mechanical properties of metals, polymers, ceramics, composites and semiconductors, fracture, fatigue, creep, microscopy, and failure analysis.

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 - ACCELERATED TESTING (3)
Prerequisite: ENRE 663 or permission of instructor. Models for life testing at constant stress. Graphical and analytical analysis methods. Test plans for accelerated testing. Competing failure modes and size effects. Models and data analyses for step and time varying stresses. Optimization of test plans.

ENRE 642 - RELIABILITY ENGINEERING MANAGEMENT (3)
Prerequisites: None. Unifying systems perspective of reliability engineering management. Design, development and management of organizations and reliability programs including: management of systems evaluation and test protocols, development of risk management-mitigation processes, and management of functional tasks performed by reliability engineers.

ENRE 643 - ADVANCED PRODUCT ASSURANCE (3)
Prerequisites: ENRE 600 and ENRE 602 or permission of instructor. Product assurance policies, objectives, and management. Material acquisition management, quality control documents and product assurance costing. Design input and process control, advanced testing technology, regression methods, and nondestructive testing. Simulation techniques, CAD/CAE methods. Software quality management, software documentation, and software testing methods. Total quality management.

ENRE 644 - BAYESIAN RELIABILITY ANALYSIS (3)
Prerequisites: ENRE 600 and ENRE 602. Foundations of Bayesian statistical inference, Bayesian inference in reliability, performing a Bayesian reliability analysis, Bayesian decision and estimation theory, prior distributions such as non-informative, conjugate, beta, gamma, and negative log gamma, estimation methods based on attribute life test data for estimating failure rates and survival probabilities. System reliability assessment and methods of assigning prior distribution. Empirical Bayes reliability estimates (implicitly or explicitly estimated priors).
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 646 - MAINTAINABILITY ENGINEERING (3)
Prerequisites: None. Role of maintainability in readiness and profitability. Design principles, including fault-tolerant design, FMECA for maintainability, maintainability quantification, establishing testability requirements, establishing hardware and software requirements, and reliability-centered maintenance.

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 653 - ADVANCED RELIABILITY & MAINTAINABILITY ENGINEERING (3)
Prerequisite: ENRE 600. Reliability and maintainability concepts in conceptual, development, production, and deployment phases of industrial products. Costing of reliability, methods of obtaining approximate reliability estimates and confidence limits. Methods of reliability testing-current research and developments in the area of reliability engineering. Modern CAD techniques in reliability design, thermal analysis of circuit boards, vibration analysis, maintainability analysis, and preventive maintenance methods.

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 657 - TELECOMMUNICATION SYSTEMS RELIABILITY (3)
Prerequisites: None. Reliability perspectives in telecommunications networks, comparison of networks with respect to operations & reliability, network reliability modeling techniques, applicable procedural/human reliability models, and network metric objectives and data collection.

EN-661 - MICROELECTRONICS DEVICE RELIABILITY (3)
Prerequisite: ENRE 600. This course develops an approach to continuous improvement of reliability of semiconductor devices. Topics covered include: Introduction to device technology, degradation mechanisms, optoelectronic components, power device reliability, and accelerated testing.

ENRE 662 - RELIABILITY & QUALITY IN MICROCIRCUIT MANUFACTURING (3)
Prerequisite: ENRE 600. Design and materials characteristics of microcircuits, including discrete chips, hybrids, printed wiring boards and electronic assemblies. Thermal design analysis. Common failure mechanisms, including metallization and interconnect degradation. Typical manufacturing processes and variability control. Design for reliability and manufacturability.

ENRE 664 - ELECTRONICS PACKAGING MATERIALS (3)
Prerequisite: ENRE 246, PHYS 263, or permission of instructor. Energy bands and carrier concentration, carrier transport phenomena, p-n junction, bipolar devices, unipolar devices, crystal growth and epitaxy, oxidation and film deposition, diffusion and ion implantation, lithography and etching, integrated devices, electromigration.

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 or 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 681 - SOFTWARE QUALITY ASSURANCE (3)
Prerequisites: None. Topics covered will include: QA roles in the software lifecycle, government and industry standards/methodologies, quality system scoring, quality system management, quality analysis metrics and tools for assessment. The principles of software configuration management, software testing, and maintenance will also be covered. A laboratory with software quality analysis tools is used.

ENRE 682 - SOFTWARE RELIABILITY AND INTEGRITY (3)
Prerequisite: ENRE 620 or permission of instructor. Defining software reliability, initiatives and standards on software reliability, inherent characteristics of software which determine reliability, types of software errors, structured design, overview of software reliability models, software fault tree analysis, software redundancy, automating tools for software reliability prototypes, and real time software reliability.

ENRE 683 - SOFTWARE SAFETY (3)
Prerequisites: None. The focus is on major software safety standards in government and industry, the software safety lifecycle, and detailed coverage in safety requirements-specification, analysis, and modeling, designing, coding, testing and maintenance. Also covered are hazard analysis and design, failure modes and effects analysis, fault tree analysis, designing for fault tolerance, and formal methods techniques for developing high assurance software. A laboratory with software tools is used.

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.

ENRE 799 - MASTER THESIS RESEARCH (1-6)
ENRE 898 – Ph.D. PRE-CANDIDACY RESEARCH CREDIT (1-12)
ENRE 899 - PH.D. THESIS RESEARCH (1-12)
## Appendix V: Contact Information

<table>
<thead>
<tr>
<th>Resource</th>
<th>Contact Person</th>
<th>Telephone</th>
<th>Office</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chair’s Office</td>
<td>Dr. Avram Bar-Cohen, Chair&lt;br&gt;Felicia Stephenson, Assistant to the Chair</td>
<td>301-405-5297</td>
<td>2181B Martin Hall</td>
</tr>
<tr>
<td>Office of Graduate Studies</td>
<td>Dr. Hugh A. Bruck, Director&lt;br&gt;Kerri Popper James, Associate Director&lt;br&gt;Fitzgerald Walker, Graduate Studies Coordinator</td>
<td>301-405-4216</td>
<td>2180 Martin Hall</td>
</tr>
<tr>
<td>Conference Room Reservation</td>
<td></td>
<td><a href="https://beauty.umd.edu/reserve/">https://beauty.umd.edu/reserve/</a></td>
<td></td>
</tr>
<tr>
<td>Keys &amp; Key Cards (RA/TA ONLY)</td>
<td>D.B. Galpoththawela, Office Clerk</td>
<td>301-405-2410</td>
<td>2181 Martin Hall</td>
</tr>
<tr>
<td>Mailbox</td>
<td>D.B. Galpoththawela, Office Clerk</td>
<td>301-405-2410</td>
<td>2181 Martin Hall</td>
</tr>
<tr>
<td>Office Assignments (RA/TA ONLY)</td>
<td>Margaret Brumfield, Director of Administrative Services</td>
<td>301-405-6580</td>
<td>2181C Martin Hall</td>
</tr>
<tr>
<td>Payroll and Health Insurance (RA/TA ONLY)</td>
<td>Lita Brown, Coordinator, Payroll and Benefits</td>
<td>301-405-7769</td>
<td>2181H Martin Hall</td>
</tr>
<tr>
<td>Health Benefits</td>
<td>Lita Brown, Coordinator</td>
<td>301-405-1230</td>
<td>2181G Martin Hall</td>
</tr>
<tr>
<td>Photocopying and Fax Accounts (RA/TA ONLY)</td>
<td>Margaret Brumfield, Director of Administrative Services</td>
<td>301-405-6580</td>
<td>2181C Martin Hall</td>
</tr>
<tr>
<td>Supplies (RA/TA ONLY)</td>
<td>D.B. Galpoththawela, Office Clerk</td>
<td>301-405-2410</td>
<td>2181 Martin Hall</td>
</tr>
<tr>
<td>Computer Account (Glue/WAM)</td>
<td>Office of Information Technology (OIT)</td>
<td>301-405-1500</td>
<td>Computer &amp; Space Sciences Bldg.</td>
</tr>
<tr>
<td>Graduate School</td>
<td>Graduate Student Services</td>
<td>301-405-0376</td>
<td>2123 Lee Bldg.</td>
</tr>
<tr>
<td>International Education Services</td>
<td>Nancy Gong, Advisor</td>
<td>301-314-0342</td>
<td>3116 Mitchell Bldg.</td>
</tr>
<tr>
<td>Parking Permits</td>
<td>Felicia Stephenson, Coordinator</td>
<td>301-405-5297</td>
<td>2181 Martin Hall</td>
</tr>
<tr>
<td>Registration</td>
<td>Office of the Registrar</td>
<td>301-314-8240</td>
<td>Mitchell Bldg., Ground Floor</td>
</tr>
<tr>
<td>University ID Card</td>
<td>Office of the Registrar</td>
<td>301-314-8218</td>
<td>Mitchell Bldg., Ground Floor</td>
</tr>
<tr>
<td>Financial Aid/Student Accounts</td>
<td>Office of the Bursar</td>
<td>301-314-9000</td>
<td>1135 Lee Bldg</td>
</tr>
</tbody>
</table>