Mechanical and Aerospace Engineering

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Daniel C.H. Yang, Ph.D.
The Department of Mechanical and Aerospace Engineering offers curricula in aerospace engineering and mechanical engineering at both the undergraduate and graduate levels. The scope of the departmental research and teaching program is broad, encompassing dynamics, fluid mechanics, heat and mass transfer, manufacturing and design, nanoelectromechanical and microelectromechanical systems, structural and solid mechanics, and systems and control. The applications of mechanical and aerospace engineering are quite diverse, including aircraft, spacecraft, automobiles, energy and propulsion systems, robotics, machinery, manufacturing and materials processing, microelectronics, biological systems, and more.

At the undergraduate level, the department offers accredited programs leading to B.S. degrees in Aerospace Engineering and in Mechanical Engineering. At the graduate level, the department offers programs leading to M.S. and Ph.D. degrees in Mechanical Engineering and in Aerospace Engineering. An M.S. in Manufacturing Engineering is also offered.

The mission of the Mechanical and Aerospace Engineering Department is to educate the nation’s future leaders in the science and art of mechanical and aerospace engineering. Further, the department seeks to expand the frontiers of engineering science and to encourage technological innovation while fostering academic excellence and scholarly learning in a collegial environment.

### Undergraduate Program Educational Objectives

The aerospace engineering and mechanical engineering programs are accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

In consultation with its constituents, the Mechanical and Aerospace Engineering Department has set its educational objectives as follows: within a few years after graduation, the students will be successful in careers in aerospace or mechanical or other engineering fields, and/or in graduate studies in aerospace or mechanical or other engineering fields, and/or in further studies in other fields such as medicine, business, and law.

### Undergraduate Study

The Aerospace Engineering and Mechanical Engineering majors are designated capstone majors. Within their capstone courses, Aerospace Engineering students are exposed to the conceptual and design phases for aircraft development and produce a structural design of a component, such as a lightweight aircraft wing. Mechanical Engineering students work in teams in their capstone courses to propose, design, analyze, and build a mechanical or electromechanical device. Graduates of both programs should be able to apply their knowledge of mathematics, science, and engineering in technical systems; design a system, component, or process to meet desired needs; function as productive members of a team; identify, formulate, and solve engineering problems; and communicate effectively, both orally and in writing.

### Aerospace Engineering B.S. Capstone Major

The aerospace engineering program is concerned with the design and construction of various types of fixed-wing and rotary-wing (helicopters) aircraft used for air transportation and national defense. It is also concerned with the design and construction of spacecraft, the exploration and utilization of space, and related technological fields. Aerospace engineering is characterized by a very high level of technology. The aerospace engineer is likely to operate at the forefront of scientific discoveries, often stimulating these discoveries and providing the inspiration for the creation of new scientific concepts. Meeting these demands requires the imaginative use of many disciplines, including fluid mechanics and aerodynamics, structural mechanics, materials and aeroelasticity, dynamics, control and guidance, propulsion, and energy conversion.

### Preparation for the Major

**Required:** Chemistry and Biochemistry 20A, 20B, 20L; Mathematics 31A, 31B, 32A, 32B, 33A; Mechanical and Aerospace Engineering M20 (or Computer Science 31), 82; Physics 1A, 1B, 1C, 4AL, 4BL.

### The Major

**Required:** Mechanical and Aerospace Engineering 101, 102, 103, 105A, 107, 150A, 150B, C150R, C150R or 161A, 154S, 157A, 157S, 166A, 171A; two departmental breadth courses (Electrical and Computer Engineering 100 and Materials Science and Engineering 104) —if one or both of these courses are taken as part of the technical breadth requirement, students must select a replacement upper-division course or courses from the department—except for Mechanical and Aerospace Engineering 155A—or, by petition, from outside the department); three technical breadth courses (12 units) selected from an approved list available in the Office of Academic and Student Affairs; two capstone design courses (Mechanical and Aerospace Engineering 154A, 154B); and two major field elective courses (8 units) from Mechanical and Aerospace Engineering 94, 105D, 131A, C132A, 133A, 135, 136, C137, CM140, CM141, 150C, C150G, C150R (unless taken as a required course), 153A, 155, C156B, 161A (unless taken as a required course), 161B, 161C, 161D, 162A, 166C, M168, 169A, 171B, 172, 174, C175A, 181A, 182B, 182C, 183A, M183B, C183C, 184, 185, C186, C187L.

For information on University and general education requirements, see Requirements for B.S. Degrees on page 21 or http://www.registrar.ucla.edu/Academics/GE-Requirement.

### Mechanical Engineering B.S. Capstone Major

The mechanical engineering program is designed to provide basic knowledge in thermodynamics, fluid mechanics, heat transfer, solid mechanics, mechanical design, dynamics, control, mechanical systems, manufacturing, and materials. The program includes fundamental subjects important to all mechanical engineers.

### Preparation for the Major

**Required:** Chemistry and Biochemistry 20A, 20B, 20L; Mathematics 31A, 31B, 32A, 32B, 33A; Mechanical and Aerospace Engi-
neering M20 (or Computer Science 31), 82, 94; Physics 1A, 1B, 1C, 4AL, 4BL.

The Major
Required: Electrical and Computer Engineering 110L, Mechanical and Aerospace Engineering 101, 102, 103, 105A, 105D, 107, 131A or 133A, 156A, 157, 162A, 171A, 183A (or M183B); two departmental breadth courses (Electrical and Computer Engineering 100 and Materials Science and Engineering 104—if one or both of these courses are taken as part of the technical breadth requirement, students must select a replacement upper-division course or courses from the department—except for Mechanical and Aerospace Engineering 166A—or, by petition, from outside the department); three technical breadth courses (12 units) selected from an approved list available in the Office of Academic and Student Affairs; two capstone design courses (Mechanical and Aerospace Engineering 162D, 162E); and two major field elective courses (8 units) from Mechanical and Aerospace Engineering 131A (unless taken as a required course), C132A, 133A (unless taken as a required course), 135, 136, C137, CM140, CM141, 150A, 150B, 150C, C150G, C150P, C150R, 153A, 154S, 155, C156B, 157A, 161A through 161D, 166C, M168, 169A, 171B, 172, 174, C175A, 181A, 182B, 182C, 183A (unless taken as a required course), M183B (unless taken as a required course), C183C, 184, 185, C186, C187L.

For information on University and general education requirements, see Requirements for B.S. Degrees on page 21 or http://www.registrar.ucla.edu/Academics/GE-Requirement.

Graduate Study
For information on graduate admission, see Graduate Programs, page 25.

The following introductory information is based on the 2017-18 edition of Program Requirements for UCLA Graduate Degrees. Complete annual editions of Program Requirements are available at https://grad.ucla.edu. Students are subject to the degree requirements as published in Program Requirements for the year in which they enter the program.

The Department of Mechanical and Aerospace Engineering offers the Master of Science (M.S.) degree in Manufacturing Engineering, Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) degrees in Aerospace Engineering, and Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) degrees in Mechanical Engineering. All new M.S. and Ph.D. students who are pursuing an M.S. degree in the Mechanical and Aerospace Engineering Department must meet with their advisers in their first term at UCLA. The goal of the meeting is to discuss the students’ plans for satisfying the M.S. degree requirements. Students should obtain an M.S. planning form from the department Student Affairs Office and return it with their advisers’ signature by the end of the first term.

Aerospace Engineering M.S. and Mechanical Engineering M.S.

Course Requirements
Students may select either the thesis plan or comprehensive examination plan. At least nine courses (and 36 units) are required, of which at least five must be graduate courses. In the thesis plan, seven of the nine must be formal courses, including at least four from the 200 series. The remaining two may be 598 courses involving work on the thesis. In the comprehensive examination plan, no units of 500-series courses may be applied toward the minimum course requirement. Courses taken before the award of the bachelor’s degree may not be applied toward a graduate degree at UCLA. The courses should be selected so that the breadth requirements and the requirements at the graduate level are met. The breadth requirements are only applicable to students who do not have a B.S. degree from an ABET-accredited aerospace or mechanical engineering program.

Undergraduate Courses. No lower-division courses may be applied toward graduate degrees. In addition, the following upper-division courses are not applicable toward graduate degrees: Chemical Engineering 102A, 199, Civil and Environmental Engineering 108, 199, Computer Science M152A, 152B, M171L, 199, Electrical and Computer Engineering 100, 101A, 102, 103, 110L, M116L, M171L, 199, Materials Science and Engineering 110, 120, 130, 131, 131L, 132, 140, 141L, 150, 160, 161L, 199, Mechanical and Aerospace Engineering 101, 102, 103, 105A, 105D, 107, 188, 194, 199.

Aerospace Engineering
Breadth Requirements. Students are required to take at least three courses from the following four categories: (1) Mechanical and Aerospace Engineering 154A or 154B or 154S, (2) 150B or C150P, (3) 155 or 166A or 169A, (4) 161A or 171A.

Mechanical Engineering
Breadth Requirements. Students are required to take at least three courses from the following five categories: (1) Mechanical and Aerospace Engineering 162A or 169A or 171A, (2) 150A or 150B, (3) 131A or 133A, (4) 156A, (5) 162D or 183A.

Comprehensive Examination Plan
The comprehensive examination is required in either written or oral form. A committee of at least three faculty members, with at least two members from within the department, and chaired by the academic adviser, is
established to administer the examination. Students may, in consultation with their adviser and the M.S. committee, select one of the following options for the comprehensive examination: (1) take and pass the first part of the Ph.D. written qualifying examination (formerly referred to as the preliminary examination) as the comprehensive examination, (2) conduct a research or design project and submit a final report to the M.S. committee, or (3) take and pass three comprehensive examination questions offered in association with three mechanical and aerospace engineering graduate courses. Contact the department Student Affairs Office for more information.

**Thesis Plan**

The thesis must describe some original piece of research that has been done under the supervision of the thesis committee. Students should normally start to plan the thesis at least one year before the award of the M.S. degree is expected. There is no examination under the thesis plan.

**Manufacturing Engineering M.S.**

**Areas of Study**

Consult the department.

**Course Requirements**

Students may select either the thesis plan or comprehensive examination plan. At least nine courses (and 36 units) are required, of which at least five must be graduate courses. In the thesis plan, seven of the nine must be formal courses, including at least four from the 200 series. The remaining two may be 598 courses involving work on the thesis. In the comprehensive examination plan, no units of 500-series courses may be applied toward the minimum course requirement. Courses taken before the award of the bachelor's degree may not be applied toward a graduate degree at UCLA. Choices may be made from the following major areas:

- **Upper-Division Courses.** Students are required to take at least three courses from the following: Mechanical and Aerospace Engineering M168, 174, 183A, 184, 185.
- **Graduate Courses.** Students are required to take at least three courses from the following: Mechanical and Aerospace Engineering 263A, 263C, 263D, C206A, M297C.

**Additional Courses.** The remaining courses may be taken from other major fields of study in the department or from the following: Architecture and Urban Design 227D, Computer Science 241B, Management 240A, 241A, 241B, 242A, 243B, Management-PhD 241A, 241B, Mathematics 120A, 120B.

**Comprehensive Examination Plan**

The comprehensive examination is required in either written or oral form. A committee of at least three faculty members, with at least two members from within the department, and chaired by the academic adviser, is established to administer the examination. Students may, in consultation with their adviser and the M.S. committee, select one of the following options for the comprehensive examination: (1) take and pass the first part of the Ph.D. written qualifying examination (formerly referred to as the preliminary examination) as the comprehensive examination, (2) conduct a research or design project and submit a final report to the M.S. committee, or (3) take and pass three comprehensive examination questions offered in association with three graduate courses. Contact the department Student Affairs Office for more information.

**Thesis Plan**

The thesis must describe some original piece of research that has been done under the supervision of the thesis committee. Students would normally start to plan the thesis at least one year before the award of the M.S. degree is expected. There is no examination under the thesis plan.

**Aerospace Engineering Ph.D. and Mechanical Engineering Ph.D.**

**Major Fields or Subdisciplines**

Dynamics; fluid mechanics; heat and mass transfer; design, robotics, and manufacturing (mechanical engineering only); nanoelectromechanical/microelectromechanical systems (NEMS/MEMS); structural and solid mechanics; systems and control.

Ph.D. students may propose ad hoc major fields, which must differ substantially from established major fields and satisfy one of the following two conditions: (1) the field is interdisciplinary in nature or (2) the field represents an important research area for which there is no established major field in the department (condition 2 most often applies to recently evolving research areas or to areas for which there are too few faculty members to maintain an established major field). Students in an ad hoc major field must be sponsored by at least three faculty members, at least two of whom must be from the department.

**Course Requirements**

The basic program of study for the Ph.D. degree is built around major and minor fields. The established major fields are listed above, and a detailed syllabus describing each Ph.D. major field can be obtained from the Student Affairs Office.

The program of study for the Ph.D. requires students to perform original research leading to a doctoral dissertation and to master a body of knowledge that encompasses material from their major field and breadth material from outside the major field. The body of knowledge should include (1) six major field courses, at least four of which must be graduate courses, (2) one minor field, (3) any three additional courses, at least two of which must be graduate courses, that enhance the study of the major or minor field.

The major field syllabus advises students as to which courses contain the required knowledge, and students usually prepare for the written qualifying examination (formerly referred to as the preliminary examination) by taking these courses. However, students can acquire such knowledge by taking similar courses at other universities or even by self-study.

The minor field embraces a body of knowledge equivalent to three courses, at least two of which must be graduate courses. Minor fields are often subsets of major fields, and minor field requirements are then described in the syllabus of the appropriate major field. Established minor fields with no corresponding major field can also be used, such as applied mathematics and applied plasma physics and fusion engineering. Also, an ad hoc field can be used in exceptional circumstances, such as when certain knowledge is desirable for a program of study that is not available in established minor fields. Grades of B– or better, with a grade-point average of at least 3.33 in all courses included in the minor field, and the three additional courses mentioned above are required. If students fail to satisfy the minor field requirements through coursework, a
minor field examination may be taken (once only).

Written and Oral Qualifying Examinations
After mastering the body of knowledge defined in the major field, students take a written qualifying (preliminary) examination covering this knowledge. Students must have been formally admitted to the Ph.D. program or admitted subject to completion of the M.S. degree by the end of the term following the term in which the examination is given. The examination must be taken within the first two calendar years from the time of admission into the Ph.D. program. Students must be registered during the term in which the examination is given and be in good academic standing (minimum GPA of 3.25). The student’s major field proposal must be completed prior to taking the examination. Students may not take an examination more than twice. Students in an ad hoc major field must pass a written qualifying examination that is approximately equivalent in scope, length, and level to the written qualifying examination for an established major field. After passing the written qualifying examination, students take the University Oral Qualifying Examination within four calendar years from the time of admission into the Ph.D. program. The nature and content of the examination are at the discretion of the doctoral committee but include a review of the dissertation prospectus and may include a broad inquiry into the student’s preparation for research. Note: Doctoral Committees. A doctoral committee consists of a minimum of four members. Three members, including the chair, are inside members and must hold appointments in the department. The outside member must be a UCLA faculty member in another department.

Fields of Study

Design, Robotics, and Manufacturing
The program is developed around an integrated approach to design, robotics, and manufacturing. It includes research on manufacturing and design aspects of mechanical systems, material behavior and processing, robotics and manufacturing systems, CAD/CAM theory and applications, computational geometry and geometrical modeling, composite materials and structures, automation and digital control systems, microdevices and nanodevices, radio frequency identification (RFID), and wireless systems.

Dynamics
Features of the dynamics field include dynamics and control of physical systems, including spacecraft, aircraft, helicopters, industrial manipulators; analytical studies of control of large space structures; experimental studies of electromechanical systems; and robotics.

Fluid Mechanics
The graduate program in fluid mechanics includes experimental, numerical, and theoretical studies related to a range of topics in fluid mechanics, such as turbulent flows, hypersonic flows, microscale and nanoscale flow phenomena, aeroacoustics, biofluid mechanics, chemically reactive flows, chemical reaction kinetics, numerical methods for computational fluid dynamics (CFD), and experimental methods. The educational program for graduate students provides a strong foundational background in classical incompressible and compressible flows, while providing elective breadth courses in advanced specialty topics such as computational fluid dynamics, microfluidics, biofluid mechanics, hypersonics, reactive flow, fluid stability, turbulence, and experimental methods.

Heat and Mass Transfer
The heat and mass transfer field includes studies of convection, radiation, conduction, evaporation, condensation, boiling and two-phase flow, chemically reacting and radiating flow, instability and turbulent flow, reactive flows in porous media, as well as transport phenomena in support of micro-scale and nanoscale thermosciences, energy, bioMEMS/NEMS, and microfabrication/nanofabrication.

Nanoelectromechanical/Microelectromechanical Systems
The nanoelectromechanical/microelectromechanical systems (NEMS/MEMS) field focuses on science and engineering issues ranging in size from nanometers to millimeters and includes both experimental and theoretical studies covering fundamentals to applications. The study topics include microscience, top-down and bottom-up nanofabrication/microfabrication technologies, molecular fluidic phenomena, nanoscale/microscale material processing, biomolecular signatures, heat transfer at the nanoscale, and system integration. The program is highly interdisciplinary in nature.

Structural and Solid Mechanics
The solid mechanics program features theoretical, numerical, and experimental studies, including fracture mechanics and damage tolerance, micromechanics with emphasis on technical applications, wave propagation and nondestructive evaluation, mechanics of composite materials, mechanics of thin films and interfaces, analysis of coupled electro-magneto-thermomechanical material systems, and ferroelectric materials. The structural mechanics program includes structural dynamics with applications to aircraft and spacecraft, fixed-wing and rotary-wing aeroelasticity, fluid structure interaction, computational transonic aeroelasticity, biomechanics with applications ranging from whole organs to molecular and cellular structures, structural optimization, finite element methods and related computational techniques, structural mechanics of composite material components, structural health monitoring, and analysis of adaptive structures.

Systems and Control
The program features systems engineering principles and applied mathematical methods of modeling, analysis, and design of continuous- and discrete-time control systems. Emphasis is on modern applications in engineering, systems concepts, feedback and control principles, stability concepts, applied optimal control, differential games, computational methods, simulation, and computer process control. Systems and control research and education in the department cover a broad spectrum of topics primarily based in aerospace and mechanical engineering applications. However, the Chemical and Biomolecular Engineering and Electrical and Computer Engineering Departments also have active programs in control systems, and collaboration across departments among faculty members and students in both teaching and research is common.

Ad Hoc Major Fields
The ad hoc major fields program has sufficient flexibility that students can form academic major fields in their area of interest if the proposals are supported by several faculty members. Previous fields of study included acoustics, system risk and reliability, and engineering thermodynamics. Nuclear science and engineering, a former active major field, is available on an ad hoc basis only.

Centers, Facilities, and Laboratories
The Mechanical and Aerospace Engineering Department has a number of experimental centers, facilities, and laboratories at which both fundamental and applied research is

**Active Materials Laboratory**

Gregory P. Carman, Director
The Active Materials Laboratory contains equipment to evaluate the coupled response of materials such as piezoelectric, magnetostrictive, shape memory alloys, and fiber-optic sensors. The laboratory has manufacturing facilities to fabricate magnetostrictive composites and thin film shape memory alloys. Testing active material systems is performed on one of four servo-hydraulic load frames in the lab. All of the load frames are equipped with thermal chambers, solenoids, and electrical power supplies.

**Autonomous Vehicle Systems Instrumentation Laboratory**

Jason L. Speyer, Director
The Autonomous Vehicle Systems Instrumentation Laboratory (AVSIL) is a testbed at UCLA for design, building, evaluation, and testing of hardware instrumentation and coordination algorithms for multiple autonomous systems. AVSIL contains a hardware-in-the-loop (HIL) simulator—designed and built at UCLA—that allows for real-time, systems-level tests of two formation control computer systems in a laboratory environment, using the Interstate Electronics Corporation GPS Satellite Constellation Simulator. The UCLA flight control software can be modified to accommodate satellite-system experiments using real-time software, GPS receivers, and inter-vehicle modern communication.

**Beam Control Laboratory**

James S. Gibson, Director
The Beam Control Laboratory involves students, faculty, and postdoctoral researchers to develop novel methods for laser-beam control in applications including directed energy systems and laser communications. Algorithms developed at UCLA for adaptive and optimal control and filtering, as well as system identification, are being used in adaptive optics and beam steering. UCLA high-bandwidth controllers correct both higher-order wavefront errors and tilt jitter to levels not achievable by classical beam control methods.

**Biomechatronics Laboratory**

Veronica J. Santos, Director
The Biomechatronics Laboratory is dedicated to improving quality of life by enhancing the functionality of artificial hands and their control in human-machine systems.

The research is advancing the design and control of human-machine systems as well as autonomous robotic systems. Current research projects involve human biomechanics, tactile sensing, control of robotic systems, and machine learning.

**Bionics Laboratory**

Jacob Rosen, Director
The Bionics Laboratory performs research at the interface between robotics, biological systems, and medicine. Primary research fields are medical robotics and biorobotics including surgical robotics, and wearable robotics as they apply to human motor control, neural control, human- and brain-machine interfaces, motor control (stroke) rehabilitation, brain plasticity, haptics, virtual reality, tele-operation, and biomechanics (full-body kinematics and dynamics, and soft/hard tissues biomechanics).

**Boiling Heat Transfer Laboratory**

Vijay K. Dhir, Director
The Boiling Heat Transfer Laboratory performs experimental and computational studies of phase-change phenomena. It is equipped with various flow loops, state-of-the-art data acquisition systems, holography, high-speed imaging systems, and a gamma densitometer.

**Center for Advanced Multifunctional Materials and Systems (CAMMS)**

Christopher S. Lynch, Director
CAMMS is involved in all aspects of multifunctional (smart) materials characterization, modeling, and applications. Materials are characterized under combined mechanical, thermal, electrical, and magnetic loading. Constitutive laws are developed that govern domain switching and phase transformations. Component-level applications include miniature solid-state piezoelectric pumps; morphing piezocomposite actuators; and nanoscale magneto-electric memory, antenna, and motors. Systems-level applications (team projects) include controlled optics for deep-space observing satellites, ultra-low-frequency magneto-mechanical antennas, morphing aircraft structures, and next-generation computer memory.

**Center for Translational Applications of Nanoscale Multiferroic Systems (TANMS)**

Gregory P. Carman, Director
The Center for Translational Applications of Nanoscale Multiferroic Systems (TANMS) is a multi-institutional engineering research center (ERC) focused on research, technology translation, and education associated with magnetism on the small scale. The TANMS vision is to develop a fundamentally new approach that couples electricity to magnetism using engineered nanoscale multiferroic elements, to enable increased energy efficiency, reduced physical size, and increased power output in consumer electronics. This new approach overcomes scaling limitations present in current electronics, providing the potential for advances in consumer devices and electronics.

**Chen Research Group**

Yong Chen, Director

**Collaborative Center for Aerospace Sciences (CCAS)**

Ann R. Karagozian, Director
The Collaborative Center for Aerospace Sciences (CCAS) is a multi-disciplinary research center focused on fundamental and applied basic studies relevant to aerospace systems. Research projects that broadly span the computational and experimental arenas are conducted at UCLA and at Air Force Research Laboratory (AFRL/RQ) at Edwards Air Force Base northeast of campus. UCLA faculty, students, and postdoctoral researchers collaborate with AFRL scientists and engineers on high-impact problems to advance U.S. capabilities in aerospace systems.

**Complex Fluids and Interfacial Physics Laboratory**

H. Pirouz Kavehpour, Director
The Complex Fluids and Interfacial Physics Laboratory is multidisciplinary, with areas of research ranging from rheology of biofluids to energy storage. The group is directed towards development of fundamental engineering and scientific knowledge.

**Cybernetic Control Laboratory**

Tetsuya Iwasa, Director
The Cybernetic Control Laboratory (CyCLab) aims to develop biologically inspired control theories for rhythmic movements and dynamic pattern formation with applications...
Design and Manufacturing Laboratory
The Design and Manufacturing Laboratory offers an environment for synergistic integration of design and manufacturing. Available equipment includes four CNC machines, two rapid-prototyping systems, coordinate measuring, X-ray radiography, robots with vision systems, audiovisual equipment, and a distributed network of more than 30 workstations.

Energy and Propulsion Research Laboratory
Ann R. Karagozian, Director
The Energy and Propulsion Research Laboratory involves the application of modern diagnostic methods and computational tools to the development of improved combustion, propulsion, and fluid flow systems. Research includes aspects of fluid mechanics, chemistry, optics, and numerical methods, as well as thermodynamics and heat transfer.

Flexible Research Group
Jonathan B. Hopkins, Director
The Flexible Research Group is dedicated to the design and fabrication of flexible structures, mechanisms, and materials that achieve extraordinary capabilities. The laboratory is equipped with state-of-the-art synthesis tools, optimization software, and a number of commercial and custom-developed additive fabrication technologies for fabricating complex flexible structures at the macro- to nano-scale.

Fusion Science and Technology Center
Mohamed A. Abdou, Director
The Fusion Science and Technology Center includes experimental facilities for conducting research in fusion science and engineering, and multiple scientific disciplines in thermonuclear fusion, thermonuclear fusion, heat/mass transfer, and materials interactions. The center includes experimental facilities for liquid metal magnetohydrodynamic fluid flow, thick and thin liquid metal systems exposed to intense particle and heat flux loads, and metallic and ceramic material thermomechanics.

Ho Systems Laboratory—Personalized Medicine
Chih-Ming Ho, Director
The Ho Systems Laboratory—Personalized Medicine researches phenotypic personalized medicine (PPM). It has discovered that drug-dose inputs are correlated with phenotypic outputs with a parabolic response surface (PRS). With a few calibration tests to determine the coefficients of its quadratic governing algebraic equation, PRS dictates the composition and ratio of a globally optimized drug combination. Based on the PRS platform, phenotypic personalized medicine (PPM) can realize unprecedented adaptability to identify the optimized drug combination for a specific patient. PRS is an indication-agnostic and mechanism-free platform technology, which has been successfully demonstrated in about 30 diseases.

Hu Research Laboratory (H-Lab)
Yongjie Hu, Director
The H-Lab research group is focused on understanding and engineering nanoscale transport phenomena and nanomaterials for wide applications including energy conversion, storage, and thermal management. The lab uses a variety of experimental and theoretical techniques to investigate nanoscale transport processes, with a particular emphasis on design and chemical synthesis of advanced materials, ultrafast optical spectroscopy, pulsed electronics, and thermal spectral mapping techniques.

Laser Spectroscopy and Gas Dynamics Laboratory
Raymond M. Spearrin, Director
The Laser Spectroscopy and Gas Dynamics Laboratory conducts research driven by applications in propulsion and energy, with extensions to health and environment. Lab activities are united by a core focus in experimental thermonuclear fusion and applied spectroscopy. Projects commonly span fundamental spectroscopy science to design and deployment of prototype sensors to investigate dynamic flow-fields.

Materials Degradation Characterization Laboratory
Ajit K. Mal, Director
The Materials Degradation Characterization Laboratory is used for characterization of the degradation of high-strength metallic alloys and advanced composites due to corrosion and fatigue, determination of adverse effects of materials degradation on the strength of structural components, and research on fracture mechanisms and ultrasonic nondestructive evaluation.

Mechanics of Soft Materials Laboratory
LiHua Jin, Director
The Mechanics of Soft Materials Laboratory investigates the fundamental physics and mechanics of soft materials, such as their constitutive relation, nonlinear deformation, instability, and fracture. The lab also strives to develop new materials, structures, and functions for soft robotics and stretchable electronics.

Mechatronics and Controls Laboratory
Tsu-Chin Tsao, Director
The Mechatronics and Controls Laboratory develops miniature, high-performance angular-rate sensors called vibratory gyroscopes. A separate long-term project seeks to understand the mixing dynamics of a jet injected into a crossflow.
The Mechatronics and Controls Laboratory conducts research in theory and innovation in dynamic systems, controls, mechatronics, and robotics. It creates high-performance systems with novel sensors, actuators, and real-time digital signal processing and embedded control. Applications include precision motion and vibration control, manufacturing equipment and processes, medical devices, and robots.

**Micro- and Nano-Manufacturing Laboratory**
Chang-Jin (CJ) Kim, Director
The Micro- and Nano-Manufacturing Laboratory is equipped with a fume hood, clean air bench, optical table, DI water generator, plating setup, probe station, various microscopes, test and measurement systems, and CAD programs for mask layout. It is used for micromachining and MEMS research, and complements the HSSEAS Nanoelectronics Research Facility.

**Modeling of Complex Thermal Systems Laboratory**
Adrienne G. Lavine, Director
The Modeling of Complex Thermal Systems Laboratory addresses a variety of systems in which heat transfer plays an important role. Thermal aspects of these systems are coupled with other physical phenomena such as mechanical or electrical behavior. Modeling tools range from analytical to custom computer codes to commercial software.

**Morrin-Gier-Martinelli Heat Transfer Memorial Laboratory**
Laurent G. Pilon, Director
The Morrin-Gier-Martinelli Heat Transfer Memorial Laboratory is shared between professors Catton and Pilon. It is used for investigating single- and two-phase convective heat transfer in energy applications, various aspects of radiation transfer in biological systems, and material synthesis and characterization. It is equipped with optical tables, lasers, FTIR, photomultiplier tubes, monochromators, nanosecond pulse diodes, lock-in amplifiers, spectrophotometers, light guides, fiber optics, lenses, and polarizers. It also has various flow loops, a wind tunnel, and a particle image velocimetry (PIV) system. For material synthesis, the lab is equipped with two high-temperature furnaces, a spin coater, a dip-coating system, and UV curing lamps. The lab can perform optical, thermal, and electrical material characterization using a guarded hot plate thermal conductivity analyzer, a 3-omega method system for thin film thermal conductivity, a normal-normal reflection probe, and an in-house electrical system for measuring dielectric constant and the q-V curve of ferroelectric materials.

**Multiscale Thermosciences Laboratory (MTSL)**
Y. Sungtaek Ju, Director
The Multiscale Thermosciences Laboratory (MTSL) is focused on heat and mass transfer phenomena at the nano- to macro-scales. A wide variety of applications are explored, including novel materials and devices for energy conversion; combined cooling, heating, and power generation; thermal management of electronics and buildings; energy-water nexus; and biomedical MEMS/NEMS devices.

**Nanoscale Transport Research Group**
Timothy S. Fisher, Director
The Nanoscale Transport Research Group works on a broad range of problems, primarily involving transport processes by electrons, phonons, photons, and fluids. It seeks to solve problems with high importance to applications in energy transport, conversion, and storage, that are relevant to major industrial segments (aerospace, micro/nanoelectronics, and sensors). The lab solves these problems through a holistic, balanced approach that spans nanomaterial synthesis, basic material characterization and modeling, and functional characterization and simulation. The group includes the Center for Integrated Thermal Management of Aerospace Vehicles (CITMAV), which develops new solutions to highly transient transport problems that occur in aerospace applications.

**Optofluids Systems Laboratory**
Pei-Yu Chiou, Director
The Optofluids Systems Laboratory develops heterogeneously integrated functional devices and systems for biomedical applications. Research areas include integrated photonics and fluidics devices; 3D micro- and nano-manufacturing technologies; and flexible mechanical, photonics, and electronics systems.

**Pilon Research Group**
Laurent G. Pilon, Director
The Pilon Research Group researches photobiological fuel production, mesoporous materials, electrochemical capacitors, waste heat energy harvesting, foams/microfoams, biomedical optics, and energy efficiency.

**Plasma and Beam Assisted Manufacturing Laboratory**
The Plasma and Beam Assisted Manufacturing Laboratory is an experimental facility for processing and manufacturing advanced materials by high-energy means (plasma and beam sources). It is equipped with plasma diagnostics, two vortex gas tunnel plasma guns, powder feeder and exhaust systems, vacuum and cooling equipment, high-power DC supplies (400kw), vacuum chambers, and large electromagnets. Current research is focused on ceramic coatings and nanophase clusters for applications in thermal insulation, wear resistance, and high-temperature oxidation resistance.

**Plasma and Space Propulsion Laboratory**
Richard E. Wirz, Director
The Plasma and Space Propulsion Laboratory investigates plasma processes related to advanced space propulsion systems using a combination of experimental, computational, and analytical perspectives. Its research is directly inspired by the rapidly emerging field of electric propulsion (EP). Other applications of its work include microplasmas, plasma processing, and fusion.

**Robotics and Mechanisms Laboratory**
Dennis W. Hong, Director
The Robotics and Mechanisms Laboratory (RoMeLa) is a facility for robotics research and education with an emphasis on studying humanoid robots and novel mobile robot locomotion strategies. Research is in the areas of robot locomotion and manipulation, soft actuators, platform design, kinematics and mechanisms, and autonomous systems. RoMeLa is active in research-based international robotics competitions, winning numerous prizes including third place in the DARPA Urban Challenge. The laboratory also took first place in the RoboCup International autonomous robot soccer competition (kid-size and adult-size humanoid divisions), and was world champion five times in a row. It also brought the prestigious Louis Vuitton Cup Best Humanoid award to the U.S. for the first time, and most recently was one of six Track A teams chosen to participate in the DARPA Robotics Challenge disaster response robot competition.

**Scifacturing Laboratory**
Xiaochun Li, Director
The Scifacturing Laboratory furnishes a creative, interdisciplinary platform for science-driven manufacturing (scifacturing) as the...
next level of manufacturing. It seeks to enable application of physics and chemistry to empower breakthroughs in manufacturing. The laboratory links molecular, nano-, and micro-scale knowledge to scalable processes/systems in manufacturing and materials processing. Current focus areas include scale-up nanomanufacturing, solidification nanomanufacturing of super-materials with dense nanoparticles, structurally integrated micro- and nano-systems (especially sensors and actuators) for manufacturing, clean energy and biomedical manufacturing, meso/micro 3D printing, and laser materials processing.

**Smart Grid Energy Research Center (SMERC)**

Rajit Gadh, Director

The Smart Grid Energy Research Center (SMERC) performs research; creates innovations; and demonstrates advanced Internet-of-things, sense-and-control technologies, and data-enabled machine learning to enable development of the next-generation electric utility grid—the smart grid. SMERC also provides thought leadership through its ESmart Consortium between utilities, government, policy makers, technology providers, electric vehicle manufacturers, energy technology companies, Department of Energy research labs, and universities, so as to collectively work on envisioning, planning, and executing the smart grid of the future. The grid will allow for integration of renewable energy sources. It will also reduce losses; improve efficiencies; increase grid flexibility; reduce power outages; allow for competitive electricity pricing; allow for integration of electric and autonomous vehicles; and overall become more responsive to market, consumer, and societal needs. SMERC is currently working electric vehicle integration (G2V and V2G), automated demand response (ADR), microgrids, distributed energy resources, renewable integration, battery energy storage integration, and autonomous vehicle infrastructure.

**Simulations of Flow Physics and Acoustics Laboratory (SOFIA)**

Jeffrey D. Eldredge, Director

The Simulations of Flow Physics and Acoustics (SOFIA) Laboratory explores a wide variety of phenomena that occur in fluid flows in nature and technology. It investigates low-order modeling of unsteady aerodynamics of agile, bio-inspired, micro-air vehicles; micro-particle manipulation by viscous streaming; the fluid dynamics of biological and biologically-inspired locomotion; interactions of fluid flows with flexible surfaces; transitional and turbulent hypersonic boundary layer flows; vortex estimation techniques for autonomous control of formation flight; and new computational tools for simulation of biomedical flows.

**Turbulence Research Group**

J. John Kim, Director

The Turbulence Research Group is primarily focused on the study of turbulence and stability. It has a long history of studying incompressible flow, and has recently begun studying compressible flow problems. All its work is carried out numerically with computational fluid dynamic (CFD) codes, which are written in-house. Its current research interests include real gas effects on compressible turbulent boundary-layer flow, drag reduction through the use of superhydrophobic surfaces on incompressible turbulent boundary-layer flow, and the effects of distributed roughness on compressible turbulent boundary-layer flows.

**Faculty Areas of Thesis Guidance**

**Professors**

Mohamed A. Abdou, Ph.D. (U. Wisconsin, 1973)

Fusion, nuclear, and mechanical engineering design, testing, and system analysis, atmospheric mechanics; thermal hydraulics; fluid dynamics, heat, and mass transfer in the presence of magnetic fields (MHD flows); neutronics; radiation transport; plasma-material interactions; blankets and high heat flux components; experiments, modeling and analysis

Gregory P. Carman, Ph.D. (Virginia Tech, 1991)

Electromagnetoelasticity models including micromagnetics, elastodynamics, and Maxwell coupled solutions. Characterization of piezo-electric ceramics, magnetostriuctive shape memory alloys, and multiferroic materials.

Yong Chen, Ph.D. (U.C Berkeley, 1996)

Nanoscale science and engineering, micro- and nano-fabrication, self-assembly phenomena, microscale and nanoscale electronic, mechanical, optical, biological, and sensing devices, circuits and systems

Pei-Yu Chiu, Ph.D. (U.C Berkeley, 2005)

BioMEMS, biophotonics, electrokinetics, optical manipulation, optoelectronic devices

Vijay K. Dhir, Ph.D. (U. Kentucky, 1972)

Two-phase heat transfer, boiling and condensation, thermal hydraulics of nuclear reactors, microgravity heat transfer, soil remediation, high-power density electronic cooling

Jeffrey D. Eldredge, Ph.D. (Caltech, 2002)

Numerical simulations of fluid dynamics, bio-inspired locomotion in fluids, transition and turbulence of high-speed flows, aerodynamically generated sound, vortex-based numerical methods, simulations of biomedical flows

Timothy S. Fisher, Ph.D. (Cornell, 1998)

Heat and mass transfer, interfacial transport, nanomaterial synthesis, nano-/micro-device fabrication, non-equilibrium thermodynamics, subcontinuum modeling and measurements of heat and charge transfer, electrochemical and thermal energy storage, mechanics and transport in granular materials and porous media, plasma science and technology, aerospace thermal systems


Smart grid, electric vehicle and grid integration, microgrid, distributed energy resource, solar- and renewable-grid integration, demand response, autonomous electric vehicle, machine learning from transportation data, radio frequency identification (RFID), Internet of things

Nasr M. Ghoniem, Ph.D. (U. Wisconsin, 1977)

Mechanics of materials in severe environments (nuclear, aerospace, transportation); radiation interaction with materials (e.g., laser, ions, plasma, electrons, and neutrons); multiscale modeling; physics and mechanics of material defects; fusion energy; materials for space propulsion

James S. Gibson, Ph.D. (U. Texas Austin, 1975)

Control and identification of dynamical systems; optimal and adaptive control of distributed systems, including flexible structures and fluid flows; adaptive filtering, identification, and noise cancellation

Vijay Gupta, Ph.D. MIT, 1989

Experimental mechanics, fracture of engineering solids, mechanics of thin film and interfaces, failure mechanisms and characterization of composite materials, ice mechanics

Dennis W. Hong, Ph.D. (Purdue, 2002)

Analysis and visualization of contact force solutions for multi-limbed mobile robots

Tetsuya Iwasaki, Ph.D. (Purdue, 1993)

Dynamical systems, robust and optimal controls, nonlinear oscillators, resonance entrainment, modeling and analysis of neuronal circuits for animal locomotion, central pattern generators, body-fluid interaction during undulatory and oscillatory swimming

Y. Sungtaek Ju, Ph.D. (Stanford, 1999)

Heat and mass transfer, energy, energy-water nexus, MEMS and nanotechnology
Ann R. Karagiozian, Ph.D. (Caltech, 1982)
Fluid mechanics and combustion with applications to air breathing, rocket propulsion, and energy-generation systems, focusing on control of instabilities improved efficiency, and reduced emissions

H. Pirouz Kavehpoor, Ph.D. (MIT, 2003)
Microscale fluid mechanics, transport phenomena in biological systems, biofluids, coating flows and physics of contact line phenomena, complex fluids, non-isothermal flows, energy systems and energy storage

Chang-Jin KJ Kim, Ph.D. (U.C. Berkeley, 1991)
Microelectromechanical systems (MEMS), micro/nano devices and fabrication technologies, microfluidics especially involving surface tension and capillarity

J. John Kim, Ph.D. (Stanford, 1978)
Numerical simulation of turbulent and transitional flows, physics and control of turbulent flows, application of modern control theories to flow and combustion problems

Adrienne Lavine, Ph.D. (U.C. Berkeley, 1984)
Heat transfer: thermomechanical behavior of shape memory alloys, thermal aspects of manufacturing processes, natural and mixed convection

Xiaochun Li, Ph.D. (Stanford, 2001)
Embedded sensors in layered manufacturing

Kuo-Nan Liou, Ph.D. (New York U., 1970)
Radiative transfer and satellite remote sensing with application to clouds and aerosols in the earth’s atmosphere

Christopher S. Lynch, Ph.D. (U.C Santa Barbara, 1992)
Field coupled materials, constitutive behavior, thermo-electro-mechanical properties, sensor and actuator applications, fracture mechanics and failure analysis

Ajit K. Mal, Ph.D. (Calcutta U., India, 1964)
Mechanics of composite materials, wave propagation, nondestructive evaluation, structural health monitoring

Robert T. M’Closkey, Ph.D. (Caltech, 1995)
Nonlinear control theory and design with application to mechanical and aerospace systems, real-time implementation

Ali Mosleh, Ph.D., NAE (UCLA, 1981)
Reliability engineering, physics of failure modeling and system life prediction, resilient systems design, prognostics and health monitoring, hybrid systems simulation, theories and techniques for risk and safety analysis

Jayath Y. Murthy, Ph.D. (U. Minnesota, 1984)
Nanoscale heat transfer, computational fluid dynamics, simulation of fluid flow and heat transfer for industrial applications, sub-micron thermal transport, multiscale multiphysics simulations and uncertainty quantifications

Laurent G. Pilon, Ph.D. (Purdue, 2002)
Interfacial and transport phenomena, radiation transfer, materials synthesis, multi-phase flow, heterogeneous media

Jacob Rosen, Ph.D. (Tel Aviv U., Israel, 1997)
Natural integration of a human arm/powered exoskeleton system

Jason L. Speyer, Ph.D. (Harvard, 1968)
Stochastic and deterministic optimal control and estimation with application to aerospace systems, guidance, flight control, and flight mechanics

Tsu-Chin Tsao, Ph.D. (U.C Berkeley, 1988)
Mechatronics and control with applications in mechanical systems, manufacturing, vehicles, medical robots, and energy

Xiaolin Zhong, Ph.D. (Stanford, 1991)
Computational fluid dynamics, advanced high-order CFD methods, hypersonic flow, numerical simulation of transient hypersonic flow with nonequilibrium real-gas effects, instability and laminar-turbulent transition of hypersonic boundary layers

Professors Emeriti

Oddvar O. Bendiksen, Ph.D. (UCLA, 1980)
Classical and computational aeroelasticity, structural dynamics and unsteady aerodynamics

Ivan Corrigan, Ph.D. (UCLA, 1966)
Heat transfer and fluid mechanics, transport phenomena in porous media, nucleo-heat transfer and thermal hydraulics, natural and forced convection, thermal/hydrodynamic stability, turbulence

Aeroelasticity of helicopters and fixed-wing aircraft, structural dynamics of rotating systems, rotor dynamics, unsteady aerodynamics, active control of structural dynamics, structural optimization with aerelastic constraints

Chih-Ming Ho, Ph.D. (Johns Hopkins, 1974)
Molecular fluidic phenomena, microelectro-mechanical systems (MEMS), biomolecular technologies, biomolecular sensor arrays, control of cellular complex systems, rapid search of combinatorial medicine

Thermal convection, thermocapillary convection, stability of shear flows, stratified and rotating flows, interfacial phenomena, microgravity fluid dynamics

Anthony F. Mills, Ph.D. (U.C Berkeley, 1965)
Convective heat and mass transfer, condensation heat transfer, turbulent flows, ablation and transpiration cooling, perforated plate heat exchangers

D. Lewis Mingori, Ph.D. (Stanford, 1966)
Dynamics and control, stability theory, nonlinear methods, applications to space and ground vehicles

Peter A. Monkewitz, Ph.D. (ETH Zürich, Switzerland, 1977)
Fluid mechanics, internal acoustics and noise produced by turbulent jets

Phil F. O’Brien, M.S. (UCLA, 1949)
Industrial engineering, environmental design, chemical and environmental engineering systems

Lucien A. Schmit, Jr., M.S. (MIT, 1950)
Structural mechanics, optimization, automated design methods for structural systems and components, application of finite element analysis techniques and mathematical programming algorithms in structural design, analysis and synthesis methods for fiber composite structural components

Owen I. Smith, Ph.D. (U.C Berkeley, 1977)
Combustion and combustion-generated air pollutants, hydrodynamics and chemical kinetics of combustion systems, semiconductor chemical vapor deposition

Richard Stern, Ph.D. (UCLA, 1964)
Experimentation in noise control, physical acoustics, engineering acoustics, medical acoustics

Mechanics of solid bodies, fracture mechanics, adhesive mechanics, composite materials, theoretical soil mechanics, mixed boundary value problems

Daniel C.H. Yang, Ph.D. (Rutgers, 1982)
Combustion and combustion-generated air pollutants, hydrodynamics and chemical kinetics of combustion systems, semiconductor chemical vapor deposition

Amiya K. Chatterjee, Ph.D. (UCLA, 1976)
Elastic wave propagation and penetration in anisotropic media

Modeling, simulation, and analysis of spacecraft dynamics and pointing control systems; nonlinear dynamics of spinning bodies; concurrent engineering methods for space mission conceptual design

Damian M. Tochey, M.S. (MIT, 2004)
Guidance, navigation, and control for autonomous aircraft, launch vehicles, and missile systems, adaptive control theory, automatic control reallocation for aircraft and re-entry vehicles

Adjunct Professors

Dan M. Goebel, Ph.D. (UCLA, 1981)
Hollow cathode, magnetic-multipole ion sources for neutral beam injection

Veronica J. Santos, Ph.D. (Cornell, 2007)
Grasp and manipulation, hand biomechanics, haptics, human-machine systems, machine learning, machine perception, neural control of movement, prosthetics, robotics, stochastic modeling, tactile sensor

Raymond M. Spearrin, Ph.D. (Stanford, 2015)
Spectroscopy and gas dynamics, advanced optical sensors including laser absorption and fluorescence with experimental application to propulsion, energy systems and other reacting flow fields

Assistant Professors

Jonathan B. Hopkins, Ph.D. (MIT, 2010)
Design and manufacturing of microstructural architectures, flexure systems, and compliant mechanisms; screw theory kinematics; precision machine design; novel micro- and nano-fabrication processes; MEMS

Jingyi Hu, Ph.D. (Harvard, 2011)
Heat transfer and electron transport in nanostructures; interfaces and packaging; thermal, electronic, optoelectronic, and thermoelectric devices and systems; energy conversion, storage, and thermal management; ultrasfast optical spectroscopy and high-frequency electronics; nanomaterials design, processing, and manufacturing

Lihua Jin, Ph.D. (Harvard, 2014)
Mechanics of soft materials; continuum mechanics and applications in technologies: additive manufacturing, soft robotics and stretchable electronics, nanomechanics, and multiscale modeling

Rémy R. Laborde, Ph.D. (Stanford, 2015)
Reliability and real-time computer system design

Lecturers

Ravash C. Amar, Ph.D. (UCLA, 1974)
Heat transfer and thermal science

Amiya K. Chatterjee, Ph.D. (UCLA, 1976)
Elastic wave propagation and penetration in anisotropic media

Modeling, simulation, and analysis of spacecraft dynamics and pointing control systems; nonlinear dynamics of spinning bodies; concurrent engineering methods for space mission conceptual design

Veronica J. Santos, Ph.D. (Cornell, 2007)
Grasp and manipulation, hand biomechanics, haptics, human-machine systems, machine learning, machine perception, neural control of movement, prosthetics, robotics, stochastic modeling, tactile sensor

Neil G. Siegel, Ph.D. (UCLA, 1982)
Thermal sciences, system design

Richard E. Witz, Ph.D. (Caltech, 2005)
Electric propulsion (ion, Hall, electrospays, cathodes); micro-electric propulsion; partially ionized plasma discharges; miniature plasma devices; spacecraft/space mission design; wind energy; solar thermal energy; thermal energy storage
133A. Engineering Thermodynamics. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Enforced requisites: courses M20 (or Civil Engineering M20), M21B, Mathematics 32B, 33A. Principles of thermodynamic principles to engineering processes. Energy conversion systems. Rankine cycle and other cycles, refrigeration, psychrometry, reactive and non-reactive fluid flow systems. Elements of nuclear thermodynamics. Letter grading. Mr. Hu (W,Sp)

135. Fundamentals of Nuclear Science and Engineering. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Requisites: courses 82, 103, 105A. Review of nuclear science and engineering principles. Introduction to nuclear power plants for commercial electricity production, space power, spacecraft propulsion, nuclear fusion, and nuclear science for medical uses. Letter grading. Mr. Abdou (F)

136. Energy and Environment. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Enforced requisite: course 105A. Global energy use and supply, electrical power generation, fossil fuel and nuclear power plants, renewable energy such as hydropower, biomass, geothermal, solar, wind, and ocean, fuel cells, transportation, energy conservation, air and water pollution, global warming. Letter grading. Mr. Plion (Sp)

C137. Design and Analysis of Smart Grids. (4) Lecture, four hours; outside study, eight hours. Demand response, transactive/price-based load control; home-area network, smart energy profile; advanced metering infrastructure; renewable energy integration; solar and wind generation intermittency and connection; microgrids; grid stability; energy storage and electric vehicles-simulation; monitoring, distribution and transmission grids; consumer-centric technologies; sensors, communications, and computing; wireless, wired, control communications for smart grids; grid modeling, stability, and control; frequency and voltage regulation; ancillary services; wide-area situational awareness, phasor measurements; analytical methods and tools for monitoring and control. Concurrently scheduled with course C237. Letter grading. Mr. Gadh (Sp)

CM140. Introduction to Biomechanics. (4) (Same as Bioengineering CM140) Lecture, four hours; discussion, two hours; outside study, six hours. Enforced requisites: courses 101, 102, and 156A or 166A. Introduction to mechanical functions of human body; skeletal adaptations to optimize load transfer, mobility, and function; kinematics and mechanisms applications. Heat and mass transfer. Power generation. Laboratory simulations and tests. Concurrently scheduled with course CM240. Letter grading.

CM141. Mechanics of Cells. (4) (Same as Bioengineering CM141) Lecture, four hours. Introduction to physical structures of cell biology and physical principles that govern how they function mechanically. Review and application of continuum mechanics and statistical mechanics to develop quantitative mathematical models of structural mechanics in cells. Structure of macromolecules, polymers as entropic springs, molecular machines as nanomachines, mechanical proteins, single-molecule force-extension, DNA packing and transcriptional regulation, lipid bilayer membranes, mechanics of cytoskeleton, molecular motors, biological electricity, muscle mechanics, pattern formation. Concurrently scheduled with course CM241. Letter grading.


Adjunct Associate Professor
Abdon E. Sepúlveda, Ph.D. (UCLA, 1990)
Optimal placement of actuators and sensors in control augmented structural optimization

Lower-Division Courses
1. Undergraduate Seminar. (1) Seminar, one hour; outside study, two hours. Introduction by faculty members to mechanical, aerospace and aerospace engineering disciplines through current and emerging applications in aerospace, medical instrumentation, automotive, entertainment energy, and manufacturing industries. P/NP grading.

Mr. Mal (F,Sp)


Ms. Lavine (Not offered 2017-18)


Mr. Chen (Not offered 2017-18)


Mr. Mal (F,Sp)


Mr. Mal (F,Sp)

102. Dynamics of Particles and Rigid Bodies. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Requisites: course 101, Mathematics 33A, Physics 1A. Fundamental concepts of Newtonian mechanics. Kinematics and kinetics of particles and rigid bodies in two and three dimensions. Impulse-momentum and work-energy relationships. Applications. Letter grading.

Ms. Santos (F,Sp)

103. Elementary Fluid Mechanics. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Requisites: Mathematics 32B, 33A, Physics 1B. Introductory course dealing with application of principles of mechanics to flow of compressible and incompressible fluids. Letter grading.

Mr. Kavehpour, Mr. J. Kim (F,Sp)

105A. Introduction to Engineering Thermodynamics. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Requisites: course 82, Chemistry 20B, Mathematics 32B. Phenomenological thermodynamics. Concepts of equilibrium, temperature, and reversibility. First law and concept of entropy. Equations of state and thermodynamic properties. Engineering applications of these principles in analysis and design of closed and open systems. Letter grading. Mr. Plion (F,Sp)

105B. Introduction to Fluid Mechanics. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Requisites: courses 82, 103, 105A. Transport phenomena; heat conduction, mass species diffusion, convective heat and mass transfer, and radiation. Engineering applications in thermal and environmental control. Letter grading. Mr. Ju, Ms. Lavine (F)

107. Introduction to Modeling and Analysis of Dynamic Systems. (4) Lecture, four hours; discussion, one hour; laboratory, two hours; outside study, five hours. Enforced requisites: courses M20 (or Computer Science 31), 82, Electrical Engineering 100. Introduction to modeling of physical systems, with examples of mechanical, fluid, thermal, and electrical systems. Description of these systems with coverage of impulse response, convolution, frequency response, first- and second-order system transient response, and system stability analysis. Nonlinear differential equation descriptions with discussion of equilibrium solutions, small signal linearization, large signal response. Block diagram representation and response of interconnected systems. Hands-on experiments reinforce lecture material. Letter grading.

Mr. M'Oloskey, Mr. Tsao (F,Sp)


Ms. Lavine (F)


Mr. Plion (Not offered 2017-18)
150B. Aerodynamics. (4) Lecture, four hours: discussion, two hours; outside study, six hours. Requisites: courses 103, 154A. Study of aerodynamics of both potential and turbulent flow theory. Compressible flow around thin airfoils (lift and moment coefficients) and wings (lift, induced drag). Gas dynamics: oblique shocks, Prandtl-Meyer expansion, Lineartized subsonic and supersonic flow in airfoils and wings. Wave drag, Transonic flow. Letter grading. Mr. Zhong (Sp)


Ms. Karagozian (Not offered 2017-18)

C150G. Fluid Dynamics of Biological Systems. (4) Lecture, four hours: outside study, eight hours. Requisite: course 103. Mechanics of aquatic locomotion; insect and bird flight aerodynamics; pulsatile flow in circulatory system; rheology of blood; transport in microcirculation; role of fluid dynamics in arterial diseases. Concurrently scheduled with course C255P. Letter grading. Mr. Eldredge (Sp)

C150P. Aircraft Propulsion Systems. (4) Formerly numbered 150P. Lecture, four hours: discussion, two hours; outside study, six hours. Requisites: courses 103, 154A, 154B. Thermodynamic properties of gases, air craft jet engine cycle analysis and component performance, component matching, advanced aircraft engine topics. Concurrently scheduled with course C255P. Letter grading. Mr. Karagozian (F)

C150R. Rocket Propulsion Systems. (4) Formerly numbered 150R. Lecture, four hours: discussion, two hours; outside study, six hours. Enforced requisites: courses 103, 154A. Rocket propulsion system concepts, including chemical rockets (liquid, gas, and solid propellants), hybrid rocket engines, electric ion (plasma) rockets, nuclear rockets, and solar-powered vehicles. Current issues in launch vehicle technologies. Concurrently scheduled with course C250R. Letter grading. Ms. Karagozian, Mr. Wiz (Sp)

153A. Engineering Acoustics. (4) Lecture, four hours: discussion, two hours; outside study, six hours. Designed for junior/senior engineering majors. Fundamental course in acoustics; propagation of sound; sources of sound. Design of field measurements. Estimation of jet and blade noise with design aspects. Letter grading. Mr. Eldredge (Not offered 2017-18)

154A. Preliminary Design of Aircraft. (4) Lecture, four hours: discussion, one hour; outside study, seven hours. Enforced requisite: course 154S. Classical preliminary design and analysis including: estimation, performance, flight stability, and control consideration. Term assignment consists of preliminary design of low-speed aircraft. Letter grading. Mr. Lynch (Wy)


154S. Engineering Acoustics. (4) Lecture, four hours; discussion, one hour; outside study, seven hours. Requisites: courses 154A, 154B. Aircraft performance, flight mechanics, stability, and control. Conception and introduction to spacecraft design for design of aircraft. Effects of airplane flexibility on stability derivatives. Letter grading. Mr. Lynch (F)

155. Intermediate Dynamics. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Requisite: course 102. Application of Newtonian mechanics, generalized coordinates, Lagrange equation, variational principles; central force motion; kinematics and dynamics of rigid bodies. Euler equations, motion of rotating bodies, oscillatory motion, normal coordinates, orthogonality relations. Letter grading.

Mr. Ross (Sp)

156A. Advanced Strength of Materials. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Requisites: courses 82, 101. Not open to students with credit for course 166A. Concepts of stress and strain of thin-walled beams loaded symmetrically and symmetrically loaded beams. Analysis of cylindrical and thin-walled structures. Failure theories. Letter grading. Mr. Mal (FSp)

C156B. Mechanical Design for Power Transmission. (4) Lecture, four hours; outside study, eight hours. Requisite: course 156A or 166A. Material selection in mechanical design. Load and stress analysis. Deflection and stiffness. Failure due to static loading. Fatigue failure. Design for safety factors and reliability. Applications of failure prevention in design of power transmission shifting. Design project involving computer-aided design (CAD) and finite element analysis. Letter grading. Mr. Ghoniem, Mr. Ju (F, W, Sp)

157A. Basic Mechanical and Aerospace Engineering. (4) Lecture, two hours; laboratory, six hours; outside study, four hours. Requisites: courses 101, 102, 103, 105A, Electrical Engineering 100. Methods of measurement of basic quantities and performance of basic experiments in fluid mechanics, structures, and thermodynamics. Primary sensors, transducers, recording equipment, signal processing, and data analysis. Letter grading. Mr. Ghoniem, Mr. Ju (F, W, Sp)

157B. Aerospace Design Laboratory. (4) Lecture, two hours; laboratory, six hours; outside study, four hours. Requisites: courses 150A, 150B, and 157 or 157S. Experimental illustration of important physical phenomena in area of fluid mechanics/aerodynamics, as well as hands-on experience with design tools, experimental programs and use of modern experimental tools and techniques in field. Letter grading. Mr. Kavehpour (Sp)

157S. Basic Aerospace Engineering Laboratory. (4) Laboratory, eight hours; outside study, four hours. Requisites: courses 150A, 150B, and 157S. Experimental laboratory work in analytical techniques in area of aerospace engineering. Letter grading.

Mr. Ghoniem, Mr. Ju (Not offered 2017-18)

161A. Introduction to Aeronautics. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Enforced requisite: course 102. Recommended: course 82. Spaceflight, including two-body and three-body problem, Kepler laws, and Keplerian orbits. Ground track and taxonomy of common orbit orbits. Orbital and transfer maneuvers, patched conics, perturbation theory, low-thrust trajectories, spaceplane parking, and entry, Spaceplane design: mission design, space environment, rendezvous, recovery, and launch. Letter grading. Mr. Wirz (F)

161B. Introduction to Space Technology. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Requisites: courses 102, 103, 105A, Electrical Engineering 100. Recommended: course 154S. Recommended: courses 150A, 150B, 157 or 157S. Experimental illustration of important physical phenomena in area of fluid mechanics/aerodynamics, as well as hands-on experience with design tools, experimental programs and use of modern experimental tools and techniques in field. Letter grading.

Mr. Ghoniem, Mr. Ju (Not offered 2017-18)

162A. Introduction to Mechanisms and Mechanical Systems. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Enforced requisite: course 162B. Limited to seniors. Second of two mechanical engineering capstone design courses. Students group continue design projects started in course 162D, making use of CAD design laboratory, CAD analysis laboratory, and mechanics laboratory. Students work in teams to begin their two-term design project. Laboratory modules include CAD design, CAD analysis, mechatronics, and conceptual design for team project. Letter grading.

Mr. Ghoniem, Mr. Tsao (W)

162E. Mechanical Engineering Design I. (4) Lecture, two hours; laboratory, four hours; outside study, six hours. Enforced requisite: course 162B. Limited to seniors. Second of two mechanical engineering capstone design courses. Students group continue design projects started in course 162D, making use of CAD design laboratory, CAD analysis laboratory, and mechanics laboratory. Students work in teams to begin their two-term design project. Laboratory modules include CAD design, CAD analysis, mechatronics, and conceptual design for team project. Letter grading. Mr. Ghoniem, Mr. Tsao (W)

166A. Analysis of Flight Structures. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Requisites: courses 82, 101. Not open to students with credit for course 156A. Introduction to two-dimensional elasticity, stress, strain, and material behavior. Analysis and design of structures/systems of relevance to aerospace engineering. Letter grading.

Mr. Ghoniem, Mr. Ju (Not offered 2017-18)

166C. Design of Composite Structures. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Enforced requisite: course 156A or 166A. History of composites, stress-strain relations for composite materials, bending and extension of symmetric laminated structures, failure analysis. Emphasis on computer-aided design and analysis. Design studies, buckling of composite components, anisotropic materials, micromechanics of composites. Letter grading.

Mr. Carman (W)

M168. Introduction to Finite Element Methods. (4) Same as Civil Engineering M135C. Lecture, four hours; discussion, one hour; outside study, seven hours. Requisite: course 156A or 166A or Civil Engineering 130. Introduction to basic concepts of finite element methods (FEM) and applications to structural and solid mechanics and heat transfer. Direct matrix structural analysis; weighted residual, least squares, and Ritz approximation methods; shape functions; convergence properties; principles of multidimensional heat flow and elasticity; numerical integration. Practical use of FEM software; geometric
and analytical modeling; preprocessing and postprocessing techniques; term projects with computers. Letter grading. Mr. Mal (F).


171A. Introduction to Feedback and Control Systems: Dynamic Systems Control I. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Enforced requisite: course 107. Introduction to feedback control system design and stability. Modeling of physical systems in engineering and other fields; transform methods; controller design using Nyquist, Bode, and pole root locus methods; compensation; computer-aided analysis and design. Letter grading. Mr. M’Closkey (F,W,Sp).


172. Control System Design Laboratory. (4) Lecture, four hours; laboratory, two hours; outside study, six hours. Enforced requisite: course 171A. Introduction to loop shaping controller design with application to laboratory electromechanical systems. Power spectrum models of noise and disturbances, and performance trade-offs imposed by conflicting requirements. Constraints on sensitivity function and complementary sensitivity function imposed by nonminimum phase plants. Lecture topics supported by weekly hands-on laboratory work. Letter grading. Mr. M’Closkey (Not offered 2017-18).

174. Probability and Its Applications to Risk, Reliability, and Quality Control. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Enforced requisite: Mathematics 33A. Introduction to probability theory; random variables, distributions, functions of random variables, models of failure of components, reliability of series and parallel systems, strong-strength models, fault tree analysis, statistical quality control by variables and by attributes, acceptance sampling. Letter grading. Mr. Mossh (F).

C175A. Probability and Stochastic Processes in Dynamical Systems. (4) Lecture, four hours; outside study, eight hours. Enforced requisite: courses 82, 107. Probability spaces, random variables, stochastic sequences and processes, expectation, conditional expectation, Gaussian/Markov sequences, and minimum variance estimator (Kalman filter) with applications. Concurrently scheduled with course C271A. Letter grading. Mr. Mal (F).

181A. Complex Analysis and Integral Transforms. (4) Lecture, four hours; outside study, eight hours. Enforced requisite: course 82. Complex variables, analytic functions, conformal mapping, contour integrals, singularities, residues, Cauchy integrals, Laplace transform; properties, convolution, inversion; Fourier transform: properties, convolution, FFT, applications in dynamics, vibrations, structures, and heat conduction. Letter grading. Mr. Gehrig (F).


182C. Numerical Methods for Engineering Applications. (4) Lecture, four hours; discussion, one hour; outside study, seven hours. Enforced requisites: courses M20 or (Civil Engineering M20 or Computer Science 31) and M31. Numerical analysis having wide application in solution of practical engineering problems, computer arithmetic, and errors. Solution of linear and nonlinear systems. Algebraic equations and eigenvalue problems; numerical quadrature, and finite difference approximations. Numerical solution of initial and boundary value problems for ordinary and partial differential equations. Letter grading. Mr. Mal (F).


183B. Introduction to Microscale and Nanoscale Manufacturing. (4) (Same as Bioengineering M153, Chemical Engineering M208, Electrical and Computer Engineering M153.) Lecture, three hours; laboratory, four hours; outside study, five hours. Enforced requisites: Chemistry 20A, Physics 1A, 1B, 1C, 4AL, 4BL. Introduction to general manufacturing methods, mechanisms, constraints, and microfabrication and nanofabrication. Focus on concepts, physics, and instruments of various microfabrication and nanofabrication technologies that have been broadly applied in industry and academia, including various photolithography technologies; physical and chemical deposition methods; and physical and chemical techniques of lithography and etching that allow the fabrication of microstructures and nanostructures in modern cleanroom environment. Letter grading. Mr. Chiu (F,Sp).

C183C. Rapid Prototyping and Manufacturing. (4) Lecture, four hours; laboratory, two hours; outside study, six hours. Enforced requisite: course 183A. Rapid prototyping (RP), solid freeform fabrication, or additive manufacturing has emerged as popular manufacturing methods. Hand-held prototype creation in last two decades. Machine for layered manufac- turing builds parts directly from CAD models. This novel manufacturing technology enables building of parts that have been impossible to fabricate because of their complex shapes or of variety in materials. In analogy to speed and flexibility of desktop publishing, rapid prototyping is also called desktop manufacturing. Rapid prototyping involves three-dimensional functional miniature compo- nents. Concurrently scheduled with course C297A. Letter grading. Mr. Li (W).

184. Introduction to Geometry Modeling. (4) Lecture, four hours; laboratory, four hours; outside study, four hours. Enforced requisite: course 183A. Rapid prototyping (RP), solid freeform fabrication, or additive manufacturing has emerged as popular manufacturing methods. Hand-held prototype creation in last two decades. Machine for layered manufac- turing builds parts directly from CAD models. This novel manufacturing technology enables building of parts that have been impossible to fabricate because of their complex shapes or of variety in materials. In analogy to speed and flexibility of desktop publishing, rapid prototyping is also called desktop manufacturing. Rapid prototyping involves three-dimensional functional miniature compo- nents. Concurrently scheduled with course C297A. Letter grading. Mr. Li (W).

184A. Introduction to Geometry Modeling. (4) Lecture, four hours; laboratory, four hours; outside study, four hours. Enforced requisite: course 183A. Rapid prototyping (RP), solid freeform fabrication, or additive manufacturing has emerged as popular manufacturing methods. Hand-held prototype creation in last two decades. Machine for layered manufac- turing builds parts directly from CAD models. This novel manufacturing technology enables building of parts that have been impossible to fabricate because of their complex shapes or of variety in materials. In analogy to speed and flexibility of desktop publishing, rapid prototyping is also called desktop manufacturing. Rapid prototyping involves three-dimensional functional miniature compo- nents. Concurrently scheduled with course C297A. Letter grading. Mr. Li (W).

185. Introduction to Radio Frequency Identification and Its Application in Manufacturing and Supply Chain. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Enforced requisites: course M20 or Civil Engineering M20 or Computer Science 31. Manufacturing today requires as- sembling of individual components into assembled products, shipping of such products, and eventually use, maintenance, and recycling of such products. Radio frequency identification (RFID) chips installed on components, subassemblies, and assemblies of products allow them to be tracked automatically as they move and transform through manufacturing supply chain. RFID tags have memory and small CPU that allows information about product status to be written, read, and transmitted wirelessly. Tag data can then be forwarded by reader to enterprise software by way of RFID middleware layer. Study of how RFID is being utilized in manufacturing, with focus on automotive and aerospace. Letter grading. Mr. Kakkar (F).


187L. Nanoscale Fabrication, Characterization, and Biodetection Laboratory. (4) Lecture, two hours; laboratory, three hours; outside study, seven hours. Multidisciplinary course that introduces laboratory techniques of nanoscale fabrication, characterization, and biodetection. Basic physical, chemical, and bio- logical principles related to nanoscale top- down and bottom-up (self-assembly) nanofabrica- tion, nanocharacterization (AEM, SEM, etc.), and optical and electrochemical biosensors. Students en- couraged to create their own ideas in self-designed experiments. Concurrently scheduled with course C287L. Letter grading. Mr. Y. Chen (Sp).

188. Special Courses in Mechanical and Aero- space Engineering. (2 to 4) Lecture, two to four hours; outside study, four to eight hours. Special topics in mechanical and aerospace engineering for undergraduate students taught on experimental or theoretical analysis, such as an independent study project or intern- and visiting faculty members. May be repeated once for credit with topic or instructor change. P/NP or letter grading. (Not offered 2017-18).

194. Research Group Seminars: Mechanical and Aerospace Engineering. (2 to 4) Seminar, two hours. Designed for undergraduate students who are part of research group. Discussion of research methods and current literature in field. Student presentation of proj- ects in research specialty. May be repeated for credit. P/NP or letter grading.

199. Directed Research in Mechanical and Aero- space Engineering. (2 to 8) Tutorial, to be arranged. Limited to juniors/seniors. Supervised individual research in area of faculty member’s specialization. Culminating paper or project required. May be repeated for credit with school approval. Indi- vidual contract required; enrollment petitions available from Office of Academic and Student Affairs. Letter grading. (F,Sp).

Graduate Courses

231A. Convective Heat Transfer Theory. (4) Lecture, four hours; outside study, eight hours. Requi- sites: courses 131A, 182B. Recommended: course 252A. Convective heat transfer: conduction of real fluids. Analysis of heat transfer in laminar and turbulent, incompressible and compressible flows. Internal and external flows; free convection. Variable wall tem-


239B. Seminar: Current Topics in Transport Phenomena. (2-4) Seminar, two to four hours; outside study, eight hours. Recommended requisite: course 105D. Topics in advanced transport phenomena. Letter grading. Ms. Lavine (W).

239C. Design and Analysis of Smart Grids. (4) Lecture, four hours; outside study, eight hours. Requisite: course 105D. Heat carriers (photons, electronics, phonons) and quantum electromagnetic phenomena, as well as analytical methods for calculating radiative properties and radiation transfer in absorbing, emitting, and scattering media. Applications cover laser-material interactions in addition to traditional areas such as combustion and thermal insulation. Letter grading. Mr. Pilon (Sp).

239D. Microscopic Energy Transport. (4) Lecture, four hours; outside study, eight hours. Requisite: course 105D. Heat carriers (photons, electronics, phonons) and quantum electromagnetic phenomena, as well as analytical methods for calculating radiative properties and radiation transfer in absorbing, emitting, and scattering media. Applications cover laser-material interactions in addition to traditional areas such as combustion and thermal insulation. Letter grading. Mr. Pilon (W).

C232A. Mass Transfer. (4) Lecture, four hours; outside study, eight hours. Requisites: courses 105D, 131A, Prior knowledge of basic transport phenomena. Transient driven mass and heat transfer, such as turbulence, stability and transition, buoyancy effects, variational methods, and measurement techniques. May be repeated for credit with topic change. S/U grading.

239F. Special Topics in Transport Phenomena. (2 to 4) Lecture, two to four hours; outside study, four to eight hours. Designed for graduate mechanical and aerospace engineering students. Advanced and current study of mass and heat transfer phenomena. Topics may vary from year to year. Letter grading. Mr. Ju (F).

239G. Seminar: Current Topics in Nuclear Engineering. (2 to 4) Lecture, two to four hours; outside study, four to eight hours. Elective for graduate mechanical and aerospace engineering students. Advanced study in areas of current interest in nuclear engineering, such as reactor safety, risk-benefit trade-offs, nuclear materials, and reactor design. May be repeated for credit with topic change. S/U grading.

239H. Special Topics in Nuclear Engineering. (2 to 4) Seminar, two to four hours; outside study, four to eight hours. Designed for graduate mechanical and aerospace engineering students. Advanced study in areas of current interest in nuclear engineering, such as reactor safety, risk-benefit trade-offs, nuclear materials, and reactor design. May be repeated for credit with topic change. S/U grading.


CM241. Mechanics of Cells. (4) (Same as Bioengineering CM241.) Lecture, four hours. Introduction to physical structures of cell biology and physical principles that govern how they function mechanically. Review and application of continuum mechanics and statistical mechanics to develop quantitative mathematical models of structural mechanics in cells. Structures selected from various organs as entropic springs, random walks and diffusion, mechanisms of single-molecule force-extension, DNA packaging and transcriptional regulation, lipid bilayer membranes, mechanics of cytoskeletal networks, molecular motors, biological electricity, muscle mechanics, pattern formation. Concurrently scheduled with course CM141. Letter grading.

242. Introduction to Multiferroic Materials. (4) Lecture, four hours; outside study, eight hours. Overview of different types of multiferroic materials, including strain mediated. Basic crystal structure of single-phase multiferroics, and multiferroics physics underlying ferroelectricity and ferromagnetism. Material science description of these materials, with focus on linear and nonlinear behavior with associated mechanisms such as spin orientation. Presentation of analytical tools necessary to predict material response ranging from constitutive relations to governing equations, including elastodynamics and Maxwellian transport equations, constitutive relations, exact solutions on the Navier/Stokes equations, vorticity dynamics, decomposition of potential flows, potential flow, and potential flows with vorticity.

250A. Foundations of Fluid Dynamics. (4) Lecture, four hours; outside study, eight hours. Requisite: course 150A. Corequisite: course 182B. Development and application of fundamental principles of fluid dynamics at graduate level, with emphasis on incompressible flow. Flow kinematics, basic equations, constitutive relations, exact solutions on the Navier/Stokes equations, vortex dynamics, decomposition of potential flows, potential flow, and potential flows with vorticity.

250B. Viscous and Turbulent Flows. (4) Lecture, four hours; outside study, eight hours. Requisite: course 150A. Fundamental principles of fluid dynamics applied to study of unsteady and steady flows of fluid motion discussed in order of advancing Reynolds number; wakes, boundary layers, instability, transition, and turbulent shear flows. Letter grading. Mr. Eldredge, Mr. J. Kim (W).


250E. Hypersonic and High-Temperature Gas Dynamics. (4) Lecture, four hours; outside study, eight hours. Requisite: course 150A, 150B, 182C. Designed for graduate mechanical and aerospace engineering students. Advanced study in areas of current interest in nuclear engineering, such as reactor safety, risk-benefit trade-offs, nuclear materials, and reactor design. May be repeated for credit with topic change. S/U grading.

255. Introduction to Multiferroic Materials. (4) Lecture, four hours; outside study, eight hours. Elective for graduate mechanical and aerospace engineering students. Advanced study in areas of current interest in nuclear engineering, such as reactor safety, risk-benefit trade-offs, nuclear materials, and reactor design. May be repeated for credit with topic change. S/U grading.

256F. Spectral Methods in Fluid Dynamics. (4) Lecture, four hours; outside study, eight hours. Requisite: course 182B. Course 182C, 250A, 250B. Introduction to basic concepts and techniques of various spectral methods applied to solving partial differential equations. Particular emphasis on techniques of solving unsteady three-dimensional Navier Stokes equations. Topics include spectral representation of functions, discrete Fourier transform, etc. Letter grading. Mr. J. Kim (Not offered 2017-18).

256G. Hypersonic and High-Temperature Gas Dynamics. (4) Lecture, four hours; outside study, eight hours. Recommended requisite: course 250C. Molecular and chemical description of equilibrium and nonequilibrium hypersonic and high-temperature gas flows, chemical thermodynamics and statistical thermodynamics for calculation gas properties, equilibrium flows of real gases, vibrational and chemical rate processes, nonequilibrium flows of real gases, and computational fluid dynamics methods for nonequilibrium hypersonic flows. Letter grading. Mr. Zhong (Sp).

C250G. Fluid Dynamics of Biological Systems. (4) Lecture, four hours; outside study, eight hours. Requisite: course 103. Mechanics of aquatic locomotion; insect and bird flight aerodynamics; pulsatile flow in circulatory system; rheology of blood; transport in microcirculation; role of fluid dynamics in arterial diseases. Concurrently scheduled with course C150G. Letter grading. Mr. Eldredge (Sp).
250H. Numerical Methods for Incompressible Flows. (4) Lecture, four hours; outside study, eight hours. Designed for graduate students. Topics in numerical mathematics, particularly the numerical solution of partial differential equations of incompressible flow, finite difference methods, and other methods of spatial approximation, time-marching schemes, numerical solution of model partial differential equations, application to Navier-Stokes equations, boundary conditions, and computational grading. Mr. Eldredge (F).


C250P. Aircraft Propulsion Systems. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Requisites: courses 105A, 150A. Thermodynamics of gases, aircraft engine cycle analysis, component performance, component matching, advanced aircraft engine topics. Concurrently scheduled with course C150P. Letter grading. Mr. Karagozian (F).

C250R. Rocket Propulsion Systems. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Required: courses 103, 105A. Rocket propulsion concepts, including chemical rockets (liquid, gas, and solid propellants), hybrid rockets, electric (ion, plasma) rockets, nuclear rockets, and solar-powered vehicles. Current issues in launch vehicle technologies. Concurrently scheduled with course C150R. Letter grading. Ms. Karagozian, Mr. Wirz (Sp).

252A. Stability of Fluid Motion. (4) Lecture, four hours; outside study, eight hours. Requisite: course 150A. Mechanisms by which laminar flows can become unstable and lead to turbulence of secondary motions. Linear stability theory; thermal, centrifugal, and shear instabilities; boundary layer instability. Nonlinear aspects: sufficient criteria for stability, supercritical instabilities, supercritical states, transition to turbulence. Letter grading. Mr. Zhong (Not offered 2017-18).


252D. Combustion Rate Processes. (4) Lecture, four hours; outside study, eight hours. Requisite: course 252C. Basic concepts in chemical kinetics: molecular collisions, distribution functions and averaging, semiempirical and ab initio potential surfaces, trajectory calculations, statistical reaction rate theories. Practical examples of large-scale chain mechanisms from combustion chemistry of several elements, etc. Letter grading. Ms. Karagozian (Not offered 2017-18).

252P. Plasma and Ionized Gases. (4) Lecture, four hours; outside study, eight hours. Requisites: courses 82, 102, 150A, 182B. Neutral and charged particle motion, magnetohydrodynamics, two-fluid plasma treatment, plasmas in gas discharges, Child/Langmuir law, basic plasma devices, electron emission and work function, thermal distributions, vacuum and vacuum systems, space-charge, particle collisions and ionization, plasma discharges, sheaths, and electric currents in materials. Mr. Wrz (Not offered 2017-18).

254A. Special Topics in Aerodynamics. (4) Lecture, four hours; outside study, eight hours. Enforced requisites: courses 82, 150A, 150B, 182B, 182C. Special topics in aerodynamics in advanced engineering fields. Examples include transonic flow, hypersonic flow, sonic booms, and unsteady aerodynamics. Letter grading. Mr. Zhong (Not offered 2017-18).


255B. Mathematical Methods in Dynamics. (4) Lecture, four hours; outside study, eight hours. Requisite: course 255A. Concepts of stability; state-space interpretation; stability determination by simulation, linearization, and Lyapunov direct method; the Hamiltonian as a Lyapunov function; nonautonomous systems; averaging and perturbation methods of nonlinear analysis; parametric excitation and nonlinear resonance. Application to mechanical systems. Letter grading. Mr. M. Closkey (Not offered 2017-18).

M256A. Linear Elasticity. (4) Same as Civil Engineering M230A.) Lecture, four hours; outside study, eight hours. Requisites: courses 82, 166A. Linear elastostatics. Cartesian tensors; infinitesimal strain tensor; Cauchy stress tensor; strain energy; equilibrium equations; linear constitutive relations; plane elasticity problems; fracture; problems of deformations, cracks; three-dimensional problems of Kelvin, Bowsinesq, and Cerruti. Introduction to boundary integral equation method. Letter grading. Mr. W. J. Ju, Mr. Mal (F).

M256B. Nonlinear Elasticity. (4) Same as Civil Engineering M230B.) Lecture, four hours; outside study, eight hours. Requisite: course M256A. Kinematics of deformation, material and spatial coordinates, deformation gradient tensor, nonlinear and linear strain tensors, strain displacement relations; balance laws, Cauchy and Piola stresses, Cauchy equations of motion, balance of energy, stored energy; constitutive relations, elasticity, hyperelasticity, thermoelasticity; linearization of field equations; solution of selected problems. Letter grading. Mr. W. Ju, Mr. Mal (W).


M256F. Analytical Fracture Mechanics. (4) Lecture, four hours; outside study, eight hours. Requisite: course M256A. Review of modern fracture mechanics, elementary stress analyses; analytical and numerical methods for calculation of crack tip stress intensity factors; engineering applications in stifened structures, pressure vessels, plates, and shells. Letter grading. Mr. Gupta (Sp).


258A. Nanomechanics and Micromechanics. (4) Lecture, four hours; outside study, eight hours. Requisite: course M256A. Analytical and computational modeling methods to describe mechanics of materials at scales ranging from atomistic through microstructure or transitional and up to continuum. Discus- sions of atomistic simulation, molecular dynamics, Langevin dynamics, and kinetic Monte Carlo) and their applications at nanoscale. Development and applications of dislocation dynamics and statistical mechanics methods in areas of nanosstructure and microstructure; self-organization, heterogeneous plastic deformation, material instabilities, and failure phenomena. Presentation of technical applica- tions of these emerging fields. Exposure to sur- faces and interfaces, grain boundaries, dislocations and defects, surface growth, quantum dots, nano- tubes, nanoclusters, thin films (e.g., optical thermal barrier coatings and ultrastrange nanolayer materials), nano-identification, smart (active) materials, nano-bending and microbending, and torsion. Letter grading. Mr. Ghoniem (Not offered 2017-18).

259A. Seminar: Advanced Topics in Fluid Mechan- ics. (4) Seminar, four hours; outside study, eight hours. Advanced study of topics in fluid mechanics, with intensive student participation involving assign- ments in research problems leading to term paper or oral presentation (periodic) and lecture. Letter grading. Mr. Kavehpour, Mr. Spearrin (F).

259B. Seminar: Advanced Topics in Solid Mech- anics. (4) Seminar, four hours; outside study, eight hours. Advanced study in various fields of solid mechanics. Topics which may vary from term to term. Topics include dynamics, elasticity, plasticity, and stability of solids. Letter grading. Mr. Mal (F).

260. Current Topics in Mechanical Engineering. (2 to 4) Seminar, two to four hours; outside study, four to eight hours. Designed for graduate mechanical and aerospace engineering students. Lectures, dis- cussions, and student presentations and projects in areas of current interest in mechanical engineering. May be repeated for credit. S/U grading.


262. Mechanics of Intelligent Material Systems. (4) Lecture, four hours; outside study, eight hours. Recommended requisite: course 155; Constitutive relations for electro-magneto-mechanical materials. Fiber-optic sensor technology. Micro/macro analysis, including classical linear elastic theory, concentric cylinder analysis, hexagonal models, and homogenization techniques as they apply to active materials. Active systems design, inch-worm, and biomorph. Letter grading. Mr. Carman (Sp).

263A. Kinematics of Robotic Systems. (4) Lecture, four hours; outside study, eight hours. Recommended requisites: courses 155, 171A. Kinematical models of serial robotic manipulators, including spa- tial descriptions and transformations (Euler angles, Denavit-Hartenberg/HR parameters, equivalent angle vector), frame assignment procedure, direct kine- matics, inverse kinematics (geometric and algebraic approaches), mechanical design topics. Letter grading. Mr. Hong (F).
283B. Dynamics of Robotic Systems. (4) Lecture, four hours; outside study, eight hours. Enforced requisites: course 263B. Dynamics of serial and parallel robotic manipulators, including review of spatial descriptions and transformations along with direct and inverse kinematics, linear and angular velocities, Jacobian matrix, velocity propagation, and force-propagation method, explicit formulation of Jacobian matrix, manipulator dynamics (Newton/ Euler formulation, Lagrangian formulation), trajectory generation, introduction to parallel and series robotic devices. Letter grading. Mr. Rosen (W)

283C. Control of Robotic Systems. (4) Lecture, four hours; outside study, eight hours. Enforced requisite: course 263B. Sensors, actuators, and control schemes for robotic systems, including computed torque control, linear feedback control, impedance and force feedback control, and advanced control techniques from nonlinear and adaptive control, hybrid control, nonholonomic systems, vision-based control, and perception. Letter grading. Ms. Santos (Sp)

283D. Advanced Topics in Robotics and Control. (4) Lecture, four hours; outside study, eight hours. Enforced requisites: courses 263B and 283C. Current and advanced topics in robotics and control, including kinematics, dynamics, control, mechanical design, advanced sensors and actuators, flexible links, manipulability, and control algorithms for robotic interaction, teleoperation, haptics. Letter grading. Mr. Rosen (Not offered 2017-18)


M269B. Advanced Dynamics of Structures. (4) Lecture, four hours; outside study, eight hours. Enforced requisite: course M269A. Analysis of linear and nonlinear response of structures to dynamic loadings. Stresses and deflections in structures. Structural damping and self-induced vibrations. Letter grading. Mr. Mal (Sp)

M269D. Aeroelastic Effects in Structures. (4) Lecture, four hours; outside study, eight hours. Enforced requisite: course M269A. Presentation of field of aeroelasticity from fundamental concepts to flight loads on suspension bridges, buildings, and other structures. Derivation of aerelastic operators and unsteady airloads from governing variational principles. Flow induced instability and nonlinear vibration of structures. Letter grading. Mr. Mal (Not offered 2017-18)

M270A. Linear Dynamic Systems. (4) (Same as Chemical Engineering M280A and Electrical and Computer Engineering M242A) Lecture, four hours; outside study, eight hours. Enforced requisite: course M269A. Analysis of linear and nonlinear response of systems to dynamic loading. Stresses and deflections in structures. Structural damping and self-induced vibrations. Letter grading. Mr. Gibson (W)

M270C. Optimal Control. (4) (Same as Chemical Engineering M280C and Electrical and Computer Engineering M242C) Lecture, four hours; outside study, eight hours. Enforced requisite: course 270B. Applications of variational methods, Pontryagin maximum principle, Hamilton/Jacobi/Bellman equation (dynamic programming) to optimal control of dynamic systems modeled by nonlinear ordinary and partial differential equations. Letter grading. Mr. Speyer (Not offered 2017-18)

C271A. Probability and Stochastic Processes in Dynamical Systems. (4) Lecture, four hours; outside study, eight hours. Enforced requisite: course 271A. Linear and nonlinear estimation theory, orthogonal projection lemma, Bayesian filtering theory, conditional mean and risk estimators. Letter grading.

C271C. Stochastic Optimal Control. (4) Lecture, four hours; outside study, eight hours. Enforced requisite: course C271A. Linear and nonlinear estimation theory, orthogonal projection lemma, Bayesian filtering theory, conditional mean and risk estimators. Letter grading.

M272A. Nonlinear Dynamic Systems. (4) (Same as Chemical Engineering M282A and Electrical and Computer Engineering M242A) Lecture, four hours; outside study, eight hours. Enforced requisite: course M270A or Chemical Engineering M280A or Electrical and Computer Engineering M242A. State-space techniques for studying solutions of time-invariant and time-varying nonlinear dynamic systems with emphasis on stability. Lyapunov theory (including converse theorems), invariance, center manifold theorem, center-manifold theorem, and Lyapunov stability. Letter grading. Mr. Speyer (Not offered 2017-18)

M272A. Nonlinear Dynamic Systems. (4) (Same as Chemical Engineering M282A and Electrical and Computer Engineering M242A) Lecture, four hours; outside study, eight hours. Enforced requisite: course M270A or Chemical Engineering M280A or Electrical and Computer Engineering M242A. State-space techniques for studying solutions of time-invariant and time-varying nonlinear dynamic systems with emphasis on stability. Lyapunov theory (including converse theorems), invariance, center manifold theorem, center-manifold theorem, and Lyapunov stability. Letter grading. Mr. Speyer (Not offered 2017-18)


275A. System Identification. (4) Lecture, four hours; outside study, eight hours. Enforced requisite: course M270A. Identification of dynamical systems from input/output data, with emphasis on identification of discrete-time (digital) models of sampled-data systems. Coverage of convolution, correlation, and cross-correlation. Physically identified transfer functions and state-space models. Discussion of applications in mechanical and aerospace engineering, including identification of flexible structures, microelectromechanical systems (MEMS) devices, and acoustic ducts. Letter grading.

Mr. Gibson (Not offered 2017-18)


277. Advanced Digital Control for Mechatronic Systems. (4) Lecture, four hours; laboratory, two hours; outside study, six hours. Enforced requisites: courses 171B, M270A. Digital signal processing and control aspects of mechatronic systems. Introduction to digital-based control algorithms and robustness properties. Youla parameterization of stabilizing controllers, previewed optimal feedback compensator, repetitive and learning control, and adaptive control. Real-time control investigation of topics to selected mechatronic systems. Letter grading. Mr. Tsao (W)

279. Dynamics and Control of Biological Oscillations. (4) Lecture, four hours; outside study, eight hours. Enforced requisites: courses 107, M270A. Analysis and design of dynamical mechanisms underlying biological control systems that generate coordinated oscillations. Topics include neuronal information processing through action potentials (spike train), central pattern generator, coupled nonlinear oscillators, optimal gait (periodic motion) for animal locomotion, and entrainment to natural oscillations via feedback control. Letter grading.

M280B. Microelectromechanical Systems (MEMS) Fabrication. (4) (Same as Bioengineering M250B and Electrical and Computer Engineering M250B) Lecture, four hours; outside study, eight hours. Enforced requisite: course M280A. Design and fabrication of micromachined devices. Topics include scale issues, surface tension, superhydrophobic surfaces and applications, and electrowetting and applications. Letter grading. Mr. C-J. Kim (Not offered 2017-18)

M282. Microelectromechanical Systems (MEMS) Device Physics and Design. (4) (Same as Bioengineering M252 and Electrical and Computer Engineering M252) Lecture, four hours; outside study, eight hours. Enforced requisites: courses 102, 103, 105D. Fundamental issues of being in microscopic world and mechanical engineering. MEMS devices. Topics include scale issues, surface tension, superhydrophobic surfaces and applications, and electrowetting and applications. Letter grading. Mr. C-J. Kim (Not offered 2017-18)


285. Interfacial Phenomena. (4) Lecture, four hours; outside study, eight hours. Enforced requisites: courses 282, 103A, 105D. Introduction to fundamental physical phenomena occurring at interfaces and application of their knowledge to engineering problems. Fundamental concepts of interfacial phenomena, including surface tension, surfactants, interfacial thermodynamics, interfacial forces, interfacial hydrodynamics, and dynamics of triple line. Presentation of various applications, including wetting, change of phase (boiling and condensation), foam and emulsions, microelectromechanical systems, and biological systems. Letter grading. Mr. Pilon (Not offered 2017-18)

C286. Applied Optics. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Enforced requisite: Physics 1C. Fundamental principles of optical systems. Geometric optics and aberration theory. Diff-

M290A. Mechanical Design for Power Transmission. (4) (Formerly numbered 290A.) Lecture, four hours; outside study, eight hours. Enroll遐: course 156A or 166A. Material selection in mechanical design. Load and stress analysis. Deflection and stiffness. Failure due to static loading. Fatigue failure. Design for safety factors and reliability. Applications of finite element analysis, design of tooling, maintenance, and manufacturing. Design project involving computer-aided design (CAD) and finite element analysis (FEA) modeling. Preparation: concurrently scheduled with course 156B. Letter grading. Mr. Ghoniem (Sp 2017-18)

M296B. High-Temperature Mechanical Design. (4) Lecture, four hours; outside study, eight hours. Requisites: course 156A or equivalent. Review of elasticity and continuum thermodynamics, multiaxial plasticity, flow rules, cyclic plasticity, viscoplasticity, creep, creep damage in cyclic loading. Damage mechanics: thermodynamics, ductile, creep, fatigue, and fatigue-creep interaction damage. Fracture mechanics: elastic and elastoplastic analysis, J-integral, brittle fracture, ductile fracture, fatigue and creep crack propagation. Applications in design of high-temperature components such as turbine blades, pressure vessels, heat exchangers, connecting rods. Design project involving CAD and FEM modeling. Letter grading. Mr. Ghoniem (Not offered 2017-18)

C297L. Nanoscience and Technology. (4) (Same as Electrical and Computer Engineering M257.) Lecture, four hours; outside study, eight hours. Enroll遐: course CM280A. Introduction to fundamentals of nanoscale science and technology. Basic physical principles, quantum mechanics, chemical bonding and nanostructures, top-down and bottom-up (self-assembly) nanofabrication; nanomaterial characterization, nanomaterials, nanoelectronics, and nanobiotechnology. Introduction to new knowledge and techniques. In-depth understanding of scientific principles behind nanotechnology and inspire students to create new ideas in multidisciplinary nano areas. Letter grading. Mr. Y. Chen (W 2017-18)

C270L. Nanoscale Fabrication, Characterization, and Biodetection Laboratory. (4) Lecture, two hours; laboratory, three hours; outside study, seven hours. Multidisciplinary course that introduces laboratory techniques of nanoscale fabrication, characterization, and biodetection. Basic physical, chemical, and biological principles related to these techniques, top-down and bottom-up (self-assembly) nanofabrication, nanomaterial characterization (AEM, SEM, etc.), and optical and electrical characterization techniques. Students encouraged to create their own ideas in self-designed experiments. Concurrently scheduled with course C187L. Letter grading. Mr. Y. Chen (Sp 2017-18)

C298. Laser Microfabrication. (4) Lecture, four hours; outside study, eight hours. Requisites: Materials Science 104, Physics 17. Science and engineering of laser microscopic fabrication of advanced materials, including semiconductors, metals, and insulators. Topics include fundamentals in laser interactions with advanced materials, transport issues (therma, mass, electrical, chemical, carrier, etc.) in laser microfabrication, state-of-the-art techniques for laser microfabrication, applications such as rapid prototyping, surface modifications (physical/chemical), micromachining for three-dimensional MEMS (microelectromechanical systems) and data storage, up-to-date research activities. Student term projects. Letter grading. (Not offered 2017-18)

C294A. Compliant Mechanism Design. (4) (Formerly numbered 294B.) Lecture, four hours; outside study, eight hours. Requisite: Linear algebra. Advanced compliant mechanism synthesis approaches, modeling techniques, and optimization tools. Fundamentals of flexible constraint theory, principles of constrained-based design, objective geometry, stress theory kinematics, and freedom and constraint topologies. Applications: precision motion stages, general purpose flexure bearings, microstructural architectures, MEMS, and nanoscale positioning systems. Hands-on exercises include build-your-own flexure kits, CAD and FEA simulations, and term project. Letter grading. Mr. Hopkins (W 2017-18)

C295A. Radio Frequency Identification Systems: Analysis. (4) (Same as Electrical and Computer Engineering M295A.) Lecture, four hours; outside study, eight hours. Designed for graduate engineering students examining emerging discipline of radio-frequency identification (RFID), including basics of RFID, how RFID systems function, design and analysis of RFID systems, and applications to fields such as supply chain, manufacturing, retail, and homeland security. Letter grading. Mr. Gadhi (Not offered 2017-18)

C296A. Design of Power Transmission. (4) (Formerly numbered 296A.) Lecture, four hours; outside study, eight hours. Requisite: course 156A or 166A. Material selection in mechanical design. Load and stress analysis. Deflection and stiffness. Failure due to static loading. Fatigue failure. Design for safety factors and reliability. Applications of finite element analysis, design of tooling, maintenance, and manufacturing. Design project involving computer-aided design (CAD) and finite element analysis (FEA) modeling. Preparation: concurrently scheduled with course C166B. Letter grading. Mr. Ghoniem (Sp 2017-18)

C296B. High-Temperature Mechanical Design. (4) Lecture, four hours; outside study, eight hours. Requisites: course 156A or equivalent. Review of elasticity and continuum thermodynamics, multiaxial plasticity, flow rules, cyclic plasticity, viscoplasticity, creep, creep damage in cyclic loading. Damage mechanics: thermodynamics, ductile, creep, fatigue, and fatigue-creep interaction damage. Fracture mechanics: elastic and elastoplastic analysis, J-integral, brittle fracture, ductile fracture, fatigue and creep crack propagation. Applications in design of high-temperature components such as turbine blades, pressure vessels, heat exchangers, connecting rods. Design project involving CAD and FEM modeling. Letter grading. Mr. Ghoniem (Not offered 2017-18)

C297A. Rapid Prototyping and Manufacturing. (4) Lecture, four hours; outside study, six hours. Recommended requisite: level of knowledge in manufacturing equivalent to course 183A and CAD capability. Rapid prototyping (RP), solid freeform fabrication, or additive manufacturing has emerged as popular manufacturing technology to accelerate product creation in last two decades. Machine for layered manufacturing builds parts directly from CAD models. This novel manufacturing technology enables building of parts that have traditionally been impossible to fabricate because of their complex shapes or of variety in materials. In analogy to chemical synthesis and organic chemistry, rapid prototyping is also called desktop manufacturing, with actual three-dimensional solid objects instead of mere two-dimensional images. Methodology of rapid prototyping has also been extended into micro-/nano-scale to produce three-dimensional functional miniature components. Concurrently scheduled with course C183C. Letter grading. Mr. Li (W 2017-18)

M297B. Material Processing in Manufacturing. (4) (Formerly numbered 297A.) (Same as Materials Science C297B.) Lecture, four hours; outside study, eight hours. Enroll遐: course 156A or equivalent. Review of elasticity and continuum thermodynamics, principles of material processing: phase equilibria and transitions, transport mechanisms of heat and mass, nucleation and growth of microstructure. Applications in casting/solidification, welding, consolidation, chemical vapor deposition, infiltration, composites. Letter grading. Mr. Li (Not offered 2017-18)

M297C. Composites Manufacturing. (4) (Formerly numbered 297D.) (Same as Materials Science M297C.) Lecture, four hours; outside study, eight hours. Requisites: course 166C, Materials Science 151. Matrix materials, fibers, fiber preforms, elements of processing, autoclave/compression molding, filament winding, pultrusion, resin transfer molding, automation, material removal and assembly, metal and ceramic matrix composites, quality assurance. Letter grading. Mr. Li (Not offered 2017-18)

C298. Seminar: Engineering. (2 to 4) Seminar, to be arranged. Limited to graduate mechanical and aeronautical engineering students. Presentations of research topics by leading academic researchers from fields of systems, dynamics, and control. Students who work in these fields present their papers and results. S/U grading.

375. Teaching Apprentice Training Seminar. (2 to 4) Seminar, to be arranged. Preparation: apprentice personnel employment as teaching assistant, associate, or fellow. Teaching apprenticeship under active guidance and supervision of regular faculty member responsible for curriculum and instruction at UCLA. May be repeated for credit. S/U grading.

Mr. Mal (F, W, Sp 2017-18)

495. Teaching Assistant Training Seminar. (2 to 4) Seminar, to be arranged. Limited to graduate mechanical and aerospace engineering students. Petition forms to request enrollment may be obtained from assistant dean, Graduate Studies. Supervised investigation of advanced technical problems. S/U grading.

597A. Preparation for M.S. Comprehensive Examination. (2 to 12) Tutorial, to be arranged. Limited to graduate mechanical and aerospace engineering students. Reading and preparation for M.S. comprehensive examination. S/U grading.

597B. Preparation for Ph.D. Preliminary Examinations. (2 to 16) Tutorial, to be arranged. Limited to graduate mechanical and aerospace engineering students. Preparation for oral qualifying examination, including preliminary research on dissertation. S/U grading.

598. Research for and Preparation of M.S. Thesis. (2 to 12) Tutorial, to be arranged. Limited to graduate mechanical and aerospace engineering students. Supervised independent research for M.S. candidates, including thesis prospectus. S/U grading.

599. Research for and Preparation of Ph.D. Dissertation. (2 to 16) Tutorial, to be arranged. Limited to graduate mechanical and aerospace engineering students. Usually taken after students have been advanced to candidacy. S/U grading.