Mechanical and Aerospace Engineering

48-121 Engineering IV
Box 951597
Los Angeles, CA 90095-1597

310-825-7793
maeapp@seas.ucla.edu
http://mae.ucla.edu

Christopher S. Lynch, Ph.D., *Chair*
H. Pirouz Kavehpour, Ph.D., *Vice Chair*
Ajit K. Mal, Ph.D., *Vice Chair*

Professors

Mohamed A. Abdou, Ph.D.
Gregory P. Carman, Ph.D.
Yong Chen, Ph.D.
Pei-Yu Chiou, Ph.D.
Vijay K. Dhir, Ph.D.
Jeffrey D. Eldredge, Ph.D.
Timothy Fisher, Ph.D.
Rajit Gadh, Ph.D.
Nasr M. Ghoniem, Ph.D.
James S. Gibson, Ph.D.
Vijay Gupta, Ph.D.
Dennis W. Hong, Ph.D.
Tetsuya Iwasaki, Ph.D.
Y. Sungtaek Ju, Ph.D.
Ann R. Karagozian, Ph.D.
H. Pirouz Kavehpour, Ph.D.
Chang-Jin (CJ) Kim, Ph.D. *(Volgenau Endowed Professor of Engineering)*
J. John Kim, Ph.D. *(Rockwell Collins Professor of Engineering)*
Adrienne G. Lavine, Ph.D.
Xiaochun Li, Ph.D. *(Raytheon Company Professor of Manufacturing Engineering)*
Kuo-Nan Liou, Ph.D.
Christopher S. Lynch, Ph.D.
Ajit K. Mal, Ph.D.
Robert T. M'Closkey, Ph.D.
Ali Mosleh, Ph.D., NAE *(Evalyn Knight Professor of Engineering)*
Jayathi Y. Murthy, Ph.D., *Dean*
Laurent G. Pilon, Ph.D.
Jacob Rosen, Ph.D.
Jason L. Speyer, Ph.D. *(Ronald and Valerie Sugar Endowed Professor of Engineering)*
Tsu-Chin Tsao, Ph.D.
Xiaolin Zhong, Ph.D.

Professors Emeriti

Oddvar O. Bendiksen, Ph.D.
Ivan Catton, Ph.D. *(Research Professor)*
Peretz P. Friedmann, Sc.D.
Chih-Ming Ho, Ph.D. *(Ben Rich Lockheed Martin Professor Emeritus of Aeronautics)*
Robert E. Kelly, Sc.D.
Anthony F. Mills, Ph.D.
D. Lewis Mingori, Ph.D.
Peter A. Monkewitz, Ph.D.
Philip F. O'Brien, M.S.
Lucien A. Schmit, Jr., M.S.
Owen I. Smith, Ph.D.
Richard Stern, Ph.D.
Russell A. Westmann, Ph.D.
Daniel C.H. Yang, Ph.D.

Associate Professors
Robert N. Candler, Ph.D.
Jaime Marian, Ph.D.
Veronica J. Santos, Ph.D.
Richard E. Wirz, Ph.D.

Assistant Professors
Jonathan B. Hopkins, Ph.D.
Yongjie Hu, Ph.D.
M. Khalid Jawed, Ph.D.
Lihua Jin, Ph.D.
Raymond M. Spearrin, Ph.D.

Lecturers
Ravnesh C. Amar, Ph.D.
Amiya K. Chatterjee, Ph.D.
Robert J. Kinsey, Ph.D.
Damian M. Toohey, M.S.

Adjunct Professors
Dan M. Goebel, Ph.D.
Leslie M. Lackman, Ph.D.
Wilbur J. Marner, Ph.D.
Neil G. Siegel, Ph.D.

Adjunct Associate Professor
Abdon E. Sepulveda, Ph.D.

Scope and Objectives

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.

Department Mission

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, C150P, 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 156A—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 Engineering 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

Energy and Propulsion Research Laboratory researchers examine planar laser-induced fluorescence (PLIF) images of acetone-seeded gaseous jets in crossflow responding to different levels of helical excitation. L-R:

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:

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.

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, C296A, 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 being conducted. More information is at http://www.mae.ucla.edu.

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 vehicle 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 modem communication.

Beam Control Laboratory

James S. Gibson, *Director*

The Beam Control Laboratory involves students, faculty, and postdoctoral scholars 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 piezocompostite 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 Oersted's magnetism control discovery of 1820. TANMS goals are to translate its research discoveries to industry, while seamlessly integrating a cradle-to-career education philosophy involving its students and future engineers in unique research and entrepreneurial experiences.

Chen Research Group

Yong Chen, *Director*

The Chen Research Group studies nanofabrication, nanoscale electronic materials and devices, micro-nano electronic/optical/bio/mechanical systems, and ultra-scale spatial and temporal characterization.

Collaborative Center for Aerospace Sciences (CCAS)

Ann R. Karagozian, *Director*

The Collaborative Center for Aerospace Sciences (CCAS) is a multi-/trans-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 Iwasaki, *Director*

The Cybernetic Control Laboratory (CyCLab) aims to develop biologically inspired control theories for rhythmic movements and dynamic pattern formation with applications to robotic vehicles, devices for human assist, and rehabilitation.

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 modem 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.

Energy Innovation Laboratory

Richard E. Wirz, *Director*

The Energy Innovation Laboratory investigates high-impact renewable energy science and technology. Its current work primarily focuses on large-scale thermal energy storage for grid-scale applications and advanced wind energy capture.

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 thermofluids, thermomechanics, 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.

Hypersonics and Computational Aerodynamics Group

Xiaolin Zhong, *Director*

The Hypersonics and Computational Aerodynamics Group primarily focuses on fundamental physics-based research of hypersonic flows using advanced numerical tools; and application of discovered fundamental knowledge to real-world aerospace systems, such as development of hypersonic planes and space vehicles. Its main research areas are computational fluid dynamics (CFD), hypersonic flows, instability and transition of hypersonic boundary layers, interaction of strong shocks and turbulence, and numerical simulation of wave energy harvesting.

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 thermofluids 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 mechanics and ultrasonic nondestructive evaluation.

Materials in Extreme Environments Laboratory (MATRIX)

Nasr M. Ghoniem, *Director*

The Materials in Extreme Environments (MATRIX) Laboratory seeks answers to two fundamental questions: What are the physical phenomena that control the mechanical properties of engineering materials operating in extreme environmental conditions; and knowing such behavior, can we design engineering materials to be more resilient.

M'Closkey Laboratory

Robert T. M'Closkey, *Director*

The M'Closkey 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.

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 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, photomultiplicator 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 materials 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.

Optofluidics Systems Laboratory

Pei-Yu Chiou, *Director*

The Optofluidics 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 nanoprocessing 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. Tha 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; microparticle 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.

Thermochemical Energy Storage Laboratory

Adrienne G. Lavine, *Director*

The Thermochemical Energy Storage Laboratory is focused on use of reversible chemical reactions to store energy for renewable energy applications. The current focus is on ammonia synthesis for supercritical steam generation in a concentrating solar power plant. The ammonia synthesis reactor testing platform consists of three subsystems (dissociation, synthesis, and steam generation) that work in unison to create a closed-loop synthesis gas generator that can operate for an indefinite period of time.

Thin Films, Interfaces, Composites, Characterization Laboratory

Vijay Gupta, *Director*

The Thin Films, Interfaces, Composites, Characterization Laboratory includes a Nd:YAG laser of 1 Joule capacity with 3 ns pulse widths, a state-of-the-art optical interferometer including an ultra high-speed digitizer, sputter deposition chamber, 56 Kip-capacity servohydraulic biaxial test frame, and polishing and imaging equipment for microstructural characterization, for measurement and control study of thin film interface strength.

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, thermomechanics; 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 piezoelectric ceramics, magnetostrictive shape memory alloys, and multiferroic materials.

Yong Chen, Ph.D. (UC 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 Chiou, Ph.D. (UC 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, vorticity-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 transport, electrochemical and thermal energy storage, mechanics and transport in granular materials and porous media, plasma science and technology, aerospace thermal systems

Rajit Gadh, Ph.D. (Carnegie Mellon, 1991)
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 solution space for multilimbed mobile robots

Tetsuya Iwasaki, Ph.D. (Purdue, 1993)
Dynamical systems, robust and optimal controls, nonlinear oscillators, resonance entrainment, modeling and analysis of neuronal control 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. Karagozian, 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 Kavehpour, 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 (CJ) Kim, Ph.D. (UC Berkeley, 1991)
Microelectromechanical systems (MEMS), micro/nano devices and fabrication technologies, microfluidics especially involving surface tension and droplets

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 control

Adrienne Lavine, Ph.D. (UC 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. (UC 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 solids, 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

Jayathi 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. (UC 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 Catton, Ph.D. (UCLA, 1966)
Heat transfer and fluid mechanics, transport phenomena in porous media, nucleonics heat transfer and thermal hydraulics, natural and forced convection, thermal/hydrodynamic stability, turbulence

Peretz P. Friedmann, Sc.D. (MIT, 1972)
Aeroelasticity of helicopters and fixed-wing aircraft, structural dynamics of rotating systems, rotor dynamics, unsteady aerodynamics, active control of structural dynamics, structural optimization with aeroelastic constraints

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

Robert E. Kelly, Sc.D. (MIT, 1964)
Thermal convection, thermocapillary convection, stability of shear flows, stratified and rotating flows, interfacial phenomena, microgravity fluid dynamics

Anthony F. Mills, Ph.D. (UC 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

Philip F. O'Brien, M.S. (UCLA, 1949)
Industrial engineering, environmental design, thermal and luminous 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. (UC 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

Russell A. Westmann, Ph.D. (UC Berkeley, 1962)
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)
Robotics and mechanisms; CAD/CAM systems, computer-controlled machines

Associate Professors

Robert N. Candler, Ph.D. (Stanford, 2006)
MEMS and nanoscale devices, fundamental limitations of sensors, packaging, biological and chemical sensing

Jaime Marian, Ph.D. (UC Berkeley, 2002)
Computational materials modeling and simulation in solid mechanics, irradiation damage, plasticity, phase transformations, thermodynamics and kinetics of alloy systems, algorithm and method development for bridging time and length scales and parallel computing applications

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

Richard E. Wirz, Ph.D. (Caltech, 2005)
Electric propulsion (ion, Hall, electrosprays, cathodes); micro-electric propulsion; partially ionized plasma discharges; miniature plasma devices; spacecraft/space mission design; wind energy; solar thermal energy; thermal energy storage

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 nanofabrication processes; MEMS

Yongjie 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; ultrafast 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

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

Lecturers

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

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

Robert J. Kinsey, Ph.D. (UCLA, 1991)
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. Toohey, M.S. (MIT, 2004)
Guidance, navigation, and control for autonomous aircraft, launch vehicles, and missile systems, adaptive control techniques, automatic control reallocation for aircraft and re-entry vehicles

Adjunct Professors

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

Leslie M. Lackman, Ph.D. (UC Berkeley, 1967)
Structural analysis and design, composite structures, engineering management

Wilbur J. Marner, Ph.D. (U. South Carolina, 1969)
Thermal sciences, system design

Neil G. Siegel, Ph.D. (USC, 2011)
Organizing complex projects around critical skills and mitigation of risks arising from system dynamic behavior

Adjunct Associate Professor

Abdon E. Sepulveda, 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 and industry lecturers to mechanical 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)

15. Technical Communication for Engineers. (2) Lecture, two hours; outside study, four hours. Requisite: English Composition 3. Understanding writing process. Determining the purpose. Prewriting. Principles of organizing technical information. Eliminating unnecessary words, structuring paragraphs clearly, structuring effective sentences. Writing abstracts, introductions, and conclusions. Drafting and revising coherent documents. Writing collaboratively. Letter grading. Ms. Lavine (Not offered 2017-18)

19. Fiat Lux Freshman Seminars. (1) Seminar, one hour. Discussion of and critical thinking about topics of current intellectual importance, taught by faculty members in their areas of expertise and illuminating many paths of discovery at UCLA. P/NP grading.

M20. Introduction to Computer Programming with MATLAB. (4) (Same as Civil Engineering M20.) Lecture, two hours; discussion, two hours; laboratory, two hours; outside study, six hours. Requisite: Mathematics 33A. Fundamentals of computer programming taught in context of MATLAB computing environment. Basic data types and control structures. Input/output. Functions. Data visualization. MATLAB-based data structures. Development of efficient codes. Introduction to object-oriented programming. Examples and exercises from engineering, mathematics, and physical sciences. Letter grading. Mr. Eldredge, Mr. Taciroglu (F,W,Sp)

82. Mathematics of Engineering. (4) (Formerly numbered 182A.) Lecture, four hours; discussion, two hours; outside study, six hours. Requisite: Mathematics 33A. Methods of solving ordinary differential equations in engineering. Review of matrix algebra. Solutions of systems of first- and second-order ordinary differential equations. Introduction to Laplace transforms and their application to ordinary differential equations. Introduction to boundary value problems, partial differential equating, and separation of variables. Letter grading. Mr. Mal (F,W,Sp)

94. Introduction to Computer-Aided Design and Drafting. (4) Lecture, two hours; laboratory, four hours. Fundamentals of computer graphics and two- and three-dimensional modeling on computer-aided design and drafting systems. Students use one or more online computer systems to design and display various objects. Letter grading. Mr. Gadh, Mr. Li (F,W,Sp)

99. Student Research Program. (1 to 2) Tutorial (supervised research or other scholarly work), three hours per week per unit. Entry-level research for lower division students under guidance of faculty mentor. Students must be in good academic standing and enrolled in minimum of 12 units (excluding this course). Individual contract required; consult Undergraduate Research Center. May be repeated. P/NP grading.

Upper-Division Courses

101. Statics and Strength of Materials. (4) (Formerly numbered 96.) Lecture, four hours; discussion, two hours; outside study, six hours. Requisites: Mathematics 31A, 31B, Physics 1A. Review of vector representation of forces, resultant force and moment, equilibrium of concurrent and nonconcurrent forces. Area moments and products of inertia. Support reactions, free-body diagrams. Forces in simple models of mechanical and aerospace structures. Internal forces in beams, shear and moment diagrams. Stress and strain components in solids, equilibrium equations, Hooke's law for isotropic solids. Bending and shear stresses in beams. Deflection of symmetric beams and indeterminate problems. Stresses in thin-walled pressure vessels and in circular cylinders under torsion. Letter grading. Mr. Mal (F,W,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,W,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,W,Sp)

105A. Introduction to Engineering Thermodynamics. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Requisites: Chemistry 20B, Mathematics 32B. Phenomenological thermodynamics. Concepts of equilibrium, temperature, and reversibility. First law and concept of energy; second 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. Pilon (F,W,Sp)

105D. Transport Phenomena. (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,W)

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 analysis, and numerical solution. Nonlinear differential equation descriptions with discussion of equilibrium solutions, small signal linearization, large signal response. Block diagram representation and response of interconnections of systems. Hands-on experiments reinforce lecture material. Letter grading. Mr. M'Closkey, Mr. Tsao (F,W,Sp)

131A. Intermediate Heat Transfer. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Enforced requisites: courses M20 (or Civil Engineering M20 or Computer Science 31), 82, 105D. Steady conduction: two-sided, two-ended, tapered, and circular fins; buried cylinders, thick fins. Transient conduction: slabs, cylinders, products. Convection: transpiration, laminar pipe flow, film condensation, boundary layers, dimensional analysis, working correlation, surface radiation. Two-stream heat exchangers. Elements of thermal design. Letter grading. Ms. Lavine (F)

C132A. Mass Transfer. (4) Lecture, four hours; outside study, eight hours. Requisites: courses 105D, 131A. Principles of mass transfer by diffusion and convection. Simultaneous heat and mass transfer. Transport in multicomponent systems. Thermal, forced, and pressure diffusion, Brownian diffusion. Analysis of evaporative and transpiration cooling, catalysis, and combustion. Mass exchangers, including automobile catalytic converters, electrostatic precipitators, filters, scrubbers, humidifiers, and cooling towers. Concurrently scheduled with course C232A. Letter grading. Mr. Pilon (Not offered 2017-18)

133A. Engineering Thermodynamics. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Requisites: courses 103, 105A. Applications of thermodynamic principles to engineering processes. Energy conversion systems. Rankine cycle and other cycles, refrigeration, psychrometry, reactive and nonreactive fluid flow systems. Elements of thermodynamic design. 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: course 82, Chemistry 20A. Review of nuclear physics, radioactivity and decay, and radiation interaction with matter. Nuclear fission and fusion processes and mass defect, chain reactions, criticality, neutron diffusion and multiplication, heat transfer issues, and applications. 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. Pilon (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 correction; microgrids; grid stability; energy storage and electric vehicles-simulation; monitoring; distribution and transmission grids; consumer-centric technologies; sensors, communications, and computing; wireless, wireline, and powerline 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. Requisites: courses 101, 102, and 156A or 166A. Introduction to mechanical functions of human body; skeletal adaptations to optimize load transfer, mobility, and function. Dynamics and kinematics. Fluid mechanics applications. Heat and mass transfer. Power generation. Laboratory simulations and tests. Concurrently scheduled with course CM240. Letter grading. Mr. Gupta (W)

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, random walks and diffusion, mechanosensitive 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. Mr. Lynch (Not offered 2017-18)

150A. Intermediate Fluid Mechanics. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Enforced requisites: courses 82, 103. Basic equations governing fluid motion. Fundamental solutions of Navier/Stokes equations. Lubrication theory. Elementary potential flow theory. Boundary layers. Turbulent flow in pipes and boundary layers. Compressible flow: normal shocks, channel flow with friction or heat addition. Letter grading. Mr. Eldredge, Ms. Karagozian (F,W)

150B. Aerodynamics. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Requisites: courses 103, 150A. Advanced aspects of potential flow theory. Incompressible flow around thin airfoils (lift and moment coefficients) and wings (lift, induced drag). Gas dynamics: oblique shocks, Prandtl/Meyer expansion. Linearized subsonic and supersonic flow around thin airfoils and wings. Wave drag. Transonic flow. Letter grading. Mr. Zhong (Sp)

150C. Combustion Systems. (4) Lecture, four hours; outside study, eight hours. Enforced requisites: courses 103, 105A. Chemical thermodynamics of ideal gas mixtures, premixed and diffusion flames, explosions and detonations, combustion chemistry, high explosives. Combustion processes in rocket, turbine, and internal combustion engines; heating applications. Letter grading.
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 C250G. 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 105A, 150A. Thermodynamic properties of gases, aircraft jet engine cycle analysis and component performance, component matching, advanced aircraft engine topics. Concurrently scheduled with course C250P. Letter grading. Ms. Karagozian (F)

C150R. Rocket Propulsion Systems. (4) (Formerly numbered 150R.) Lecture, four hours; discussion, two hours; outside study, six hours. Enforced requisites: courses 103, 105A. Rocket propulsion 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. Wirz (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 of aircraft, including weight estimation, performance and stability, and control consideration. Term assignment consists of preliminary design of low-speed aircraft. Letter grading.
Mr. Lynch (W)

154B. Design of Aerospace Structures. (4) Lecture, four hours; outside study, eight hours. Requisites: courses 154A, 166A. Design of aircraft, helicopter, spacecraft, and related structures. External loads, internal stresses. Applied theory of thin-walled structures. Material selection, design using composite materials. Design for fatigue prevention and structural optimization. Field trips to aerospace companies. Letter grading. Mr. Lynch (Sp)

154S. Flight Mechanics, Stability, and Control of Aircraft. (4) Lecture, four hours; discussion, one hour; outside study, seven hours. Requisites: courses 150A, 150B. Aircraft performance, flight mechanics, stability, and control; some basic ingredients needed 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. Axioms 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. Gibson (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, strain, and material behavior. Stresses in loaded beams with symmetric and asymmetric cross sections. Torsion of cylinders and thin-walled structures, shear flow. Stresses in pressure vessels, press-fit and shrink-fit problems, rotating shafts. Curved beams. Contact stresses. Strength and failure, plastic deformation, fatigue, elastic instability. Letter grading.
Mr. Mal (F,Sp)

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 shafting. Design project involving computer-aided design (CAD) and finite element analysis (FEA) modeling. Concurrently scheduled with course C296A. Letter grading.
Mr. Ghoniem (Sp)

157. Basic Mechanical and Aerospace Engineering Laboratory. (4) Laboratory, eight 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)

157A. 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 of 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. Enforced requisites: courses 102, 103, 105A, Electrical Engineering 100. Recommended: course 15. Measurements of basic physical quantities in fluid mechanics, thermodynamics, and structures. Operation of primary transducers, computer-aided data acquisition, signal processing, and data analysis. Performance of experiments to enhance understanding of basic physical principles and characteristics of structures/systems of relevance to aerospace engineering. Letter grading.
Mr. Ghoniem, Mr. Ju (Not offered 2017-18)

161A. Introduction to Astronautics. (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 orbits. Orbital and transfer maneuvers, patched conics, perturbation theory, low-thrust trajectories, spacecraft pointing, and spacecraft attitude control. Space mission design, space environment, rendezvous, reentry, and launch. Letter grading. Mr. Wirz (F)

161B. Introduction to Space Technology. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Recommended preparation: courses 102, 161A. Spacecraft systems and dynamics, including spacecraft power, instruments, communications, structures, materials, thermal control, and attitude/orbit determination and control. Space mission design, launch vehicles/considerations, space propulsion. Letter grading. Mr. Wirz (W)

161C. Spacecraft Design. (4) Lecture, four hours; outside study, eight hours. Enforced requisite: course 161B. Preliminary design and analysis by students of Earth-orbiting or interplanetary space missions and spacecraft. Students work in groups of three or four, with each student responsible primarily for one subsystem and for integration with whole. Letter grading.
Mr. Wirz (Sp)

161D. Space Technology Hardware Design. (4) Lecture, four hours; laboratory, four hours; outside study, four hours. Enforced requisite: course 161B. Design by students of hardware with applications to space technology. Designs are then built by HSSEAS professional machine shop and tested by students. Letter grading. Mr. Wirz (Not offered 2017-18)

162A. Introduction to Mechanisms and Mechanical Systems. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Enforced requisites: courses M20 (or Computer Science 31), 102. Analysis and synthesis of mechanisms and mechanical systems. Kinematics, dynamics, and mechanical advantages of machinery. Displacement velocity and acceleration analyses of linkages. Fundamental law of gearing and various gear trains. Computer-aided mechanism design and analysis. Letter grading.
Mr. Hopkins (F,Sp)

162D. Mechanical Engineering Design I. (4) Lecture, two hours; laboratory, four hours; outside study, six hours. Enforced requisites: courses 94, 156A (or 183A or M183B), 162A (or 171A). Limited to seniors. First of two mechanical engineering capstone design courses. Lectures on engineering project management, design of thermal systems, mechatronics, mechanical systems, and mechanical components. 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 II. (4) Lecture, two hours; laboratory, four hours; outside study, six hours. Enforced requisite: course 162D. Limited to seniors. Second of two mechanical engineering capstone design courses. Student groups continue design projects started in course 162D, making use of CAD design laboratory, CAD analysis laboratory, and mechatronics laboratory. Design theory, design tools, economics, marketing, manufacturability, quality, intellectual property, design for manufacture and assembly, design for safety and reliability, and engineering ethics. Students conduct hands-on design, fabrication, and testing. Culminating project demonstrations or competition. Preparation of design project presentations in both oral and written formats. Letter grading. Mr. Ghoniem, Mr. Tsao (Sp)

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 laws, yield and fatigue; bending of beams; torsion of beams; warping; torsion of thin-walled cross sections: shear flow, shear-lag; combined bending torsion of thin-walled, stiffened structures used in aerospace vehicles; elements of plate theory; buckling of columns. Letter grading. Mr. Carman (F)

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 laminates, failure analysis, design examples and design studies, buckling of composite components, nonsymmetric laminates, 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; isoparametric formulation 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 (Sp)

169A. Introduction to Mechanical Vibrations. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Requisites: courses 101, 102, 107. Fundamentals of vibration theory and applications. Free, forced, and transient vibration of one and two degrees of freedom systems, including damping. Normal modes, coupling, and normal coordinates. Vibration isolation devices, vibrations of continuous systems. 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 principles, control systems design, and system stability. Modeling of physical systems in engineering and other fields; transform methods; controller design using Nyquist, Bode, and root locus methods; compensation; computer-aided analysis and design. Letter grading. Mr. M'Closkey (F,W,Sp)

171B. Digital Control of Physical Systems. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Enforced requisite: course 171A or Electrical Engineering 141. Analysis and design of digital control systems. Sampling theory. Z-transformation. Discrete-time system representation. Design using classical methods: performance specifications, root locus, frequency response, loop-shaping compensation. Design using state-space methods: state feedback, state estimator, state estimator feedback control. Simulation of sampled data systems and practical aspects: roundoff errors, sampling rate selection, computation delay. Letter grading. Mr. Tsao (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. Requisite: Mathematics 33A. Introduction to probability theory; random variables, distributions, functions of random variables, models of failure of components, reliability, redundancy, complex systems, stress-strength models, fault tree analysis, statistical quality control by variables and by attributes, acceptance sampling. Letter grading. Mr. Mosleh (F)

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

182B. Mathematics of Engineering. (4) Lecture, four hours; discussion, one hour; outside study, seven hours. Enforced requisite: course 82. Analytical methods for solving partial differential equations arising in engineering. Separation of variables, eigenvalue problems, Sturm/Liouville theory. Development and use of special functions. Representation by means of orthonormal functions; Galerkin method. Use of Green's function and transform methods. Letter grading. Mr. Eldredge, Mr. J. Kim (W)

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), 82. Basic topics from numerical analysis having wide application in solution of practical engineering problems, computer arithmetic, and errors. Solution of linear and nonlinear systems. Algebraic eigenvalue problem. Least-square methods, numerical quadrature, and finite difference approximations. Numerical solution of initial and boundary value problems for ordinary and partial differential equations. Letter grading. Mr. Zhong (F)

183A. Introduction to Manufacturing Processes. (4) (Formerly numbered 183.) Lecture, three hours; laboratory, four hours; outside study, five hours. Enforced requisite: Materials Science 104. Manufacturing fundamentals. Materials in manufacturing. Solidification processes. Metal forming processes. Material removal processes. Welding/joining. Rapid prototyping. Electronics manufacturing. Microelectromechanical systems (MEMS) and nanotechnology. Letter grading. Mr. C-J. Kim (F,W,Sp)

M183B. Introduction to Microscale and Nanoscale Manufacturing. (4) (Same as Bioengineering M153, Chemical Engineering M153, and 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, constrains, and microfabrication and nanofabrication. Focus on concepts, physics, and instruments of various microfabrication and nanofabrication techniques that have been broadly applied in industry and academia, including various photolithography technologies, physical and chemical deposition methods, and physical and chemical etching methods. Hands-on experience for fabricating microstructures and nanostructures in modern cleanroom environment. Letter grading. Mr. Chiou (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 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 speed and flexibility of desktop publishing, 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 meso-/micro-/nano-scale to produce three-dimensional functional miniature components. 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 requisites: courses M20 (or Civil Engineering M20 or Computer Science 31), 94. Fundamentals in parametric curve and surface modeling, parametric spaces, blending functions, conics, splines and Bezier curve, coordinate transformations, algebraic and geometric form of surfaces, analytical properties of curve and surface, hands-on experience with CAD/CAM systems design and implementation. Letter grading. Mr. Gadh (Not offered 2017-18)

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 requisite: course M20 or Civil Engineering M20 or Computer Science 31. Manufacturing today requires assembling 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, stored, 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. Gadh (Sp)

C186. Applied Optics. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Requisite: Physics 1C. Fundamental principles of optical systems. Geometric optics and aberration theory. Diffraction and interference. Fourier optics, beam optics. Propagation of light, Snell's law, and Huygen principle. Refraction and reflection. Plane waves, spherical waves, and image formation. Total internal reflection. Polarization, polarizers, and wave-plates. Lenses and aberrations, lens laws and formation of images, resolution and primary aberrations. Simple optical instruments, still cameras, shutters, apertures. Design of telescopes, microscope design, projection system design. Interference, Young's slit experiment and fringe visibility, Michelson interferometer, multiple-beam interference and thin film coatings. Diffraction theory, Fraunhofer and Fresnel diffraction, Fresnel zone plate. Fiber optics, waveguides and modes, fiber coupling, types of fiber: single and multimode. Concurrently scheduled with course C286. Letter grading. Mr. Chiou (F)

C187L. 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, nanocharacterization (AEM, SEM, etc.), and optical and electrochemical biosensors. Students encouraged 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 Aerospace 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 temporary basis, such as those taught by resident 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 projects in research specialty. May be repeated for credit. P/NP or letter grading.

199. Directed Research in Mechanical and Aerospace Engineering. (2 to 8) Tutorial, to be arranged. Limited to juniors/seniors. Supervised individual research or investigation under guidance of faculty mentor. Culminating paper or project required. May be repeated for credit with school approval. Individual contract required; enrollment petitions available in Office of Academic and Student Affairs. Letter grading. (F,W,Sp)

Graduate Courses

231A. Convective Heat Transfer Theory. (4) Lecture, four hours; outside study, eight hours. Requisites: courses 131A, 182B. Recommended: course 250A. Conservation equations for flow of real fluids. Analysis of heat transfer in laminar and turbulent, incompressible and compressible flows. Internal and external flows; free convection. Variable wall temperature; effects of variable fluid properties. Analogies among convective transfer processes. Letter grading. Ms. Lavine (W)

231B. Radiation Heat Transfer. (4) Lecture, four hours; outside study, eight hours. Requisite: course 105D. Radiative properties of materials and radiative energy transfer. Emphasis on fundamental concepts, including energy levels and electromagnetic waves 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)

231C. Phase Change Heat Transfer and Two-Phase Flow. (4) Lecture, four hours; outside study, eight hours. Requisites: courses 131A, 150A. Two-phase flow, boiling, and condensation. Generalized constitutive equations for two-phase flow. Phenomenological theories of boiling and condensation, including forced flow effects. Letter grading.
Ms. Lavine (W)

231G. Microscopic Energy Transport. (4) Lecture, four hours; outside study, eight hours. Requisite: course 105D. Heat carriers (photons, electronics, phonons, molecules) and their energy characteristics, statistical properties of heat carriers, scattering and propagation of heat carriers, Boltzmann transport equations, derivation of classical laws from Boltzmann transport equations, deviation from classical laws at small scale. Letter grading. Mr. Ju (F)

C232A. Mass Transfer. (4) Lecture, four hours; outside study, eight hours. Requisites: courses 105D, 131A. Principles of mass transfer by diffusion and convection. Simultaneous heat and mass transfer. Transport in multicomponent systems. Thermal, forced, and pressure diffusion, Brownian diffusion. Analysis of evaporative and transpiration cooling, catalysis, and combustion. Mass exchangers, including automobile catalytic converters, electrostatic precipitators, filters, scrubbers, humidifiers, and cooling towers. Concurrently scheduled with course C132A. Letter grading. Mr. Pilon (Not offered 2017-18)

233. Nanoscience for Energy Technologies. (4) Lecture, four hours; outside study, eight hours. Introduction to fundamental principles of energy transport, conversion, and storage at nanoscale, and recent development for these energy technologies involving nanotechnology. Focus on basics of thermal science, solid state, quantum mechanics, electromagnetics, and statistical physics. Topic discussions given for examples that connect technological application, fundamental challenge, and scientific-solution-based nanotechnology to improve device performance and energy efficiency. Letter grading.
Mr. Hu (Sp)

235A. Nuclear Reactor Theory. (4) Lecture, four hours; outside study, eight hours. Underlying physics and mathematics of nuclear reactor (fission) core design. Diffusion theory, reactor kinetics, slowing down and thermalization, multigroup methods, introduction to transport theory. Letter grading. Mr. Abdou (F)

C237. 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 correction; microgrids; grid stability; energy storage and electric vehicles-simulation; monitoring; distribution and transmission grids; consumer-centric technologies; sensors, communications, and computing; wireless, wireline, and powerline 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 C137. Letter grading.
Mr. Gadh (Not offered 2017-18)

M237B. Fusion Plasma Physics and Analysis. (4) (Same as Electrical and Computer Engineering M287.) Lecture, four hours; outside study, eight hours. Fundamentals of plasmas at thermonuclear burning conditions. Fokker/Planck equation and applications to heating by neutral beams, RF, and fusion reaction products. Bremsstrahlung, synchrotron, and atomic radiation processes. Plasma surface interactions. Fluid description of burning plasma. Dynamics, stability, and control. Applications in tokamaks, tandem mirrors, and alternate concepts. Letter grading. Mr. Abdou (F)

237D. Fusion Engineering and Design. (4) Lecture, four hours; outside study, eight hours. Fusion reactions and fuel cycles. Principles of inertial and magnetic fusion. Plasma requirements for controlled fusion. Plasma-surface interactions. Fusion reactor concepts and technological components. Analysis and design of high heat flux components, energy conversion and tritium breeding components, radiation shielding, magnets, and heating. Letter grading.
Mr. Abdou (Not offered 2017-18)

239B. Seminar: Current Topics in Transport Phenomena. (2 to 4) Seminar, two to four hours; outside study, four to eight hours. Designed for graduate mechanical and aerospace engineering students. Lectures, discussions, student presentations, and projects in areas of current interest in transport phenomena. May be repeated for credit. 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 one or more aspects of heat and mass 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.

239G. Special Topics in Nuclear Engineering. (2 to 4) Lecture, 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.

239H. Special Topics in Fusion Physics, Engineering, and Technology. (2 to 4) Seminar, two to four hours; outside study, four to eight hours. Designed for graduate mechanical and aerospace engineering students. Advanced treatment of subjects selected from research areas in fusion science and engineering, such as instabilities in burning plasmas, alternate fusion confinement concepts, inertial confinement fusion, fission-fusion hybrid systems, and fusion reactor safety. May be repeated for credit with topic change. S/U grading.

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

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. Structure of macromolecules, polymers as entropic springs, random walks and diffusion, mechanosensitive 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 CM141. Letter grading.
Mr. Lynch (Not offered 2017-18)

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, as well as fundamental physics underlying ferroelectricity and ferromagnetism. Material science description of these materials, with focus on linear and nonlinear behavior with associated mechanisms such as spin reorientation. Presentation of analytical tools necessary to predict material response ranging from constitutive relations to governing equations, including elastodynamics and Maxwell's. Analytical and physical descriptions used to explain several devices manufactured with multiferroics, including magnetometers, memory devices, motors, and antennas. Letter grading.
Mr. Carman (Sp)

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 mechanics at graduate level, with emphasis on incompressible flow. Flow kinematics, basic equations, constitutive relations, exact solutions on the Navier/Stokes equations, vorticity dynamics, decomposition of flow fields, potential flow. Letter grading.
Mr. Eldredge, Mr. J. Kim (W)

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 fluid resistance. States of fluid motion discussed in order of advancing Reynolds number; wakes, boundary layers, instability, transition, and turbulent shear flows. Letter grading.
Ms. Karagozian, Mr. J. Kim (Sp)

250C. Compressible Flows. (4) Lecture, four hours; outside study, eight hours. Requisites: courses 150A, 150B. Effects of compressibility in viscous and inviscid flows. Steady and unsteady inviscid subsonic and supersonic flows; method of characteristics; small disturbance theories (linearized and hypersonic); shock dynamics. Letter grading.
Ms. Karagozian, Mr. Zhong (F)

250D. Computational Aerodynamics. (4) Lecture, eight hours. Requisites: courses 150A, 150B, 182C. Introduction to useful methods for computation of aerodynamic flow fields. Coverage of potential, Euler, and Navier/Stokes equations for subsonic to hypersonic speeds. Letter grading.
Mr. Zhong (Not offered 2017-18)

250E. Spectral Methods in Fluid Dynamics. (4) Lecture, four hours; outside study, eight hours. Enforced requisites: courses 82, 182B, 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)

250F. 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. Requisites: courses 150A, 182C. Review of 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. Letter grading. Mr. Eldredge (F)

250M. Introduction to Microfluids/Nanofluids. (4) Lecture, four hours; outside study, eight hours. Requisite: course 150A. Introduction to fundamentals of microfluids. No-slip and slip boundary conditions. Sedimentation and diffusion in liquids. Osmotic pressure and Donnan equilibrium in fluid mixtures. Fundamentals of surface phenomena, spreading, and contact angles. Introduction to van der Waals interactions, electrical double layer, and zeta potential. Basics of non-Newtonian fluid mechanics. Letter grading. Mr. Kavehpour (Not offered 2017-18)

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

C250R. Rocket Propulsion Systems. (4) Lecture, four hours; discussion, two hours; outside study, six hours. Enforced requisites: courses 103, 105A. Rocket propulsion 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 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, subcritical instabilities, supercritical states, transition to turbulence. Letter grading. Mr. Zhong (Not offered 2017-18)

252B. Turbulence. (4) Lecture, four hours; outside study, eight hours. Requisites: courses 250A, 250B. Characteristics of turbulent flows, conservation and transport equations, statistical description of turbulent flows, scales of turbulent motion, simple turbulent flows, free-shear flows, wall-bounded flows, turbulence modeling, numerical simulations of turbulent flows, and turbulence control. Letter grading. Mr. J. Kim (Not offered 2017-18)

252C. Fluid Mechanics of Combustion Systems. (4) Lecture, four hours; outside study, eight hours. Requisites: courses 150A, 150B. Recommended: course 250C. Review of fluid mechanics and chemical thermodynamics applied to reactive systems, laminar diffusion flames, premixed laminar flames, stability, ignition, turbulent combustion, supersonic combustion. Letter grading. Ms. Karagozian (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 treatments, ion and electron diffusion, gas diffusion, 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 arcs. Letter grading. Mr. Wirz (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 of current interest in advanced aerodynamics. Examples include transonic flow, hypersonic flow, sonic booms, and unsteady aerodynamics. Letter grading. Mr. Zhong (Not offered 2017-18)

255A. Advanced Dynamics. (4) Lecture, four hours; outside study, eight hours. Requisites: courses 155, 169A. Variational principles and Lagrange equations. Kinematics and dynamics of rigid bodies; procession and nutation of spinning bodies. Letter grading. Mr. Gibson (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. Requisite: course 156A or 166A. Linear elastostatics. Cartesian tensors; infinitesimal strain tensor; Cauchy stress tensor; strain energy; equilibrium equations; linear constitutive relations; plane elastostatic problems, holes, corners, inclusions, cracks; three-dimensional problems of Kelvin, Boussinesq, and Cerruti. Introduction to boundary integral equation method. Letter grading. Mr. W. 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)

M256C. Plasticity. (4) (Same as Civil Engineering M230C.) Lecture, four hours; outside study, eight hours. Requisites: courses M256A, M256B. Classical rate-independent plasticity theory, yield functions, flow rules and thermodynamics. Classical rate-dependent viscoplasticity, Perzyna and Duvant/Lions types of viscoplasticity. Thermoplasticity and creep. Return mapping algorithms for plasticity and viscoplasticity. Finite element implementations. Letter grading. Mr. Gupta (Not offered 2017-18)

256F. 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 stiffened structures, pressure vessels, plates, and shells. Letter grading. Mr. Gupta (Sp)

M257A. Elastodynamics. (4) (Same as Earth, Planetary, and Space Sciences M224A.) Lecture, four hours; outside study, eight hours. Requisites: courses M256A, M256B. Equations of linear elasticity, Cauchy equation of motion, constitutive relations, boundary and initial conditions, principle of energy. Sources and waves in unbounded isotropic, anisotropic, and dissipative solids. Half-space problems. Guided waves in layered media. Applications to dynamic fracture, nondestructive evaluation (NDE), and mechanics of earthquakes. Letter grading. Mr. Mal (Not offered 2017-18)

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. Discussion of atomistic simulation methods (e.g., molecular dynamics, Langevin dynamics, and kinetic Monte Carlo) and their applications at nanoscale. Developments and applications of dislocation dynamics and statistical mechanics methods in areas of nanostructure and microstructure self-organization, heterogeneous plastic deformation, material instabilities, and failure phenomena. Presentation of technical applications of these emerging modeling techniques to surfaces and interfaces, grain boundaries, dislocations and defects, surface growth, quantum dots, nanotubes, nanoclusters, thin films (e.g., optical thermal barrier coatings and ultrastrong nanolayer materials), nano-identification, smart (active) materials, nanobending and microbending, and torsion. Letter grading. Mr. Ghoniem (Not offered 2017-18)

259A. Seminar: Advanced Topics in Fluid Mechanics. (4) Seminar, four hours; outside study, eight hours. Advanced study of topics in fluid mechanics, with intensive student participation involving assignments in research problems leading to term paper or oral presentation (possible help from guest lecturers). Letter grading. Mr. Kavehpour, Mr. Spearrin (F)

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

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, discussions, and student presentations and projects in areas of current interest in mechanical engineering. May be repeated for credit. S/U grading.

261A. Energy and Computational Methods in Structural Mechanics. (4) Lecture, four hours; outside study, eight hours. Requisite: course 156A or 166A. Review of theory of linear elasticity and reduced structural theories (rods, plates, and shells). Calculus of variations. Virtual work. Minimum and stationary variational principles. Variational approximation methods. Weighted residual methods, weak forms. Static finite element method. Isoparametric elements, beam and plate elements. Numerical quadrature. Letter grading. Mr. Mal (F)

261B. Computational Mechanics of Solids and Structures. (4) Lecture, four hours; outside study, eight hours. Requisite: course 261A. Variational formulation and computer implementation of linear elastic finite element method. Error analysis and convergence. Methods for large displacements, large deformations, and other geometric nonlinearities. Solution techniques for nonlinear equations. Finite element method for dynamics of solids and structures. Time integration algorithms. Term projects using digital computers. Letter grading. Mr. Mal (Not offered 2017-18)

262. Mechanics of Intelligent Material Systems. (4) Lecture, four hours; outside study, eight hours. Recommended requisite: course 166C. Constitutive relations for electro-magneto-mechanical materials. Fiber-optic sensor technology. Micro/macro analysis, including classical lamination theory, shear lag theory, concentric cylinder analysis, hexagonal models, and homogenization techniques as they apply to active materials. Active systems design, inch-worm, and bimorph. 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 spatial descriptions and transformations (Euler angles, Denavit-Hartenberg/DH parameters, equivalent angle vector), frame assignment procedure, direct kinematics, inverse kinematics (geometric and algebraic approaches), mechanical design topics. Letter grading. Mr. Hong (F)

263B. Dynamics of Robotic Systems. (4) Lecture, four hours; outside study, eight hours. Enforced requisite: course 263A. Recommended: course 255B. Dynamics models 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 and force), velocity propagation method, force propagation method, explicit formulation of Jacobian matrix, manipulator dynamics (Newton/Euler formulation, Lagrangian formulation), trajectory generation, introduction to parallel manipulators. Letter grading. Mr. Rosen (W)

263C. 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 topics from nonlinear and adaptive control, hybrid control, nonholonomic systems, vision-based control, and perception. Letter grading. Ms. Santos (Sp)

263D. Advanced Topics in Robotics and Control. (4) Lecture, four hours; outside study, eight hours. Enforced requisite: course 263C. Current and advanced topics in robotics and control, including kinematics, dynamics, control, mechanical design, advanced sensors and actuators, flexible links, manipulability, redundant manipulators, human-robot interaction, teleoperation, haptics. Letter grading. Mr. Rosen (Not offered 2017-18)

M269A. Dynamics of Structures. (4) (Same as Civil Engineering M237A.) Lecture, four hours; outside study, eight hours. Requisite: course 169A. Principles of dynamics. Determination of normal modes and frequencies by differential and integral equation solutions. Transient and steady state response. Emphasis on derivation and solution of governing equations using matrix formulation. Letter grading. Mr. Mal (W)

269B. Advanced Dynamics of Structures. (4) Lecture, four hours; outside study, eight hours. 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)

269D. Aeroelastic Effects in Structures. (4) Lecture, four hours; outside study, eight hours. Requisite: course M269A. Presentation of field of aeroelasticity from unified viewpoint applicable to flight structures, suspension bridges, buildings, and other structures. Derivation of aeroelastic operators and unsteady airloads from governing variational principles. Flow induced instability and response of structural systems. Letter grading. Mr. Mal (Not offered 2017-18)

M270A. Linear Dynamic Systems. (4) (Same as Chemical Engineering M280A and Electrical and Computer Engineering M240A.) Lecture, four hours; outside study, eight hours. Requisite: course 171A or Electrical and Computer Engineering 141. State-space description of linear time-invariant (LTI) and time-varying (LTV) systems in continuous and discrete time. Linear algebra concepts such as eigenvalues and eigenvectors, singular values, Cayley/Hamilton theorem, Jordan form; solution of state equations; stability, controllability, observability, realizability, and minimality. Stabilization design via state feedback and observers; separation principle. Connections with transfer function techniques. Letter grading. Mr. M'Closkey (F)

270B. Linear Optimal Control. (4) Lecture, four hours; outside study, eight hours. Requisite: course M270A or Electrical Engineering M240A. Existence and uniqueness of solutions to linear quadratic (LQ) optimal control problems for continuous-time and discrete-time systems, finite-time and infinite-time problems; Hamiltonian systems and optimal control; algebraic and differential Riccati equations; implications of controllability, stabilizability, observability, and detectability solutions. Letter grading. Mr. Gibson (W)

M270C. Optimal Control. (4) (Same as Chemical Engineering M280C and Electrical and Computer Engineering M240C.) Lecture, four hours; outside study, eight hours. 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 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 requisites: courses 82, 107. Probability spaces, random variables, stochastic sequences and processes, expectation, conditional expectation, Gauss/Markov sequences, and minimum variance estimator (Kalman filter) with applications. Concurrently scheduled with course C175A. Letter grading. Mr. Speyer (F)

271B. Stochastic Estimation. (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. Mr. Speyer (W)

271C. Stochastic Optimal Control. (4) Lecture, four hours; outside study, eight hours. Requisite: course 271B. Stochastic dynamic programming, certainty equivalence principle, separation theorem, information statistics; linear-quadratic-Gaussian problem, linear-exponential-Gaussian problem. Relationship between stochastic control and robust control. Letter grading. Mr. Speyer (Not offered 2017-18)

271D. Seminar: Special Topics in Dynamic Systems Control. (4) Seminar, four hours; outside study, eight hours. Seminar on current research topics in dynamic systems modeling, control, and applications. Topics selected from process control, differential games, nonlinear estimation, adaptive filtering, industrial and aerospace applications, etc. 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. Requisite: course M270A or Chemical Engineering M280A or Electrical and Computer Engineering M240A. 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, input-to-state stability and small-gain theorem. Letter grading. (Not offered 2017-18)

273A. Robust Control System Analysis and Design. (4) Lecture, four hours; outside study, eight hours. Requisites: courses 171A, M270A. Graduate-level introduction to analysis and design of multivariable control systems. Multivariable loop-shaping, performance requirements, model uncertainty representations, and robustness covered in detail from frequency domain perspective. Structured singular value and its application to controller synthesis. Letter grading. Mr. M'Closkey (Not offered 2017-18)

275A. System Identification. (4) Lecture, four hours; outside study, eight hours. Methods for identification of dynamical systems from input/output data, with emphasis on identification of discrete-time (digital) models of sampled-data systems. Coverage of conversion to continuous-time models. Models identified include 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)

M276. Dynamic Programming. (4) (Same as Electrical and Computer Engineering M237.) Lecture, four hours; outside study, eight hours. Recommended requisite: Electrical and Computer Engineering 232A or 236A or 236B. Introduction to mathematical analysis of sequential decision processes. Finite horizon model in both deterministic and stochastic cases. Finite-state infinite horizon model. Methods of solution. Examples from inventory theory, finance, optimal control and estimation, Markov decision processes, combinatorial optimization, communications. Letter grading. (Not offered 2017-18)

277. Advanced Digital Control for Mechatronic Systems. (4) Lecture, four hours; laboratory, two hours; outside study, six hours. Requisites: courses 171B, M270A. Digital signal processing and control analysis of mechatronic systems. System inversion-based digital control algorithms and robustness properties, Youla parameterization of stabilizing controllers, previewed optimal feedforward 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. 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 gaits (periodic motion) for animal locomotion, and entrainment to natural oscillations via feedback control. Letter grading. Mr. Iwasaki (Sp)

M280B. Microelectromechanical Systems (MEMS) Fabrication. (4) (Same as Bioengineering M250B and Electrical and Computer Engineering M250B.) Lecture, three hours; discussion, one hour; outside study, eight hours. Enforced requisite: course M183B. Advanced discussion of micromachining processes used to construct MEMS. Coverage of many lithographic, deposition, and etching processes, as well as their combination in process integration. Materials issues such as chemical resistance, corrosion, mechanical properties, and residual/intrinsic stress. Letter grading. Mr. C-J. Kim (W)

281. Microsciences. (4) Lecture, four hours; outside study, eight hours. Requisites: courses 102, 103, 105D. Fundamental issues of being in microscopic world and mechanical engineering of microscale 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. Introduction to MEMS design. Design methods, design rules, sensing and actuation mechanisms, microsensors, and microactuators. Designing MEMS to be produced with both foundry and nonfoundry processes. Computer-aided design for MEMS. Design project required. Letter grading. Mr. Chiou (Sp)

284. Sensors, Actuators, and Signal Processing. (4) Lecture, four hours; outside study, eight hours. Principles and performance of micro transducers. Applications of using unique properties of micro transducers for distributed and real-time control of engineering problems. Associated signal processing requirements for these applications. Letter grading. Mr. C-J. Kim (Not offered 2017-18)

285. Interfacial Phenomena. (4) Lecture, four hours; outside study, eight hours. Requisites: courses 82, 103, 105A, 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), forms 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. Requisite: Physics 1C. Fundamental principles of optical systems. Geometric optics and aberration theory. Diffraction and interference. Fourier optics, beam optics. Propagation of light, Snell's law, and Huygen principle. Refraction and reflection. Plane waves, spherical waves, and image formation. Total internal reflection. Polarization, polarizers, and wave-plates. Lenses and aberrations, lens laws and formation of images, resolution and primary aberrations. Simple optical instruments, still cameras, shutters, apertures. Design of telescopes, microscope design, projection system design. Interference, Young's slit experiment and fringe visibility, Michelson interferometer, multiple-beam interference and thin film coatings. Diffraction theory, Fraunhofer and Fresnel diffraction, Fresnel zone plate. Fiber optics, waveguides and modes, fiber coupling, types of fiber: single and multimode. Concurrently scheduled with course C186. Letter grading. Mr. Chiou (F)

M287. Nanoscience and Technology. (4) (Same as Electrical and Computer Engineering M257.) Lecture, four hours; outside study, eight hours. Enforced requisite: 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; nanocharacterization; nanomaterials, nanoelectronics, and nanobiodetection technology. Introduction to new knowledge and techniques in nano areas to understand scientific principles behind nanotechnology and inspire students to create new ideas in multidisciplinary nano areas. Letter grading. Mr. Y. Chen (W)

C287L. 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, nanocharacterization (AEM, SEM, etc.), and optical and electrochemical biosensors. Students encouraged to create their own ideas in self-designed experiments. Concurrently scheduled with course C187L. Letter grading. Mr. Y. Chen (Sp)

288. 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, chemical, carrier, etc.) in laser microfabrication, state-of-art optics and instrumentation for laser microfabrication, applications such as rapid prototyping, surface modifications (physical/chemical), micromachines for three-dimensional MEMS (microelectromechanical systems) and data storage, up-to-date research activities. Student term projects. Letter grading. (Not offered 2017-18)

294A. 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 constraint-based design, projective geometry, screw theory kinematics, and freedom and constraint topologies. Applications: precision motion stages, general purpose flexure bearings, microstructural architectures, MEMs, optical mounts, 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)

295A. Radio Frequency Identification Systems: Analysis, Design, and Applications. (4) (Formerly numbered 295C.) Lecture, four hours; outside study, eight hours. Designed for graduate engineering students. Examination of 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. Gadh (Not offered 2017-18)

C296A. Mechanical Design for 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 failure prevention in design of power transmission shafting. Design project involving computer-aided design (CAD) and finite element analysis (FEA) modeling. Concurrently scheduled with course C156B. Letter grading. Mr. Ghoniem (Sp)

296B. High-Temperature Mechanical Design. (4) Lecture, four hours; outside study, eight hours. Requisite: 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; laboratory, two 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 speed and flexibility of desktop publishing, 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 meso-/micro-/nano-scale to produce three-dimensional functional miniature components. Concurrently scheduled with course C183C. Letter grading.
Mr. Li (W)

M297B. Material Processing in Manufacturing. (4) (Formerly numbered 297A.) (Same as Materials Science M297B.) Lecture, four hours; outside study, eight hours. Enforced requisite: course 183A. 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. Ghoniem (Not offered 2017-18)

298. Seminar: Engineering. (2 to 4) Seminar, to be arranged. Limited to graduate mechanical and aerospace engineering students. Seminars may be organized in advanced technical fields. If appropriate, field trips may be arranged. May be repeated with topic change. Letter grading. (Not offered 2017-18)

M299A. Seminar: Systems, Dynamics, and Control Topics. (2) (Same as Chemical Engineering M297 and Electrical and Computer Engineering M248S.) Seminar, two hours; outside study, six hours. Limited to graduate 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 Practicum. (1 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)

495. Teaching Assistant Training Seminar. (2) Seminar, two hours; outside study, four hours. Preparation: appointment as teaching assistant in department. Seminar on communication of mechanical and aerospace engineering principles, concepts, and methods; teaching assistant preparation, organization, and presentation of material, including use of visual aids; grading, advising, and rapport with students. S/U grading. Mr. Mal (W,Sp)

596. Directed Individual or Tutorial Studies. (2 to 8) Tutorial, 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. S/U grading.

597C. Preparation for Ph.D. Oral Qualifying Examination. (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.