

GRADUATE PROGRAMS  
IN  
THE DEPARTMENT OF MECHANICAL ENGINEERING

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Howard University  
College of Engineering and Architecture  
Washington, D.C. 20059

# *Graduate Programs*

*in*

## *The Department of Mechanical Engineering*

### **1. Introduction**

The graduate program in the Department of Mechanical Engineering has been in existence since 1967 when the Master of Engineering program was implemented. The Doctor of Philosophy degree program was initiated in 1976. The Department of Mechanical Engineering offers graduate study leading to the Masters of Engineering and Doctor of Philosophy degrees with specializations in dynamics and controls in aerospace engineering, fluids and thermal sciences, applied mechanics, and design and manufacturing.

In addition to the degree specializations listed above, the Department of Mechanical Engineering also offers interdisciplinary degree programs in Atmosphere Sciences and Materials Sciences. With the approval of the department, special interdisciplinary programs in mechanical engineering may also be designed utilizing the course offerings of other departments and the Washington Consortium of Universities.

### **2. Admission Requirements**

Students admitted into the graduate program must have at least a bachelor's degree and a GPA of 3.0 in their undergraduate program.

Applicants with inadequate preparation in mechanical engineering will be required to take necessary undergraduate courses to remove any deficiencies. Special cases will be addressed on an individual basis by the departmental Executive and Graduate Program Committees.

#### *Master of Engineering*

Students admitted to the program typically will have completed a bachelor's degree in mechanical engineering or a closely allied field (physics, mathematics, or other engineering disciplines). There is no single criterion for admission; consideration is given to all aspects of an applicant's academic and/or career history, grades, recommendations, special examinations, and other sources of information.

Students having less than a 3.0 out of a 4.0 undergraduate cumulative average may be admitted provisionally for one semester, provided there is other evidence of aptitude for further study.

### *Doctor of Philosophy*

Highly qualified applicants holding a bachelor's or master's degree in engineering, physical sciences, or mathematics, from a nationally accredited institution or applicants with equivalent qualifications from foreign institutions are eligible for admission into the Mechanical Engineering doctoral program.

### **3. Degree Requirements**

All graduate students must take the following courses or their equivalent: MEEG 503, Advanced Thermodynamics I; MEEG 505, Advanced Dynamics I; MEEG 507, Advanced Fluid Mechanics I and MEEG 512, Applications of Continuum Mechanics. Additionally, a minimum of two higher - level courses in advanced engineering mathematics are required for all students, normally, ELEG - 502, Engineering Analysis A and ELEG - 503, Engineering Analysis B for master's students and PHYS-216, Mathematical Methods in Physics I and PHYS-217, Mathematical Methods in Physics II for Ph.D. students.

In addition to the above requirements, new entrants to both the master's and doctoral programs are required to demonstrate their competency in the English Language by successful completion of the graduate school's English Proficiency Examination in Expository Writing and must also successfully complete Responsible Conduct of Research Workshop.

### *Master of Engineering*

Candidates are offered the option to write a thesis or to complete a project. Students choosing to write a thesis must complete a minimum of 30 credit hours of course work, of which 24 must be in graduate or approved undergraduate courses in mechanical engineering or related fields, and a minimum of 6 in research for the thesis.

Enrollment in the non-thesis option will be permitted upon the written request by the student, supporting written recommendation of the student's graduate adviser (including a proposed program of student) and the written approval of the departmental chairman and the chairman of the department's Graduate Program Committee.

A student can elect to apply for enrollment in the non-thesis option after completion of a minimum of 12 semester hours with a minimum cumulative GPA of 3.0. Such students must complete a minimum of 33 credit hours of course work, of which 30 must be spent in graduate or approved undergraduate course work in mechanical engineering or allied fields, and at least 3 in project work culminating in a written project report. These students must pass a comprehensive examination after successfully completing 24 credit hours of course work with a minimum cumulative GPA of 3.0.

### *Doctor of Philosophy*

Candidates for the Ph.D. must complete a minimum of 72 credit hours beyond the baccalaureate, of which 60 must be spent in course work and 12 in dissertation work. Students with no previous graduate work experience may be required to complete the academic requirements for the master's program during the first 30 semester hours in the doctoral program.

Students must complete a minimum of six semesters of full-time residence, or the equivalent, beyond the bachelor's degree, of which at least four must be completed in the graduate school of Howard University. Two of the four semesters must be consecutive. At least nine credit hours per semester constitute full-time study.

### *Qualifying Examination*

Each doctoral candidate must pass a written and oral qualifying or comprehensive examination, administered and supervised by the department. This examination must be taken at any time during the student's first 48 semester hours of relevant course work beyond the bachelor's degree credited toward the Ph.D. with the permission of the Graduate Program Committee. This examination is given only once each semester.

The Graduate Committee may pass one of the following resolutions regarding the student's performance on the qualifying exam:

*Pass.* The student may proceed to complete the other requirement for the Ph.D.

*Pass with Stipulations.* The student has passed a majority of the areas covered in the examination but in lieu reexamination in certain area(s), the student will be required to complete additional specified course(s) with a specified minimum grade at the earliest opportunity.

*Reexamination.* The student must appear for the reexamination to be given the following semester. The Committee may request the student to strengthen his/her knowledge in a specific area and then to appear for reexamination in that area, or the student may be asked to take the entire examination again. Any student who fails the qualifying examination twice will be automatically dropped from the Ph.D. program.

*Termination.* The student if not eligible to work towards the Ph.D. but may complete work for a master's degree in Mechanical Engineering. If the candidate already holds a master's in Mechanical Engineering, it will be recommended that the student terminate graduate studies in the department.

#### **4. Program of Study**

##### *Master of Engineering*

The Master's program consists of 24 or 30 hours of course work for the thesis or non-thesis option, respectively. Of these, eighteen hours are required of all students in the program. The remaining courses must be selected from the elective options of the various specializations.

<u>Required Course</u>		<u>Credit</u>
MEEG-503	Advanced Thermodynamics I	(3)
MEEG-505	Advanced Dynamics I	(3)
MEEG-507	Advanced Fluid Mechanics	(3)
MEEG-512	Applications of Continuum Mechanics	(3)
ELEG-502	Engineering Analysis A	(3)
ELEG-503	Engineering Analysis B	(3)
<u>Thesis Option</u>		
2 Elective Courses*	Area of Specialization	(6)
MEEG-518	MS Research	(6)
MEEG-519	Graduate Seminar	(1)
<u>Non-Thesis Option</u>		
4 Elective Courses*	Area of Specialization	(12)
MEEG-615	Special Project	(3)
MEEG-519	Graduate Seminar	(1)

\*Selections to be made with advisor's approval

##### *Doctor of Philosophy*

Candidates for the Ph.D. degree must complete a minimum of 72 credit hours beyond the baccalaureate, of which a minimum of 60 must be spent in course work and 12 in dissertation work. The 60 credit hours must include the following course or their equivalent: MEEG-503, MEEG-505, MEEG-507, MEEG-512, PHYS-216 and PHYS-217. The remaining credit hours are to be selected from the elective options for the various areas of specialization, in consultation with the student's advisor and in accordance with the individual's needs and interests.

#### **5. Elective Options**

For specialization in dynamics and controls of aerospace systems, elective options, include the following course: Mechanical Engineering 501, 505, 506, 520, 610, 612, 431, 503, 507, 509, 512, 515, 521, 613 and 615; Physics 206 and 207; Civil Engineering 536 and 513;

Electrical Engineering 502/503, 555, 553, and 556; Computer Science 551, 628 and 339 and Mathematics 234, 245, 246, 235, and 236.

For specialization in fluid and thermal sciences, elective options include the following courses: Mechanical Engineering 503, 504, 505, 507, 509, 510, 511, 512, 519, 611, 514, 521, 607, 612, and 614.; Physics 204, 205, 222, 223, 272, 216 and 273; Electrical Engineering 502/503; Mathematics 234, 236, 245, 246, and 237.

For specialization in applied mechanics, elective options include the following courses: Mechanical Engineering 505, 507, 508, 512, 521, and 612; Civil Engineering 524, 535, 536, 513, 514, and 520; Electrical Engineering 555 and 556; Mathematics 229, 245, 246, 230, 231, 232, 234, 236, 239, 247, and 248.

For specialization in Manufacturing, elective options include the following courses: Mechanical Engineering 505, 532, 535, 606, 533, 534, 612, 616, 419, 436, 444, 501, 503, 507, 508, 511, 512, 521, and 609; Electrical Engineering 502, 503, 509, 510, 555, 561, 604, and 605; Computer Science 522, 548, 551, 552, 556, 615, 632, and 750; Physics – 219; Mathematics 245, 246, 234, 235, 236, 240, 247, and 248.

## ***6. Mechanical Engineering Courses***

MEEG 500. MS Directed Research. 1-6 Credits. This course can be used by master's students to meet their course registration requirements and also conduct some preliminary work on their master's research projects.

MEEG 501. Aerodynamics Theory. 3 crs. Covers the foundations of incompressible, compressible, and ideal and viscous aerodynamics theory.

MEEG 503. Advanced Thermodynamics I. 3 crs. Reviews of the basic laws of classical thermodynamics, cycles, and reactive systems.

MEEG 504. Advanced Thermodynamics II. 3 crs. Examines the statistical basis of thermodynamics and irreversible thermodynamics.

MEEG 505. Advanced Dynamics I. 3 crs. Analyzes particle dynamics, systems of particles, Hamilton's principle, Lagrange's equations, central force motion, rigid body dynamics, and Euler's equations.

MEEG 506. Astronautics. 3 crs. Studies the satellite position relative to rotating earth, perturbation theory, restricted three-body problem, ascent trajectories, staging, mass ratio, and near – earth atmosphere. Prereq.: MEEG 505.

MEEG 507. Advanced Fluid Mechanics I. 3 crs. Studies the physical properties of fluids, kinematics and conservation equations of fluid motion in rigid coordinate systems, tensor analysis, boundary conditions, vorticity, Navier – Stokes equations, some of their analytic

solutions and selected topics on creeping flows, laminar boundary layers, instability of viscous flows and turbulence.

MEEG 508. Advanced Heat Transfer I. 3 crs. Presents analytical and numerical techniques for the analysis of convective heat-transfer problems.

MEEG 509. Advanced Gas Dynamics. 3 crs. Examines sound waves, waves of finite amplitudes in gases, shock and expansion waves, one-dimensional gas-dynamic flows, linearized steady subsonic and supersonic flows and the theory of characteristics.

MEEG 510. Advanced Fluid Mechanics II. 3 crs. Deals with the mathematical formulation of basic equations of fluid dynamics and potential flow theory.

MEEG 511. Advanced Heat Transfer II. 3 crs. Presents analytical and numerical techniques for the solution of heat conduction problems.

MEEG 512 Applications of Continuum Mechanics. 3 crs. Presents the kinematics of a general continuum and fundamental laws of continua.

MEEG 514 Acoustics and Noise. 3 crs. Covers fundamentals as well as contemporary topics in acoustics.

MEEG 515. Experimental Stress Analysis. 3 crs. Specialized experimental stress analysis course, with emphasis on design, construction, and use of complex models.

MEEG 518. Master's Thesis. 1-6 crs. Intensive investigation carried out by students involving analysis, design, and/or experimentation in the student's area of interest.

MEEG 519. Graduate Seminar. 1 crs. Forum for the presentation of current research activities of graduate students, faculty, and guest speakers.

MEEG 521. Variational Methods in Applied Mechanics. 3 crs. Emphasizes formulation and application of variational principles for static, steady state and transient problems in solid and fluid mechanics.

MEEG 523. Radiation Heat Transfer. 3 crs. Analyzes radiation heat transfer, including radiation exchange between surfaces and radiative transfer in participating and non-participating media.

MEEG 524. Special Topics in Solid Mechanics. 3 crs. Varies on demand; topics offered include finite element methods, fracture mechanics and fatigue.

MEEG 532. Advanced Robotics. 3 crs. Advanced treatment for several complex topics for robotic manipulator analysis, design and control. Robot kinematics, dynamics based on

Newton, Euler-Lagrange and Kane's method of formulations, linearization and control techniques, determination of positioning errors and modeling, and computer simulation.

MEEG 533. CAD in Manufacturing. 3 crs. Advanced work in computer-aided analysis and 3D geometric modeling with integration of manufacturing automation system, application of CAD techniques such as expert system and other advance developments to the concept of computer integrated manufacturing and flexible manufacturing system.

MEEG 534. Finite Element Analysis. 3 crs. Basic concepts, formulation, and application of finite element techniques for numerical solution of problem in structural mechanics, heat transfer, dynamic response and fluid mechanics. Applications using general purpose FEM software such as ANSYS.

MEEG 535. Projects in Manufacturing. 3 crs. Advanced treatment of several topics of an interdisciplinary manufacturing environment and the critical examination of recent literature describing application of these topics to new technology areas.

MEEG 600. Ph.D. Directed Research. 1-9 Credits. This course can be used by doctoral students to meet their course registration requirements and also conduct some preliminary work on their master's research projects.

MEEG 606. Computer Applications in Mechanical Engineering. 3 crs. Theory and practice of the application of digital computers to mechanical engineering problems.

MEEG 609. Computational Fluid Dynamics. 3 crs. Includes numerical analysis fundamentals and difference methods for partial differential equations of fluid dynamics.

MEEG 610. Space Flight Dynamics and Attitude Control. 3 crs. Examines rigid body dynamics, forces and torques that act on a spacecraft, passive and active stabilization of spacecraft, stability theory-Lyapunov's direct method, and Floquet theory. Prereqs.: MEEG 505 and MEEG 506.

MEEG 611. Turbulence. 3 crs. Presents theories of turbulence, dynamics of turbulence and closure schemes, turbulent shear flows, and turbulent transport of momentum and heat.

MEEG 612. Advanced Dynamics II. 3 crs. Treats stability of linear systems – small oscillations; Hamilton's equations – phase space; canonical transformations; and the Hamilton- Jacobi equation.

MEEG 613. Special Topics in Aerospace Mechanics. 3 crs. Presentation of selected topics in contemporary aerospace mechanics that are of current interest to student and faculty researchers.

MEEG 614. Special Topics in Fluid Mechanics. 3 crs. Presentation of selected topics in contemporary fluid mechanics that are of interest to researchers.



MEEG 615. Special Projects. 3 crs. Project course taken by master's program students enrolled in the non-thesis option with specialization in various areas of interest.

MEEG 616. Special Topics in CAD/CAM. 3 crs. Presentation of specialized topics in contemporary CAD/CAM discipline that are of interest to researchers.

MEEG 617. Spacecraft Attitude Estimation. 3 crs. The attitude representations, attitude kinematics, attitude measuring devices, elementary estimation theory, three-axis and spin-axis attitude estimation, deterministic and optimal attitude estimation, the Kalman filter, attitude error analysis and accuracy prediction, spacecraft system identification.

Prereq.: MEEG 505

MEEG 618. Ph.D. Thesis. 1-6 crs. Intensive investigation carried out by Ph. D. candidates involving analysis, design, and/or experimentation in the student's area of interest that will culminate in an original contribution to the field.

## **7. Faculty**

Peter M. Bainum, Ph.D., PE

Distinguished Professor of Aerospace Engineering, Emeritus

*Research Topics:*

Structural/control optimization of large space structures; formation flying of orbiting satellites.

Emmanuel K. Glakpe, Ph.D., PE

Graduate Professor

*Research topics:*

Convective (Free, Forced and Mixed) Heat Transfer, Numerical Methods for Computational Fluid Dynamics, Renewable & Non-Renewable Energy Applications, Efficient Energy Utilization, Thermal State of Charge in Solar Heat Receivers.

Hyung D. Bae, Jr, Ph.D.

Graduate Assistant Professor

*Research Topics:*

Fiber Optic Sensors for Multi-Parameter Sensing, Optical Sensors for Biomedical Applications, MEMS, Polymer based Nano/Micro Fabrication.

Mohsen Mosleh, Ph.D.

Graduate Professor

*Research Topics:*

Surface Engineering and Tribiology, Engineering Materials, Design Methodology, Manufacturing Processes.

Gbadebo M. Owolabi Ph.D., P.Eng.

Graduate Associate Professor

*Research Topics:*

Fatigue and Fracture Mechanics, Constitutive Modeling, Multi-scale Modeling and Simulations, Non-destructive Techniques and Structural Integrity.

Sonya Smith, Ph.D.

Graduate Professor

*Research Topics:*

Aerodynamics, Acoustics, Computational Fluid Dynamics, Turbulence.

Lewis Thigpen, Ph.D., PE

Professor Emeritus

*Research Topics:*

Impact dynamics and penetration mechanics, micro-mechanical modeling of the constitutive behavior of materials.

Naren Vira, Ph.D.

Graduate Professor

*Research Topics:*

Robotics, CAD/CAM, manufacturing engineering, symbolic computation, optimal design.

Grant M. Warner, Ph.D.

Graduate Associate Professor

*Research Topics:*

Energy Harvesting, Biomechanics, Structural Optimization, Solid Mechanics.

Horace A. Whitworth, D. Sc.

Graduate Professor

*Research Topics:*

Analytical and experimental characterization of the fatigue damage development in fiber reinforced composites; stress and strength analysis and failure modes of composite joints.

Nadir Yilmaz, Ph.D. PE.

Graduate Professor & Chair of Department

*Research Topics:*

Combustion, CFD, Rocket Propulsion, Aluminum Behavior at High Temperature, Automotive

Achille Messac, Ph.D.

Graduate Professor & Dean

*Research Topics:*

Multidisciplinary Design Optimization, Engineering Design Optimization, Structures, Dynamics, Physical Programming