Mechanical and Aerospace Engineering, Ph.D.

The Mechanical and Aerospace Engineering faculty have special interest and expertise in five thrust areas: dynamics and controls; fluid dynamics and propulsion; mechanics of materials and structures; systems and design; and thermal and transport sciences.

Research in dynamics and controls covers a broad multi-disciplinary area of theory and practical applications. The general aim is to model, analyze and regulate the behavior of dynamical systems in the presence of modeling errors, perturbations and disturbances, while ensuring a level of optimality in carrying out a sought objective. Additional challenges are introduced when the task is to be carried out by a collection of autonomous systems in a distributed, decentralized manner. Estimating parameters and learning while carrying out assigned tasks is yet another layer of increasingly more powerful capabilities becoming available with new technologies and availability of computational resources. Specific areas of interest include control theory and algorithms, autonomous and distributed systems, navigation and flight systems and machine learning.

The area of fluid dynamics and propulsion includes incompressible and compressible turbulent flows, multiphase flows, chemically reacting and other nonequilibrium flows, turbomachinery, electrosprays, aeroelasticity, aerodynamic optimization and aeroacoustics. Computational approaches include direct numerical simulation and large-eddy simulation; laboratories include wind tunnels, anechoic chambers, and high-speed jet facilities. Specific areas of interest include: aeroacoustics; aeroelasticity; biomedical flows; combustion theory; computational fluid dynamics; electrosprays; jet and rocket propulsion; multiphase flow; and turbomachinery.

The field of mechanics of materials and structures emphasizes theoretical, computational, and experimental approaches that contribute to a fundamental understanding of and new insight into the properties and behavior of materials and structures. Areas of interest include nano- and micro-scale solid mechanics, modeling and design of lightweight structures and materials, deformation and failure mechanisms, smart and morphing structures, uncertainty quantification and propagation, structural synthesis and optimization, and machine learning applications in materials design and modeling. The emphasis of the research efforts is on predicting and enhancing stiffness, shape-change, stability, damage tolerance, manufacturability, optimal life-cycle costs, and self-adaptivity of materials and structures.

Systems and design is a broad disciplinary area that involves the development of methodologies to address issues ranging from defining the size and shape of components needed for force and motion specifications, to characterizing performance in terms of design parameters, cost and complexity. Applications include microdevices; biomechanics; air pollution; manufacturing; and automotive and aerospace systems. Areas of specific interest include: design and control of MEMS; machine information systems integration; computer aided design; robotics including microrobotics; biomechanics; carbon and magnetic MEMS; CD-based fluidics; rehabilitation, prosthetics and exoskeletons; kinematics of spatial motion; design of mechanical systems; modeling of global air pollution; and aerospace systems.

The field of thermal and transport sciences encompasses energy generation and harvesting, environmental impacts, and heat transfer. The topic of combustion addresses the chemical mechanisms governing combustion in diverse settings. Fuel-cell research encompasses the development of fuel-cell technology, hybrid engines and thermionic devices. Activities cover the thermodynamics of energy systems, the controls associated with advanced energy systems and systems analyses. Thermal solutions for emerging areas of nanotechnology are being developed where heat conduction is critical to performance. Areas of specific interest include: combustion and emissions; fuel cell technologies; advanced energy systems; renewable energy; heat transfer; atomization and sprays; reaction kinetics; nanomaterials.

Aerospace engineering research efforts combine specialties from each of the five thrust areas toward the design, modeling, and operation of complex aerospace systems.

The doctoral program in Mechanical and Aerospace Engineering is tailored to the individual needs and background of the student. The detailed program of study for each Ph.D. student is formulated in consultation with a Faculty Advisor who takes into consideration the objectives and preparation of the candidate.

Within this flexible framework the Department maintains specific guidelines that outline the milestones of a typical doctoral program. All doctoral students should consult the Departmental Ph.D. guidelines for program details, but there are several milestones to be passed: admission to the Ph.D. program by the faculty; completion of three non-research graduate, technical courses beyond M.S. degree requirements; passage of a preliminary examination or similar assessment of the student's background and potential for success in the doctoral program; course work; meeting departmental teaching requirements, which can be satisfied through service as a teaching assistant or equivalent; research preparation; formal advancement to candidacy in the third year (second year for students who entered with a master's degree) through a qualifying examination conducted on behalf of the Irvine Division of the Academic Senate, which includes the development of a research proposal; completion of a significant research investigation, and completion and defense of an acceptable dissertation. There is no foreign language requirement. The degree is granted upon the recommendation of the Doctoral Committee and the Dean of Graduate Studies. Students enrolled in the Ph.D. program must take a full-time load (minimum of 12 units). The normative time for completion of the Ph.D. is five years (four years for students who entered with a master's degree). The maximum time permitted is seven years. Before seeking admission, Ph.D. applicants are encouraged to communicate directly and in some detail with prospective faculty sponsors. The student's objectives and financial resources must coincide with a faculty sponsor's research interests and research support. Financial aid in the form of a teaching assistantship or fellowship may not cover the period of several years required to complete the program. During the balance of the period the student will be in close collaboration with the faculty research advisor.