THE GRADUATE STUDENT HANDBOOK

Department of Aerospace and Mechanical Engineering
University of Southern California
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ADMISSION REQUIREMENTS FOR GRADUATE DEGREES IN AEROSPACE AND MECHANICAL ENGINEERING

Application

An application is available on-line at http://www.usc.edu/admission/graduate/apply/index.html.

Official Transcript(s) and GPA Admission Requirements

The University requires official transcripts from the colleges or universities the applicant has attended. DO NOT SEND TRANSCRIPTS TO THE DEPARTMENT. For admission to AME graduate programs the department requires a B.S. degree in Aerospace or Mechanical Engineering. Candidates with B.S. degrees in other disciplines may be admitted after clearing course deficiencies identified by a graduate advisor. The deficiencies can be cleared by either taking undergraduate prerequisites, at USC or at another institution, or specific graduate and 400 level classes that can be a part of a graduate coursework. In all cases, to be considered for admission to AME graduate programs a minimum undergraduate GPA of 3.0 is required. Any exceptions can be approved only by the full faculty of the AME department. Admission into the Ph.D. program is highly competitive and satisfying the minimum GPA requirements is no guarantee of admission because GRE scores, recommendation letters, statement of interest, and other factors are used in making the decision. The average undergraduate GPA of recently admitted Ph.D. students is 3.61.

Statement of Purpose/Study Proposal

The statement should include the reason for the applicant's desire to obtain a graduate degree in Aerospace or Mechanical Engineering. If applying to the Ph.D. program it must describe a proposed program of study and research at USC. Indicate scholarly and professional goals, and personal qualifications relative to the chosen program.

Graduate Record Exam

The Department requires a minimum score of 650 and 750 in the Quantitative portion of the GRE for the MS and Ph.D. programs, respectively. The GRE must be taken within five years preceding the application date. A hard copy of the Report of Scores must be submitted. The school code is 4852.

TOEFL (International Students only)

All international students are required to demonstrate their English proficiency by taking the International Student English (ISE) placement and following course requirements that may result. Students who meet the following conditions may not be required to take the ISE exam upon arrival at USC:

1. Students with TOEFL scores of 100 or higher with no less than 20 on each of the four individual sections of the new Internet-based TOEFL (iBT), 600 or higher on the paper-based TOEFL or 250 or higher on the computer based TOEFL taken within the last 2 years.
2. Students with a bachelor's degree from a college or university in the US.
3. Students whose native language is English. This applies to students from countries such as the United Kingdom, Australia, New Zealand and Canada (except Quebec) where English is both the first language of the country and the language of instruction.

Recommendation Letters

For M.S. programs letters of reference are accepted but not required. For Engineer and Ph.D. programs a minimum of three letters of reference are required. It is preferred that former

instructors provide the letters, however, the department will accept letters from the applicant's advisors from work if the applicant has been out of school for a few years.

Application Deadlines

MS: October 1 for spring, February 15 for summer, April 30 for fall; Ph.D.: December 15 for fall, October 1 for spring. If interested in financial aid the application deadlines may be earlier – see the Financial Support section below. *Please note that verification and processing of materials by the Office of Graduate and International Admission may take four to six weeks.*

Financial Support

The School's policy is that only Ph.D. students are eligible for Teaching and Research Assistantships. An application to the AME Ph.D. program will be automatically considered for all available USC fellowships and AME Teaching and Research Assistantships. The USC fellowships include the Provost, Viterbi, and Chevron fellowships. The AME graduate committee evaluates all Ph.D. applications for admission with the financial aid early in the Spring semester for the following Fall semester. For exceptional applications, admission and fellowship decisions may be made as early as October for the following Fall semester. The committee recommends students for USC graduate fellowships but the decisions are made on the School or University level. Decisions about Teaching and Research Assistantships are made in the department on the basis of departmental needs, available research funding, and comparison among applicants. There are also few specific USC fellowships available to MS students. See the following website for more information:
http://mapp.usc.edu/mastersprograms/scholarships.html.
All fellowships are highly competitive. To be considered for fellowships letters of recommendation and GRE scores must be submitted even if a student satisfies conditions for admission without them, e.g., to USC Progressive Degree programs. Applications to the Ph.D. program should be submitted as early as possible but no later than December 15 in order to meet deadlines for USC fellowships, and TA and RA funding. Applications to MS should be submitted by early January to be able to apply for MS fellowships which have an application deadline of March 1st.

Please forward the application, official transcript(s), GRE report, statement of purpose and letters of recommendation to the USC Office of Admission, making sure that the applicant's name is on each form.

USC Office of Admission
GRADUATE
University Park Campus
Los Angeles, CA 90089-0915

NOTE: Any materials sent via express mail services must be addressed to:

USC Office of Admission
3601 South Flower Street
Tyler 1
Los Angeles, CA 90089-0911

GENERAL INFORMATION FOR NEW GRADUATE STUDENTS

This information supplements and sometimes repeats information contained in the University Catalogue and the Graduate Assistant Handbook. In case of conflict between documents the University Catalogue always takes precedence. Consult both documents for the description of general requirements for the graduate degrees and duties of Graduate Assistants.

- **Master of Science students**: Follow program requirements in your chosen area of specialization as shown in the M.S. Curriculum.
- **Engineer students**: Total of 30 units with minimum 12 units of coursework in one area of engineering (major) and 9 units in another (minor) are required for graduation. The Engineer degree is a terminal degree and students who complete it will not be considered for admission to the Ph.D. program.
- **Ph.D. or prospective Ph.D. students**: A necessary condition for being in the Ph.D. program is to pass the Screening Examination (information enclosed), usually held at the end of a Fall and Spring semester. Students who enter the Graduate Program without an M.S. degree are expected to take the Screening Exam during their *third* semester at USC, while students who already hold an M.S. are expected to take the exam in their *first* or *second* semester here. It is also expected that students taking the Screening Exam have identified a general research area for a Ph.D. thesis and a potential academic advisor.
- **Students with RA/TA positions**: The department awards a limited number of Teaching Assistant (TA) and Research Assistant (RA) positions. The School's policy is that only Ph.D. students are eligible for TA positions. The graduate committee evaluates applications some time in spring for the following fall semester. Decisions are made on the basis of departmental needs, available research funding, and comparison among applicants. TA positions are usually given to new Ph.D. students for one year and sometimes extended for another year and the total TA support for any student cannot exceed an equivalent of 4 semesters at 50% level. Because a Ph.D. degree normally takes longer than two years to complete, Ph.D. students awarded TA should identify sources of support other than a TA during their first year at USC. It is expected that after one year and not later than two years on a TA position, a Ph.D. student will have either external support or will secure an RA position in the Department. RA positions are at the discretion of individual faculty members and students are encouraged to explore possibilities of obtaining them directly with the faculty members.

  Graduate Assistants are subject to the University rules described in the Graduate Assistant Handbook. The rules range from English Language Proficiency requirements to Policy on Academic Integrity and Policy Against Sexual Harassment. It is expected that all TA/RAs familiarize themselves with these rules and policies and abide by them.

Students holding RA/TA positions are required to enroll in AME 550 (Seminar).

REQUIREMENTS FOR THE M.S. DEGREE

At the Master's level, the department offers degrees in

- Aerospace Engineering
- Mechanical Engineering
- Aerospace & Mechanical Engineering (Dynamics & Control)
- Aerospace & Mechanical Engineering (Computational Fluid & Solid Mechanics)
- Product Development Engineering

The general M.S. programs in Aerospace and Mechanical Engineering allow for specialization in a number of topical areas, listed separately. In addition to the general M.S. degree programs the department also offers separate M.S. programs focused on single areas of Aerospace and Mechanical Engineering: Dynamics and Control, Computational Fluid and Solid Mechanics, Product Development Engineering, Systems Architecture and Engineering.

The minimum number of units required for the M.S. degree in a program without Thesis is 27. At least 18 units must be at the 500 level in the major department and closely related departments. No more than three units of Directed Research (AME 590) can be applied to the 27-unit requirement. Exceptions are the programs with a design project that can have six units of Directed Research. For a program with Thesis four of 27 units are to be thesis (594ab); however the total number of research and thesis units cannot exceed eight. The maximum number of transfer credits that may be applied towards the 27-unit requirement, subject to departmental approval, is four units. A newly admitted student to regular standing may request a credit evaluation after official transcripts have been received by the Degree Progress Department (213) 740-7070. It is advisable to submit the course work for evaluation by the end of the first semester of enrollment at USC or before filing for the Master's Degree.

M.S. degree candidates in each area of specialization must satisfy core requirements (three or six units, depending on specialization), core elective requirements (three or six units), engineering mathematics requirements (six units), and in the Aerospace Engineering a breadth requirement (three units). The core courses for each specialization are divided into required and core electives. Required core courses are usually offered every academic year. Those which may not be offered regularly are grouped as core electives. Students must take the required core courses if they are offered during the duration of their program. A core elective may replace a required course only if the latter is not being offered during that time. The remaining courses, beyond those needed to satisfy the requirements, are taken as engineering technical electives. They are selected by a student according to her/his interests but it is recommended that they are from the list of core electives from the same area of specialization. A list of required and recommended courses is provided below and their description may be found in the USC Catalogue.

Listed coursework is intended only as a guideline for students wishing to achieve a competence in a specific area of Aerospace or Mechanical Engineering. For candidates who wish to specialize in some combination of the topical areas a Graduate Advisor may approve individual M.S. programs. Note that for general MSAE and MSME degrees neither the diploma nor transcripts reflect the specialization chosen – all students receive the same degree either in Aerospace or Mechanical Engineering – but, upon request, the department will provide a student with a letter specifying area(s) pursued in his/her studies.

The majority of the specializations are available through the Distance Education Network (http://mapp.usc.edu/distanceeducation/index.html), which allows students to obtain a MS degree from the convenience of their home or office.

PROGRAM REQUIREMENTS FOR THE GENERAL M.S. DEGREE IN AEROSPACE ENGINEERING

The Master of Science degree in Aerospace Engineering is designed to give students exposure to at least two different areas of Aerospace Engineering through concentration and breadth requirements, and at the same time allowing students to pursue their interests through flexibility in the selection of technical electives.

The Master of Science degree in Aerospace Engineering allows for specialization in the following topical areas:

- Aerodynamics/Fluid Dynamics
- Aerospace Control
- Aerospace Design
- Aerospace Structures
- Computational Fluid Dynamics
- Hypersonics/Kinetics of Gases and Plasmas
- Propulsion
- Space Science

The courses listed are 3 units each.

REQUIREMENTS COMMON FOR ALL AREAS OF SPECIALIZATION

Applied Math Requirements: AME 525 Engineering Analysis & AME 526 Engineering Analytical Methods

Breadth Requirement: a core requirement course from a different area of specialization than the one being followed.

AERODYNAMICS/FLUID DYNAMICS

Core Requirements:	AME 530a	Dynamics of Incompressible Fluids
	AME 511	Compressible Gas Dynamics
Core Electives:	AME 530b	Dynamics of Incompressible Fluids
(choose one)	AME 457	Engineering Fluid Dynamics
	AME 535a	Introduction to Computational Fluid Mechanics
	AME 620	Aero and Hydrodynamic Wave Theory
	AME 621	Stability of Fluids
	AME 651	Statistical Theories of Turbulence
	AME 652	Turbulent Shear Flows

AEROSPACE CONTROL

Core Requirements:	AME 532a	Flight Vehicle Stability and Control
	AME 541	Linear Control Systems II
Core Electives:	AME 532b	Flight Vehicle Stability and Control
(choose one)	AME 552	Nonlinear Control Systems
	AME 544	Computer Control of Mechanical Systems
	AME 545	Modeling and Control of Distributed Dynamic Systems
	ASTE 585	Spacecraft Attitude Control
	ASTE 586	Spacecraft Attitude Dynamics

AEROSPACE DESIGN

Core Requirement:	AME 527	Elements of Vehicle and Energy Systems Design
Core Electives:	ASTE 520	Spacecraft System Design
(choose two)	AME 528	Elements of Composite Structure Design
	AME 408	Computer-Aided Design of Mechanical Systems
	or	Six units of a supervised design project

AEROSPACE STRUCTURES

Core Requirement:	AME 529	Aircraft Structures Analysis
Core Electives:	AME 546	Basic Aeroelasticity
(choose one)	CE 529a	Finite Element Analysis
	CE 541a	Dynamics of Structures
	AME 509	Applied Elasticity
	or	CE 507 Mechanics of Solids I
	AME 521	Engineering Vibrations II
	AME 559	Creep
	AME 560	Fatigue and Fracture
	AME 584	Fracture Mechanics and Mechanisms

COMPUTATIONAL FLUID DYNAMICS

Core Requirements:	AME 530a	Dynamics of Incompressible Fluids
	AME 535a	Introduction to Computational Fluid Mechanics
Core Electives:	Choose two courses, each from a different category.	
	Numerical Methods	
	AME 535b	Introduction to Computational Fluid Mechanics
	ASTE 545	Computational Techniques in Rarefied Gas Dynamics
	Math 504ab	Numerical Solution of Ordinary and Partial Differential Equations

Fluid Mechanics

AME530b	Dynamics of Incompressible Fluids
AME 511	Compressible Gas Dynamics
AME 620	Aero and Hydrodynamic Wave Theory
AME 621	Stability of Fluids
AME 651	Statistical Theories of Turbulence
AME 652	Turbulent Shear Flows
AME 457	Engineering Fluid Dynamics

HYPERSONICS/KINETICS OF GASES AND PLASMAS

Core Requirements:	ASTE 445	Molecular Gas Dynamics
	ASTE 501a	Physical Gas Dynamics
Core Electives:	ASTE 501b	Physical Gas Dynamics
(choose one)	AME 511	Compressible Gas Dynamics
	ASTE 545	Computational Techniques in Rarefied Gas Dynamics
	ASTE 535	Space Environments and Spacecraft Interactions
	ASTE 541	Partially Ionized Plasmas
	AME 587	Gas-Surface Processes
	EE 539	Engineering Quantum Mechanics

PROPULSION

Core Requirements:	AME 511	Compressible Gas Dynamics
	AME 513	Principles of Combustion
Core Electives:	ASTE 470	Spacecraft Propulsion
(choose one)	ASTE 501a	Physical Gas Dynamics
	AME 436	Energy and Propulsion
	AME 514	Applications of Combustion
	AME 512	Advanced Thermodynamics
	ChE 530	Thermodynamics for Chemical Engineers

SPACE SCIENCES

Core Requirements:	AME 477	Solar System Exploration
	ASTE 501a	Physical Gas Dynamics
Core Electives:	ASTE 445	Molecular Gas Dynamics
(choose one)	ASTE 520	Spacecraft System Design
	ASTE 553	Systems for Remote Sensing from Space
	ASTE 535	Space Environments and Spacecraft Interactions
	ASTE 541	Partially Ionized Plasmas

PROGRAM REQUIREMENTS FOR THE GENERAL M.S. DEGREE IN MECHANICAL ENGINEERING

For a Master's degree in Mechanical Engineering, the student should follow a coherent program of study in a chosen area of specialization. These are suggested programs that provide for focused education in four areas of concentration:

- Thermal and Fluid Sciences
- Engineering Design
- Mechanics and Materials
- Microelectromechanical Systems (MEMS)

In addition, the department also offers specialized M.S. programs: Dynamics and Control, Computational Fluid and Solid Mechanics, and Product Development Engineering. The details of the specific requirements in each specialization are given below. The courses listed are 3 units each.

REQUIREMENTS COMMON FOR ALL AREAS OF SPECIALIZATION

Engineering Analysis Requirements: AME 525 Engineering Analysis and AME 526 Engineering Analytical Methods.

THERMAL AND FLUID SCIENCES: COMBUSTION, FLUID DYNAMICS AND HEAT TRANFER

The Thermal & Fluid Sciences encompasses concentration in one of the following areas: (1) Combustion, (2) Fluid Dynamics, and (3) Heat Transfer. A coherent degree program in one of these concentrations will require four core courses (12 units), two required engineering analysis courses (6 units), two core electives (6 units), and one engineering elective (3 units) by advisement. A minimum cumulative GPA of 3.00 is required for graduation. Additional requirements may need to be met as per the University Catalogue.

Core Courses

COMBUSTION	*FLUID DYNAMICS*	*HEAT TRANSFER*
AME 436	AME 457	AME 457
AME 513	AME 511	AME 515
AME 514	AME 530a	AME 516
AME 530a	AME 535a	AME 517

Core Electives (take two courses from the following list, not duplicating the above selection)

AME 436	Energy and Propulsion
AME 457	Engineering Fluid Dynamics
AME 511	Compressible Gas Dynamics
AME 513	Principles of Combustion
AME 514	Advanced Topics in Combustion
AME 515	Advanced Problems in Heat Conduction
AME 516	Convective Processes
AME 517	Radiation Heat Transfer
AME 530a	Dynamics of Incompressible Fluids
AME 533	Multi-Phase Flows
AME 535a	Introduction to Computational Fluid Dynamics

AME 535b	Introduction to Computational Fluid Dynamics
AME 537	Microfluidics
ASTE 552	Spacecraft Thermal Control

Engineering Elective:
Approved (by advisement) one 400-, 500- or 600-level graduate course

ENGINEERING DESIGN

The Engineering Design is a program concentration that focuses on engineering design process and techniques. A coherent degree program in this concentration will require two required engineering analysis courses (6 units), three core courses (9 units), two core elective courses (6 units), and two engineering electives approved by advisement (6 units). A minimum cumulative GPA of 3.00 is required for graduation. Additional requirements may need to be met as per the University Catalogue.

Core Courses

AME 503	Advanced Mechanical Design
AME 505	Engineering Information Modeling
AME 509	Applied Elasticity

Core Electives (take two courses from the following)

AME 404	Mechanical Engineering Problems
ASTE 520	Spacecraft System Design
ASTE 523	Design of Low Cost Space Missions
AME 527	Elements of Vehicle and Energy Systems Design
AME 541	Linear Control Systems II
AME 549a	System Architecting
CE 529a	Finite Element Analysis

Engineering Electives (take two courses from the following)

Approved (by advisement) 400-, 500-, or 600-level engineering courses.

MECHANICS AND MATERIALS

A coherent degree program in Mechanics of Materials will require two required engineering analysis courses (6 units), four core courses (12 units), one core elective course (3 units), and two engineering electives approved by advisement (6 units). A minimum cumulative GPA of 3.00 is required for graduation. Additional requirements may need to be met as per the University Catalogue.

Core Courses

AME 509	Applied Elasticity
AME 551	Mechanical Behavior of Engineering Materials
AME 559	Creep
AME 560	Fatigue and Fracture
AME 561	Dislocation Theory and Applications
AME 584	Fracture Mechanics

Core Elective (take one course from the following)

AME 542	Theory of Plates (CE 542)
AME 588	Materials Selection
CE 529a	Finite Element Analysis

Engineering Electives (take two courses from the following)

Approved (by advisement) 400-, 500-, or 600-level engineering courses

MICROELECTROMECHANICAL SYSTEMS (MEMS) – not available on DEN

Core Courses

AME 455	Introduction to MEMS
AME 537	Microfluidics
EE 607	Microelectromechanical Systems
BME 551	Introduction to Bio-MEMS & Nanotechnology

Core Electives: Take one courses from the following

AME 535a	Computational Fluid Dynamics
AME 520a	Physical Gas Dynamics
ASTE 545	Computational Techniques in Rarefied Dynamics

Engineering Electives: Take two courses from the following

Approved (by advisement) 400, 500 or 600 level engineering courses

SPECIALIZED DEGREE OPTIONS IN AEROSPACE AND MECHANICAL ENGINEERING

The department offers several specialized M.S. degrees that differ from general M.S. degrees by imposing stricter coursework requirements. While graduating students receive the same diploma as those following the general M.S. program, the specialization appears on a student's transcript.

MASTER OF SCIENCE IN AEROSPACE AND MECHANICAL ENGINEERING (COMPUTATIONAL FLUID AND SOLID MECHANICS)

The program prepares students for professional careers in engineering companies that develop products using computational tools of fluid and solid mechanics. The program also provides the necessary background for pursuing higher degrees, Engineer and Ph.D., in aerospace and mechanical engineering with specializations in computational fluid mechanics, computational solid mechanics and computational heat transfer. The degree course-work provides a necessary background in basic aerospace and mechanical engineering disciplines (solid mechanics, fluid mechanics, heat transfer), engineering mathematics and numerical methods. The capstone project courses, AME 535b and CE 551, provide practical examples using existing numerical programs to simulate structures, heat transfer and fluid flows as well as commercial mathematical packages for analyzing data.

Admission requirements follow the general admission rules for aerospace and mechanical engineering graduate programs. The program requires completion of a minimum of 27 units and a cumulative GPA of at least 3.0 for graduation. The program with a thesis requires 28 units, four of which are to be thesis.

Required Core Courses (24 units)

AME 404	Mechanical Engineering Problems
AME 509	Applied Elasticity
OR	
CE 507	Mechanics of Solids I
AME 525	Engineering Analysis
AME 526	Engineering Analytical Methods
AME 530a	Dynamics of Incompressible Fluids
AME 535a	Introduction to Computational Fluid Mechanics
CE 529a	Finite Element Analysis
AME 535b	Introduction to Computational Fluid Mechanics
OR	
CE 551	Computer-Aided Engineering Project

Selected technical electives from the following list or other electives approved by a graduate advisor: 3 units.

Technical Electives		**units**
AME 511	Compressible Gas Dynamics	3
AME 516	Convection Processes	3
ASTE 545	Computational Techniques in Rarefied Gas Dynamics	3
AME 590	Directed Research	1-12
AME 599	Special Topics	2-4, max 9
CE 529b	Finite Element Analysis	3
CE 541a	Dynamics of Structures	3
CE 542	Theory of Plates	3

One core class requirement may be waived at the discretion of a graduate advisor if a student documents that he or she completed or is enrolled in an equivalent course. The waived class must be replaced by a technical elective. Credit for one course of not more than 4 units from another accredited institution may be approved by a graduate advisor. The Master's Thesis (4 units) may be substituted for a technical elective class (3 units).

MASTER OF SCIENCE IN AEROSPACE & MECHANICAL ENGINEERING (DYNAMICS & CONTROL)

The Master of Science with emphasis in Dynamics and Control educates and trains multidisciplinary professionals in the modeling, analysis, simulation and control of complex time-evolutionary systems. It is a program of study that encompasses advanced analytical dynamics,

nonlinear dynamical systems, linear and nonlinear dynamics and vibrations, and linear and nonlinear control. The program equips students to apply their knowledge to a variety of complex systems encountered in nature and society, especially those in civil, mechanical and aerospace engineering and applied mechanics.

Students will be given advisement in the first semester of their study. In addition to AME 525 and AME 526, students are required to take the following core courses:

Core Courses

AME 521	Engineering Vibrations II
AME 522	Nonlinear Dynamical Systems, Vibrations, and Chaos
AME 524	Advanced Engineering Dynamics
AME 541	Linear Control Systems II
AME 552	Nonlinear Control Systems

Elective courses can be chosen in areas of specific interest to the student such as orbital dynamics, spacecraft control, aircraft dynamics and control, chaos and chaotic dynamics, random vibrations, computer control of mechanical systems and robotics. The program provides the graduate student with a broad, well-rounded, advanced education that can be applied to many specific, technologically advanced fields in which dynamics and control play a pivotal role.

MASTER OF SCIENCE IN PRODUCT DEVELOPMENT ENGINEERING

The AME department offers this program as 'Product Development Technology,' and a similar program in 'Product Development Systems,' is available through the Industrial and Systems Engineering Department (ISE). A minimum of 27 units of course-work are required for this degree. This includes two required program core courses, two required "area of specialization" (AOS) courses, two AOS elective courses, and three general elective courses approved by an advisor. A minimum cumulative GPA of 3.0 is required for graduation. In addition to classroom lectures, emphases are placed on case studies and team projects. Students can choose a thesis option to develop new technology products or services of their choice as part of their degree program requirements.

Core Courses

AME 503	Advanced Mechanical Design
ISE 545	Technology Development and Implementation

Required AOS Courses

AME 505	Engineering Information Modeling
AME 525	Engineering Analysis
OR	
AME 526	Engineering Analytical Methods

AOS Technical Electives (select two)

ASTE 520	Spacecraft Systems Design
ASTE 523	Design of Low-Cost Space Missions
AME 549ab	Systems Architecting
AME 599	Advanced Topics in Product Development

Engineering Electives: Take three courses from the following

Approved (by advisement) 400, 500 or 600 level engineering courses

Students interested in Product Development Systems program are referred to the ISE Department (go to **http://wisdom.usc.edu/** for details).

FILING FOR THE MASTER'S DEGREE

Please file for the Master's Degree in order to have your academic program approved and verified for ***completion*** of degree requirements. The application is available online at http://viterbi.usc.edu/assets/031/51737.pdf. Students should file this form at the start of their last semester of registration. Please fax the form to (213) 740-7774 or mail the form to the following address:

Department of Aerospace and Mechanical Engineering
University of Southern California
854 Downey Way
Los Angles, CA 90089-1191
USA

REQUIREMENTS FOR THE PH.D. DEGREE IN AEROSPACE AND MECHANICAL ENGINEERING PROGRAMS

General Requirements for the Doctor of Philosophy

This degree is granted under the jurisdiction of the USC Graduate School. Students should also refer to the **Requirements for Graduation** section and the **Graduate School** section of the University Catalogue for general regulations. All courses applied toward the degree must be courses accepted by the Graduate School.

Course Requirements

Satisfactory completion of at least 60 units of approved graduate level coursework beyond baccalaureate, with a cumulative grade point average of at least 3.0 is required of all Ph.D. students in engineering. The 60 units minimum include research courses (590, 690, 790) and four units of 794ab Doctoral Dissertation. Ph.D. students in the AME department typically take at least 45 lecture units, i.e. regular, non-research courses. Students with a completed graduate degree from an accredited institution, e.g. an M.S. degree, can be admitted to a Ph.D. Program with Advanced Standing. For such students a minimum of 36 units of course work beyond that graduate degree, exclusive of 794 Doctoral Dissertation, will be required for the degree. The number of units taken at USC can be reduced by transferring graduate credits from another institution, as long as transfer work has not been counted towards student's previous degree. A maximum of six units can be transferred for students admitted with Advanced Standing and four for those without. Transfer units are subject to approval by the Degree Progress Department (for course-work taken at institutions in the U.S.) or by International Admission (for course-work taken at institutions outside the U.S.) and by the guidance committee.

Guidance Committee

The Ph.D. student's program of study is supervised by the guidance committee, consisting of five tenured or tenure-track USC faculty, three of whom must be from the major department, at least one of whom must be tenured, and an outside member from a different Ph.D. granting department at USC. The students are encouraged to select as early as possible the primary advisor, who will chair the guidance committee. Having a Ph.D. advisor is critical for the student's success. The advisor assists in the selection of the research topic, appropriate course-work, and monitors progress toward meeting degree requirements.

Screening Procedure

The initial admission decision admitting a student to the Ph.D. program is based on the student's previous academic records, Graduate Record Examination scores and other evidence of scholastic abilities indicating promise for completing graduate studies. It is also a prerequisite that all Ph.D. students successfully complete the screening procedures designated by the department and described separately below. The screening exam must be taken before completion of 24 units at USC, including research courses. Students who fail the screening procedure will be advised that they are not recommended to continue in the Ph.D. program and that any additional work may not be counted toward the degree.

Qualifying Examination

To be eligible to take the qualifying examination, the student must have completed at least 24 units toward degree in residence at USC with a cumulative GPA of 3.0. The Request to take the Qualifying Examination must be filed in the semester prior to taking the examination and at least 30 days before beginning the examination. The examination, administered by the guidance committee, is intended to determine the extent of the student's knowledge in basic science and engineering areas as well as the ability to do original and scholarly research. The format of the qualifying exam in the department of Aerospace and Mechanical Engineering is described separately below. The committee examines the candidate's overall scholarly ability as well as the ability to complete the proposed research together with its originality and potential for archival publication. The examination may be scheduled at any time during the semester provided that all members of the committee are available to administer them. All portions of the examination must be completed within 60 days.

After passing the qualifying examinations the Ph.D. student is admitted to candidacy by the Dean of Graduate Studies and the guidance committee becomes the dissertation committee. The dissertation committee may be reduced to three members, with at least one member being a tenured faculty member in the student's home department, and one must be an outside member from a different Ph.D. granting department at USC. After this step students will normally engage in at least one year of full-time graduate study and research on campus. Following the admission to candidacy continuous enrollment in AME 794 (a, b, c, d, z) is required in subsequent semesters. AME 794 a and b are required minimum.

Doctoral Dissertation

An acceptable dissertation based on original investigation and supervised directly by the dissertation committee is required. The dissertation must show mastery of a special field, capacity for independent research and a scholarly result. Candidates are expected to keep all members of the dissertation committee informed of their progress at all stages of the dissertation. The department offers the opportunities for research experience in a variety of areas, representing state-of-the-art activity in the frontiers of science and engineering.

Defense of the Dissertation

After satisfactorily meeting all other requirements and after the research and writing of the dissertation are substantially complete, the Ph.D. candidate must pass a general final oral examination devoted to the major field and to the topic of the dissertation. The examination will be conducted in such a manner as to determine to the satisfaction of the dissertation committee that the candidate has attained the stage of scholarly advancement and power of investigation demanded by the University for final recommendation to the doctorate. In the Aerospace and Mechanical Engineering the dissertation defense has a form of a technical seminar open to the general university community, followed by an optional closed examination session at the discretion of the committee. Only members of the dissertation committee have the authority to recommend the acceptance of the dissertation. The recommendation must be unanimous and all members of the committee must be present during the oral defense.

If the defense is satisfactory, the committee will sign the Approval to Submit Defended & Final Copy of Doctoral Work; if additional work is required, the committee may postpone signing the form until the additional work is completed to the satisfaction of the committee.

THE Ph.D. SCREENING EXAMINATION

The screening exam is one component of the overall screening procedure that involves each student's complete academic/research record. The exam is offered twice a year, at the end of the Fall and Spring semesters. A Pass/Fail decision will be made for each student at the AME faculty meeting. The general policy is that the screening exam can be taken only once. Individual exceptions to this policy may be approved by the faculty on the basis of other significant indicators, such as, for example, research potential.

Students must register for the exam in advance. The registration **Deadline** for Fall 2009 is Monday, November 2, 2009. Students should register in person with Ms. Samantha Graves in RRB 101 or by phone at (213) 740-1735. Sample copies of past exams will be posted on the AME web page. Alternatively, sample copies of past exams can be obtained from the AME offices at RRB 101 or OHE 430. At the time of registration, a student must:

1. Be admitted to the AME Graduate Program, with all conditions cleared in case of a conditional admission.
2. Have completed at least 9 units of graduate work (taken for a letter grade) in AME;
3. Have completed no more than 24 units of graduate work at USC including research courses, as per AME graduate student handbook;
4. Have a cumulative GPA of 3.25 or greater in the AME Graduate Program;
5. Declare his/her major and minor in which he/she wishes to be examined;
6. Provide evidence that an AME faculty member has agreed to serve as his/her Ph.D. advisor.

Note for students not yet admitted in the Ph.D. program:
Passing the screening exam does not guarantee admission to the Ph.D. program, as a formal application must be submitted and all conditions must be met as per AME graduate student handbook.

The exam is closed book. Candidates are expected to solve a total of four problems. One problem must be in Applied Mathematics and two problems in the chosen major. The fourth problem is

chosen from the student's selected minor area. The major and minor must be selected from the list of research areas enumerated in bold below; Applied Mathematics *cannot* be chosen either as a major or a minor area. Note that some areas on the list are subdivided but the subdivisions cannot be selected. For example, neither Incompressible Flow nor Compressible Flow is a correct choice. Instead, Fluid Dynamics must be declared. To facilitate preparation, the material covered in the screening exam, for some research areas, is identified below by a relevant AME course number and a typical textbook and/or names of the AME faculty members, who may be contacted for further information.

1. Applied Mathematics (Profs. Campbell, Kanso, Newton, Sadhal, Udwadia)

Complex Variables

- AME 525, Text: "Complex Variables and Applications" by Churchill and Brown.

Linear Algebra

- AME 525, Text: "Linear Algebra" by Shilov.

Differential Equations

- AME 526

2. Combustion (Profs. Egolfopoulos, Ronney, Wang)

- AME 513, Texts: "Combustion" by Glassman; "An Introduction to Combustion" by Turns.
- AME 514
- AME 579

3. Control Theory (Profs. Flashner, Udwadia, Yang)

- AME 451, Text: "Modern Control Engineering" by K. Ogata.
- AME 541, Text: "Linear Systems and Theory" by C.-T. Chen.

4. Design and Manufacturing (Profs. Jin, Lu)

- AME 410
- AME 503
- AME 505

5. Dynamics (Profs. Newton, Udwadia)

- AME 524

6. Elasticity and Solid Mechanics (Prof. Dravinski)

- AME 509, Text: "Deformation of Elastic Solids" by A.K. Mal and S.J. Singh.

7. Fluid Dynamics (Profs. Campbell, Domaradzki, Newton, Pottebaum, Redekopp)

Incompressible Flow

- AME 530a, Text: "Incompressible Flow" by Panton.

Compressible Flow

- AME 511, Text: "Modern Compressible Flow" by Anderson.

Computational Fluid Dynamics

- AME 535a, Text: "Computational Techniques for Fluid Dynamics, Vol. I" by Fletcher.

8. Heat transfer (Profs. Campbell, Ronney, Sadhal)

Conduction

- AME 515, Text: "Heat Conduction" by Ozisik, Ch. 1-4,7-8.

Convection

- AME 516, Text: "Convective Heat Transfer" by Burmeister, Ch. 5.3, 6.1-6.7, 7.1-7.6,

8.1-8.3, 12.1-12.2.

Radiation

- AME 517, Text: "Radiation Heat Transfer" by Siegel & Howell.

9. Materials (Profs. Hodge, Kassner, Langdon, Nutt)

- AME 551
- AME 559

10. Micro-Electro-Mechanical Systems (MEMS) (Profs. Kim, Muntz, Ronney, Sadhal, Shiflett)

- AME 455, Profs. Muntz, Shiflett
- AME 514, weeks 4 - 6, Prof. Ronney
- AME 537, Prof. Sadhal
- EE607, weeks 1-6, 12-14, Prof. Kim; Texts: "Fundamentals of Micro-Fabrication: the Science of Miniaturization" (2nd Ed.) by Marc J. Madou; "Fundamentals and Applications of Microfluidics" by Nguyen & Wereley, Artech House, 2002, Chapters, 1,2,5,6,7,8.

11. Molecular Physics and Rarefied Gas Dynamics (Profs. Muntz, Wang)

Molecular Physics, Prof. Wang; Text: AME579 Lecture Notes.

Rarefied Gas Dynamics

- AME 485, Prof. Muntz
- ASTD 435

12. Planetary and Space Science (Prof. Muntz)

- AME 477
- AME 587

13. Vibrations (Profs. Flashner, Udwadia, Yang)

- AME 420
- AME 521

THE PH.D. QUALIFYING EXAMINATION

It is expected that the Qualifying Exam will be taken no later than one semester following completion of graduate courses or after the completion of 60 units of graduate work, whichever comes first. All portions of the examination must be completed within 60 days.

The written portion of the examination consists of a research proposal and literature search on a topic chosen by the graduate student with the agreement of the potential Ph.D. advisor. The subject of the proposal may or may not be the same as the topic of the Ph.D. dissertation. It is suggested that the student aim at producing a report consisting of 30–50 pages of standard-sized typing, including figures. The typed document should include:

- a statement of the problem under consideration;
- a critical survey of the literature;
- the research goals of the project;
- a research plan;

- a discussion of preliminary results (if applicable).

The student is expected to write the report independently with the minimal input from the advisor. The typed document will be given to the members of the guidance committee at least one week before the scheduled date of the oral examination.

The oral portion of the Ph.D. Qualifying Examination consists of a formal defense of the written report in the presence of the guidance committee. The candidate first makes an oral presentation with appropriate visual aids (slides, viewgraphs, etc.). It is recommended that the candidate plan for a 30–40 minute presentation emphasizing a clear definition of the problem, pertinent related contributions from the literature, proposed problem area to be researched, and proposed approaches to be used in the research. The candidate should give careful attention to the formulation of the research problem and to the scientific bases which motivate various choices underlying the research plan. The presentation is followed by a discussion and question period on the topic of the proposal conducted by the members of the guidance committee. The discussion is aimed at assessing the ability of the candidate to do original research work and to think critically about the implication of results. It is not a defense of a significant fraction of the dissertation research. In the course of the discussion, members of the guidance committee may also choose to test the student's knowledge in his/her major area of research interest. The guidance committee may choose, in individual cases and based on perceived weaknesses in the student's performance, to conduct an oral examination testing mainly the student's knowledge of fundamentals.

FACULTY

All faculty members have Ph.D. degrees in science or engineering. Three are members of the National Academy of Engineering, one is a Fellow of the Royal Academy of Engineering, one is a member of the European Academy of Sciences, and twelve are Fellows of major professional societies.

Ron Blackwelder, Professor; Fellow of APS; experimental fluid mechanics, flight aerodynamics, turbulence

Charles Campbell, Professor; Two-phase flow, flow of granular material, heat transfer, slurry flows, fluidized beds, comminutron, particle fracture

Julian A. Domaradzki, Professor; Fellow of APS; Computational fluid mechanics, turbulence, environmental and geophysical fluid mechanics

Marijan Dravinski, Professor; Propagation and diffraction of elastic waves, geophysical wave propagation, earthquake engineering

Fokion Egolfopoulos, Professor; Aerodynamic and Kinetic Processes in Flames, High-speed air-breathing propulsion, Microgravity Combustion, Mechanisms of Combustion-Generated Pollutants, Heterogeneous Reacting Flows, Conventional and Alternative Fuels, Detailed Modeling of Reacting Flows, Laser-Based Experimental Techniques

Henryk Flashner, Professor; Dynamics and control of systems, control of structurally flexible systems, analysis of nonlinear systems, biomechanics

Roger Ghanem, Professor; Risk assessment and mitigation, computational mechanics and computational stochastic mechanics, dynamics and identification, inverse problems and optimization under uncertainty, multiscale modeling; applications of these to problems in science and engineering

Andrea Hodge, Assistant Professor; Nanomechanics, nanocrystalline materials processing, high temperature mechanics, thin and thick film coatings, biomaterials mechanics, foam processing

Veronica Eliasson, Assistant Professor; Shock wave behavior in gases and liquids, shock wave focusing, shock wave-solid interactions

Yan Jin, Professor; Collaborative engineering, design theory and methods, knowledge-based esign and manufacturing systems, intelligent agents for engineering support

Eva Kanso, Assistant Professor; Dynamical systems, animal hydrodynamic propulsion

Michael E. Kassner, Professor; Fellow of ASM; Metal plasticity theory, creep, fracture, phase diagrams, fatigue, and semi-solid forming

Terence G. Langdon, William E. Leonhard Professor of Engineering, Professor of AME, Materials Science and Earth Sciences,; Fellow of RAE, Member of EAS; Fellow of ASM; Fellow of ACeramS; Fellow of TMS; Fellow of Inst. Phys; Fellow of Inst. Mater.; Honorary Member of JIM; Mechanical properties of metals and ceramics, creep, superplasticity, processing and properties of ultrafine-grained materials, severe plastic deformation

Stephen C.-Y. Lu, David Packard Chair in Manufacturing Engineering (Industrial and Systems Engineering, Computer Science); Collaborative design, innovative product development, manufacturing systems, concurrent engineering, knowledge-based expert systems, AI-based machine learning technologies

Tony Maxworthy, Smith International Professor; Member of NAE; Fellow of APS; Fellow of the American Academy of Arts and Sciences; experiments in aerodynamics, environmental and geophysical fluid mechanics, turbulence, convection, and solidification, bio-fluid dynamics

E. Phil Muntz, Arthur B. Freeman Professor; Member of NAE; Fellow of AIAA; Fellow of APS; hypersonics, gas kinetics and plasmas, high performance materials, micro-mechanical devices, space science

Paul Newton, Professor; theoretical fluid mechanics, nonlinear dynamical systems, waves and stability

Denis Phares, Assistant Professor; Aerosol Mechanics, Aerosol Mass Spectrometry, Atmospheric Aerosols, Microscale Fluid Flow

Tait Pottebaum, Assistant Professor; Convective heat transfer, bluff-body aerodynamics, fluid-structure interactions, microscale fluid flow

Larry Redekopp, Professor; Fellow of APS; theoretical fluid mechanics, nonlinear waves and stability, geophysical fluid dynamics

Paul Ronney, Professor; Combustion, micro-scale power generation and propulsion, biophysics and biofilms, turbulence, internal combustion engines and control systems, low-gravity phenomena, radiative transfer

Satwindar Singh Sadhal, Professor, Fellow ASME; Drops and bubbles in acoustic fields, thermocapillary flows with drops in low gravity, levitation studies, non-contact thermophysical property measurement, fluid flow and heat transfer in microchannels

Geoffrey R. Shiflett, Associate Professor; Kinematics and dynamics of mechanical systems, computer-aided design, optimal design techniques, microelectromechanical systems (MEMS)

Geoff Spedding, Professor; geophysical fluid dynamics, animal aero- and hydro-dynamics, turbulence

Firdaus Udwadia, Professor (Civil Engineering, Systems Architecture Engineering, Mathematics, Information and Operations Management); Fellow of AIAA; Fellow of ASME; Dynamics and control, mechanics and mathematics, collaborative engineering, engineering management, structural dynamics, system identification

Hai Wang, Professor; Combustion chemistry, high-temperature chemical kinetics, soot formation and its effects on climate forcing, nano-material synthesis, characterization and modelling, transport theory of nanomaterials, chemical sensors, catalysis and photocatalysis.

Bingen Yang, Professor; Fellow ASME; Dynamics, vibration and control of mechanical systems, distributed-parameter systems, modeling and control of space structures, computational mechanics

FACULTY OF ENGINEERING PRACTICE

M. Oussama Safadi, Structural Dynamics, finite element, stress analysis, fracture mechanics

EMERITUS FACULTY

Don Shemansky, Professor Emeritus; astrophysics, space science, surface phenomena

Fred Browand, Professor Emeritus; Fellow of APS; experimental fluid mechanics, environmental and geophysical fluid mechanics, flight and transportation aerodynamics, turbulence

RESEARCH FACULTY
Adam Fincham, Research Associate Professor

ASSOCIATED FACULTY WITH PRIMARY APPOINTMENT IN OTHER DEPARTMENTS
Daniel Erwin, Professor (Astronautics and Space Technology Division); advanced propulsion, hypersonics, gas kinetics and plasmas

Mike Gruntman, Professor (Astronautics and Space Technology Division); Astronautics, spacecraft design and space missions, propulsion, space science and instrumentation, gas kinetics and plasmas.

Petros Ioannou, Professor (Electrical Engineering); Control Systems and Applications; Intelligent Transportation Systems; Congestion Control of Computer Networks Bandwidth allocation and control of queues using nonlinear control techniques

Joseph Kunc, Professor (Astronautics and Space Technology Division); Fellow of APS; hypersonics, gas kinetics and plasmas, space science, molecular and radiative processes

Sami Masri, Professor (Civil Engineering); Modeling and control of nonlinear systems, structural health monitoring

Steven R. Nutt, Professor (Materials Science); Fellow of ACeramS; Composite materials, deformation and damage mechanisms of metal- and ceramic-matrix composites, interface structures and defects, electron microscopy

Costas Sioutas, Fred Champion Professor (Civil Engineering); Technologies for measuring physicochemical characteristics of air pollutants, toxic properties, and novel technologies for reducing the emissions of air pollutants Air pollution, aerosol technology, particle sampling, pollution control

Costas Synolakis, Professor (Civil Engineering); computer tomography, free surface hydrodynamics

Abbreviations

AIAA: American Institute of Aeronautics and Astronautics
ACeramS: American Ceramic Society
APS: American Physical Society
ASM: American Society for Materials
ASME: American Society of Mechanical Engineers
EAS: European Academy of Sciences
IAE: Institute for Advancement of Engineering
Inst. Mater.: Institute of Materials (U.K.)

Inst. Phys.: Institute of Physics (U.K.)
NAE: National Academy of Engineering
RAE: Royal Academy of Engineering (U.K.)
TMS: The Minerals, Metals and Materials Society