

Manufacturing and Design

The program is developed around an integrated approach to manufacturing and design. 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 material and structures; automation and digital control systems, micro- and nano-devices, RFID and wireless systems.

Summary of Major Field Body of Knowledge:

Students should master the major field body of knowledge covered in six of the following courses: MAE 262, 263C, 270A, 277, 293, 294, 295C, 296A, 296B, 297, CM280A.

The written qualifying (preliminary) examination covers a subset of the major field body of knowledge, defined by four of the following pairs of undergraduate and graduate course. Note that the undergraduate courses provide proper background for the graduate courses and may have been taken as part of the student's undergraduate program.

MAE 156A and 296A
MAE 162A and 263C
MAE 183 and either 297 or 296B
MAE 184 and 294
MAE 163A or 171B and either 270A or 277
MAE 185 and 295C
MAE 166C and 262
MAE 174 and 293

The written qualifying (preliminary) examination covers the same selection of four pairs of courses.

More details concerning the major field body of knowledge can be found in the **Syllabus for the Major Field**, on the next page.

Minimum Requirements for Ph.D. Major Field Students:

The student must pass a written examination in the major field and satisfy other program requirements for the Ph.D. in the MAE Department besides completing all other formal University requirements.

Format of Written Qualifying Examination:

The exam consists of a 4-hour closed book part and a 4-hour open book part.

Timing of Written Qualifying Examination:

Offered every spring.

Link to old exams:

<http://stdntsvcs.mae.ucla.edu/exam/index.htm>

Ph.D. Minor Field Requirements:

Minor field requirements can be satisfied by completing three of the courses listed below with grades of B or better with at least one A. At least two of the courses must be graduate courses: MAE 156A, 162A, 163A, 166C, 171B, 185, 183, 184, 262, 263C, 270A, 277, 293, 294, 295C, 296A, 296B, 297.

Syllabus for the Major Field in Manufacturing and Design

Students majoring in Manufacturing and Design are required to have knowledge in six subject areas from the list below:

- I. Intelligent Material Systems [262]
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.
- II. Robotics [263C]
Theory and implementation of industrial robots. Design considerations. Kinematic structure modeling, trajectory planning, and system dynamics. Differential motion and static forces. Individual student projects.
- III. Linear Dynamic Systems [270A]
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, the 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.
- IV. Mechatronics [277]
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. Applications to mechatronic systems.
- V. MEMS Fabrication [CM280A]
Introduction to micromachining technologies and microelectromechanical systems (MEMS). Methods of micromachining and how these methods can be used to produce variety of MEMS, including microstructures, microsensors, and microactuators. Students learn to design microfabrication processes that produce desired MEMS device.
- VI. Quality in Design and Manufacturing [293]
Quality engineering concepts and approaches. Taguchi methods of robust technology development and off-line control. Quality loss function, signal-to-noise ratio, and orthogonal array. Parametric design of products and production processes. Tolerance design. Online quality control systems.
- VII. Computational Geometry for Design and Manufacturing [294]
Computational geometry for design and manufacturing with special emphasis on curve and surface theory, geometric modeling of curves and surfaces, B-splines and NURBS, composite curves and surfaces, computing methods for surface design and manufacture, and current research topics in computational geometry for CAD/CAM systems.
- VIII. RFID in Manufacturing and Supply Chain [295C]
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.
- IX. Damage and Failure of Materials in Design [296A]
Role of failure prevention in mechanical design and case studies. Mechanics and physics of material imperfections: voids, dislocations, cracks and inclusions. Statistical and deterministic design methods. Plastic, fatigue and creep damage.
- X. Thermochemical Processing of Materials [296B]
Thermodynamics, heat and mass transfer, principles of material processing: phase equilibria and transitions, transport mechanisms of heat and mass, moving interfaces and heat sources, natural convection, nucleation and growth of microstructure, manufacturing defects, materials instabilities. Applications in Chemical Vapor Deposition (CVD), Infiltration, Solidification, Welding, Consolidation, Coatings and Thin Films.

- XI. Composites Manufacturing [297]
Matrix materials, fibers, fiber performs, elements of processing, autoclave/compression molding, filament winding, pultrusion, resin transfer molding, automation, material removal and assembly, metal and ceramic matrix composites, quality assurance.

References:

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A.C. Ugural and S. K. Fenster, Advanced Strength and Applied Elasticity, Elsevier, 1987
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R. C. Jaeger, Introduction to Microelectronic Fabrication, Vol. 5 of Modular Series on Solid State Devices, 2nd ed., Prentice Hall, 2002.
S. Wolf and R. Tauber, Silicon Processing for the VLSI Era, Vol. 1, Process Technology, 2nd ed., Lattice Press, 1999.
S. D. Senturia, Microsystem Design, Kluwer Academic, 2001.
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Lung-Wen Tsai, Robot Analysis - The Mechanics of Serial and Parallel Manipulators, the latest edition.
I.D. Faux and M.J. Pratt, Ellis Horwood, Computational Geometry for Design and Manufacture, the latest edition.
Michael E. Mortenson, Geometric Modeling, John Wiley & Sons, Inc., the latest edition.
Brent Strong, Fundamentals of Composites Manufacturing: Materials, Methods, and Applications, Society of Manufacturing Engineers, 1989.
Gutowski, Timothy G., Ed., Advanced Composites Manufacturing, John Wiley & Sons, Inc., 1997.
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