Department of Mechanical Engineering

Chairperson: Ghaddar, Nesreen K.
Professors: PaZoury, Pierre; Darwish, Marwan; Ghaddar, Nesreen K.; Moukalled, Fadl
Associate Professors: Kuran, Albert; Smaili, Ahmad
Assistant Professors: Abdallah, Samer; Al-Khalidy, Abdulrahman; Hamade, Ramsey; Kanko, Eva; Khalaf, Kinda; Lakkis, Issam; Owies, Ghanem; Shihadeh, Alan
Lecturers: Abu Ghali, Kamel; Kasamani, Jihad; Kasti, Najib; Najm, Wajih
Instructors: Berjaoui, Samir; Jabakhanji, Rami; Seif, Cherbel; Zazah, Abdulrahman
Assistant Instructors: Farshoukh, Ahmed; Jaroudi, Ezzat

Undergraduate Program

Bachelor of Engineering: major, Mechanical Engineering

The mechanical engineering program extends over a four-year period offered exclusively on a daytime on-campus basis. The program is offered in 11 terms, eight terms are 16-week fall/spring semesters given over four years, and three terms are eight-week summer terms taken during the first three years of the program. In the summer term of the third year (Term IX), students are required to participate in a practical training program with a local, regional, or international organization. The entire program duration is equivalent to five academic years without the summer terms, but is completed in four calendar years.

The undergraduate program also provides the students with options to pursue minors in the following:

- Information Technology offered by ECE
- Biomedical Engineering offered by ECE
- Engineering Management offered by EM Program

Other minors can be sought in the Faculty of Arts and Sciences and the Suliman S. Olayan School of Business.

Program Mission

The mechanical engineering faculty has agreed that the undergraduate program mission is as follows:

The undergraduate program in Mechanical Engineering seeks to empower students to pursue successful careers, and to create a learning environment in which they can develop their creative and critical thinking, their ability to grow into lifelong learners in the light of ever-increasing challenges of modern technology, and their commitment to the ethical and
professional responsibilities required in their calling at the global level while focusing on the needs of Lebanon and the region.


**Program Educational Objectives**

Students who attain a BE degree possess a tool chest of technical and non-technical skills and knowledge that positions them for a successful professional practice as entry-level engineers in existing firms or graduate students in any program in the world, while having the aptitude to contribute to society. This does not preclude other activities, such as volunteerism, self-employment, or academic study in another discipline. Graduates succeed in this goal by a program that strives to

- develop in students the ability to integrate mechanical engineering fundamentals with contemporary applications
- equip students with the ability to use modern experimental and computational tools in design and engineering practices
- motivate students to continually learn on their own, to think critically and creatively in order to allow them to evaluate new ideas, to identify problems, and to advance innovative solutions
- instill in the students the necessary interpersonal skills to perform professionally in a highly competitive and dynamically changing profession

**Program Requirements**

- General Engineering: CIVE 210, EECE 210, EECE 230, EECE 312, EECE 312L, ENGM 400
- Mathematics: MATH 201, MATH 202, MATH 212, MATH 218, MATH 251, STAT 230
- Sciences: PHYS 211, PHYS 211L, CHEM 202, CHEM 203, and one biology elective (BIOL 210, BIOL 290E, or any other 200 level biology course)
- General Education: Arabic course (based on APT), ENGL 206, one English elective, two social sciences courses, three humanities courses, ENGM 504 or a course on ethics
- ME Core Courses: MECH 200, MECH 220, MECH 230, MECH 310, MECH 314, MECH 320, MECH 332, MECH 412, MECH 414, MECH 340, MECH 341, MECH 410, MECH 420, MECH 421, MECH 431, MECH 433, MECH 420, MECH 430
- Restricted Technical Electives: One Design/Mechatronics Elective: MECH 520, MECH 522, or MECH 530. One Thermal/Fluid Systems Elective: MECH 510, MECH 511, or MECH 513
- Technical Electives: Five courses, at least three from ME track, and one can be from outside the major
- Approved Experience: MECH 500
- Final Year Project: MECH 501 and MECH 502
## Curriculum

### Term I (Fall) | Credits
--- | ---
MATH 201 | Calculus and Analytic Geometry III | 3
CIVE 210 | Statics | 3
EECE 230 | Computers and Programming | 3
MECH 200 | Mechanical Engineering Tools | 3
MECH 220 | Engineering Graphics | 1
ENGL 206 | Technical English | 3

**Total 16**

### Term II (Spring) | Credits
--- | ---
MATH 202 | Differential Equations | 3
PHYS 211 | Electricity and Magnetism | 3
PHYS 211L | Electricity and Magnetism Laboratory | 1
EECE 210 | Electric Circuits | 3
MECH 230 | Dynamics | 3
English Elective | | 3

**Total 16**

### Term III (Summer) | Credits
--- | ---
STAT 230 | Introduction to Probability and Random Variables | 3
CHEM 202 | Introduction to Environmental Chemistry | 3
CHEM 203 | Introductory Chemical Techniques | 2

**Total 8**

### Term IV (Fall) | Credits
--- | ---
EECE 312 | Electronics | 3
EECE 312L | Circuits and Electronics Lab | 1
MATH 212 | Vector Analysis, Fourier Series and PDE | 3
MECH 310 | Thermodynamics I | 3
MECH 340 | Engineering Materials | 3
Humanities Elective | | 3

**Total 16**

### Term V (Spring) | Credits
--- | ---
MATH 218 | Linear Algebra | 3
MECH 314 | Introduction to Fluid Mechanics | 3
MECH 320 | Mechanics of Materials | 3
MECH 332 | Mechanics of Machines (or MECH 430) | 3
MECH 341 | Materials Lab | 1
Biological Elective | | 3

**Total 16**
### Term VI (Summer) Credits
- Humanities Elective: 3
- Arabic Elective: 3
- MECH 430 Instrumentation and Measurements (or MECH 332): 3

**Total 9**

### Term VII (Fall) Credits
- MATH 251 Numerical Computing: 3
- MECH 410 Thermal/Fluid Systems Laboratory: 1
- MECH 414 Thermodynamics II: 3
- MECH 420 Mechanical Design: 3
- MECH 421 Manufacturing Processes I: 3
- Social Sciences Elective: 3

**Total 16**

### Term VIII (Spring) Credits
- ENGM 400 Engineering Economy: 3
- MECH 412 Heat Transfer: 3
- MECH 431 Control Systems: 3
- MECH 431L Control Systems Laboratory: 1
- Restricted Design/Mechatronics Elective (MECH 520, MECH 522, or MECH 530): 3
- Social Sciences Elective: 3

**Total 16**

### Term IX (Summer) Credits
- MECH 500 Approved Experience: 0

### Term X (Fall) Credits
- ENGM 504 Engineering Ethics or any course on ethics: 3
- MECH 501 Final Year Project I: 1

### Restricted Thermal Fluid Sciences Elective
- MECH 510, MECH 511, or MECH 513: 3

### Technical Electives
- Technical Elective I: 3
- Technical Elective II: 3
- Humanities Elective: 3

**Total 16**
Mechanical Engineering Optional Tracks

The core courses in the mechanical engineering program are balanced in the following track areas:

- Thermal and Fluid Engineering
- Mechatronics
- Design, Materials, and Manufacturing

The student may opt for any track by taking at least three technical electives in the selected track. Normally one technical elective is allowed from outside the mechanical engineering major.
<table>
<thead>
<tr>
<th><strong>Thermal and Fluid Engineering Track</strong></th>
<th><strong>Credits</strong></th>
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</thead>
<tbody>
<tr>
<td>MECH 310 Thermodynamics I</td>
<td>3</td>
</tr>
<tr>
<td>MECH 314 Introduction to Fluid Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>MECH 414 Thermodynamics II</td>
<td>3</td>
</tr>
<tr>
<td>MECH 410 Thermal/Fluid Systems Lab I</td>
<td>1</td>
</tr>
<tr>
<td>MECH 412 Heat Transfer</td>
<td>3</td>
</tr>
<tr>
<td>MECH 501 FYP I and MECH 502 FYP II</td>
<td>6</td>
</tr>
<tr>
<td><strong>One restricted thermal/fluid systems elective</strong></td>
<td>3</td>
</tr>
<tr>
<td>MECH 510 Modeling and Design of Thermal Systems</td>
<td></td>
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<tr>
<td>MECH 511 Intermediate Fluid Mechanics</td>
<td></td>
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<tr>
<td>MECH 513 Air Conditioning</td>
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<thead>
<tr>
<th><strong>Technical Electives Courses (at least three technical electives are selected)</strong></th>
<th><strong>Credits</strong></th>
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</thead>
<tbody>
<tr>
<td>MECH 510 Modeling and Design of Thermal Systems</td>
<td>3</td>
</tr>
<tr>
<td>MECH 511 Intermediate Fluid Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>MECH 512 Internal Combustion Engine</td>
<td>3</td>
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<tr>
<td>MECH 513 Air Conditioning</td>
<td>3</td>
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<tr>
<td>MECH 514 Gas Turbines</td>
<td>3</td>
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<tr>
<td>MECH 515 Steam Turbines</td>
<td>3</td>
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<tr>
<td>MECH 516 Aerodynamics</td>
<td>3</td>
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<tr>
<td>MECH 517 Energy Efficient Buildings</td>
<td>3</td>
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<tr>
<td>MECH 602 Energy Conservation and Utilization</td>
<td>3</td>
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<tr>
<td>MECH 603 Solar Energy</td>
<td>3</td>
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<tr>
<td>MECH 604 Refrigeration</td>
<td>3</td>
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<tr>
<td>MECH 606 Aerosol Dynamics</td>
<td>3</td>
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<tr>
<td>MECH 607 Micro Flows</td>
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<table>
<thead>
<tr>
<th><strong>Design, Materials, and Manufacturing Track II</strong></th>
<th><strong>Credits</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>CIVE 210 Statics</td>
<td>3</td>
</tr>
<tr>
<td>MECH 200 Mechanical Tools</td>
<td>3</td>
</tr>
<tr>
<td>MECH 220 Engineering Graphics</td>
<td>1</td>
</tr>
<tr>
<td>MECH 332 Mechanics of Machines</td>
<td>3</td>
</tr>
<tr>
<td>MECH 340 Engineering Materials</td>
<td>3</td>
</tr>
<tr>
<td>MECH 341 Materials Lab</td>
<td>1</td>
</tr>
<tr>
<td>MECH 320 Mechanics of Materials</td>
<td>3</td>
</tr>
<tr>
<td>MECH 420 Mechanical Design II</td>
<td>3</td>
</tr>
<tr>
<td>MECH 421 Manufacturing Processes I</td>
<td>3</td>
</tr>
<tr>
<td>MECH 501 FYP I and MECH 502 FYP II</td>
<td>6</td>
</tr>
<tr>
<td><strong>One restricted design elective</strong></td>
<td>3</td>
</tr>
<tr>
<td>MECH 520 Product Design and Development</td>
<td></td>
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<tr>
<td>MECH 522 Mechanical CAD/CAE/CAM</td>
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</tbody>
</table>
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<table>
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<tr>
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<tbody>
<tr>
<td>MECH 520</td>
<td>Product Design and Development</td>
<td>3</td>
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<tr>
<td>MECH 521</td>
<td>Manufacturing Processes II</td>
<td>3</td>
</tr>
<tr>
<td>MECH 522</td>
<td>Mechanical CAD/CAE/CAM</td>
<td>3</td>
</tr>
<tr>
<td>MECH 540</td>
<td>Selection of Properties of Materials</td>
<td>3</td>
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<tr>
<td>MECH 550</td>
<td>Computer Applications in Mechanical Engineering</td>
<td>3</td>
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<tr>
<td>MECH 622</td>
<td>Advanced Manufacturing Processes</td>
<td>3</td>
</tr>
<tr>
<td>MECH 624</td>
<td>Mechanics of Composite Materials</td>
<td>3</td>
</tr>
<tr>
<td>MECH 625</td>
<td>Fatigue of Materials</td>
<td>3</td>
</tr>
<tr>
<td>MECH 626</td>
<td>Metals and their Properties</td>
<td>3</td>
</tr>
<tr>
<td>MECH 627</td>
<td>Polymers and their Properties</td>
<td>3</td>
</tr>
<tr>
<td>MECH 628</td>
<td>Design of Mechanisms</td>
<td>3</td>
</tr>
<tr>
<td>MECH 633</td>
<td>Biomechanics</td>
<td>3</td>
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<tr>
<td>MECH 634</td>
<td>Biomaterials and Medical Devices</td>
<td>3</td>
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</tbody>
</table>

### Mechatronics Track

<table>
<thead>
<tr>
<th>ME Core Courses in Mechatronics</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>MECH 230 Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>EECE 200 Electric Circuits</td>
<td>3</td>
</tr>
<tr>
<td>EECE 312 Electronics</td>
<td>3</td>
</tr>
<tr>
<td>EECE 312L Circuits and Electronics Lab</td>
<td>1</td>
</tr>
<tr>
<td>MECH 430 Instrumentation and Measurements</td>
<td>3</td>
</tr>
<tr>
<td>MECH 431 Control Systems</td>
<td>3</td>
</tr>
<tr>
<td>MECH 431L Control Systems Lab</td>
<td>1</td>
</tr>
<tr>
<td>Restricted Design/Mechatronics Elective</td>
<td>3</td>
</tr>
<tr>
<td>MECH 530 Mechatronics System Design</td>
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</tr>
<tr>
<td>MECH 501 FYP I and MECH 502 FYP II</td>
<td>6</td>
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<tbody>
<tr>
<td>MECH 531</td>
<td>Mechanical Vibration</td>
<td>3</td>
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<tr>
<td>MECH 641</td>
<td>Robotics</td>
<td>3</td>
</tr>
<tr>
<td>MECH 628</td>
<td>Design of Mechanisms</td>
<td>3</td>
</tr>
<tr>
<td>MECH 631</td>
<td>Micro-Electro Mechanical Systems (MEMS)</td>
<td>3</td>
</tr>
<tr>
<td>MECH 634</td>
<td>Biomaterials and Medical Devices</td>
<td>3</td>
</tr>
<tr>
<td>MECH 642</td>
<td>Computer Vision</td>
<td>3</td>
</tr>
<tr>
<td>MECH 643</td>
<td>Mechatronics and Intelligent Machines Engineering II</td>
<td>3</td>
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<tr>
<td>MECH 644</td>
<td>Modal Analysis</td>
<td>3</td>
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<tr>
<td>MECH 645</td>
<td>Noise and Vibration Control</td>
<td>3</td>
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</tbody>
</table>
Course Descriptions

MECH 200  Mechanical Engineering Tools  3 cr.
The course seeks to introduce students to mechanical engineering discipline, build the students interpersonal and communication skills, and give them insight about engineering concepts and creative design principles. Overview of engineering as a profession, and ethics in engineering. Introduces students to the creative process of identifying needs and then devising practical solutions to fill those needs through designing, building, integrating, and testing and evaluating of an engineering product. Teamwork experience is highly stressed. An effort is made to introduce students to representative software and hardware tools that s/he is likely to utilize in the process of product development.

MECH 220  Engineering Graphics  1 cr.
An introductory course on 2-D Drawing, orthogonal projection, auxiliary views, sectioning and sectional views, dimensioning and tolerance schemes, and standard drawing layouts. Introduction to the use of AutoCAD. Pre- or corequisite: MECH 200. Annually.

MECH 230  Dynamics  3 cr.
A course on kinematics and kinetics of particles, systems of particles, and rigid bodies in 2-D and 3-D motion, Newton’s laws, work and energy, impulse and momentum, impact, and mass moments of inertia. Pre- or corequisites: Math 201, CIVE 210.

MECH 310  Thermodynamics I  3 cr.
A course on the thermodynamic state and properties of a pure substance, energy and mass conservation, entropy, and the second law; applications to closed setups and flow devices; simple vapor and gas cycles applications. Prerequisite: discretion of adviser. Annually.

MECH 312  Introduction to Fluid and Thermal Engineering  3 cr.
A course on equations of thermal equilibrium; concepts of work, heat, and internal energy: the first law; reversibility, entropy, and the second law; applications to processes and power cycles; mechanics of incompressible flow; hydrostatics; Euler’s and Bernoulli’s equations; linear and angular momentum; laminar and viscous flows in ducts; turbulence; head loss in pipes. Annually.

MECH 314  Introduction to Fluids Engineering  3 cr.
An introductory course on fluid behavior emphasizing conservation of mass, momentum, and energy and dimensional analysis; study of fluid motion in terms of the velocity field, fluid acceleration, the pressure field, and the viscous effects; applications of Bernoulli’s equation, Navier-Stokes, and modeling; flow in ducts, potential flows, and boundary layer flows. Prerequisite: MECH 310. Annually.

MECH 320  Mechanics of Materials  3 cr.
A course on stresses, strains, and stress-strain relationship; tension and compression; torsion of circular bars; bending and shear in beams; combined stresses; stress transformation and Mohr’s circle. Stress concentration; stresses in pressurized cylinders; press and shrink fits; curved beams in bending; contact stresses. Deflection and stiffness; deflection due to bending; beams deflection by superposition; beam deflection by singularity functions; Castigliano’s theorem; deflection of curved beams; deflection in columns. Prerequisite: CIVE 210.

MECH 332  Mechanics of Machines  3 cr.
A course that deals with the mechanization of motion, kinematics analysis of linkage mechanisms, synthesis of cam-follower mechanisms, gear terminology and types of gears, analysis and synthesis of gear trains, force analysis, and introduction to linkage synthesis; computer aided project. Prerequisite: MECH 230. Annually.
MECH 340  **Engineering Materials**  3 cr.
The course introduces fundamental concepts in materials science as applied to engineering materials: crystalline structures; imperfections, dislocations, and strengthening mechanisms; diffusion; phase diagrams and transformations. Ferrous and non-ferrous metal alloys, ceramics, and polymers. Structure-property relationships. Material selection case studies.  
**Prerequisite:** CIVE 210. Annually.

MECH 341  **Materials Lab**  1 cr.
A laboratory course consisting of standard metallurgical and mechanical characterization tests on metals. Stress-strain plots, derived properties, fracture toughness, crystallography, hardness, and other properties. Ceramic flexure testing: Weibull plots. Polymers: stress-strain plots and derived properties, impact properties, creep, and relaxation.  
**Prerequisite:** MECH 340. Annually.

MECH 410  **Thermal/Fluid Systems Laboratory**  1 cr.
A series of experiments on basic thermodynamic cycles, psychrometry, combustion, and elementary fluid mechanics, with special emphasis on the use of the computer as a laboratory tool for data acquisition, reduction, analysis, and report preparation.  
**Prerequisite:** MECH 310. Annually.

MECH 412  **Heat Transfer**  3 cr.
A course investigating steady and transient heat conduction; extended surfaces; numerical simulations of conduction in one and two-dimensional problems; external and internal forced convection of laminar and turbulent flows; natural convection; heat exchanger principles; thermal radiation, view factors and radiation exchange between diffuse and gray surfaces as well as the use of computer packages in problem solving.  
**Prerequisite:** MECH 314. Annually.

MECH 414  **Thermodynamics II**  3 cr.
A course investigating the availability and work potential of systems; irreversibility; second law efficiency; availability; gas mixtures, air-conditioning; chemical reactions; high speed flow, nozzles and diffusers, environmental, economic, and social implications.  
**Prerequisites:** MECH 310 and CHEM 202. Annually.

MECH 420  **Mechanical Design**  3 cr.
A course covering the analytical tools needed for the mechanical design of various machine components for rigidity and strength. The course deals with failures theories that results from static and variable loading. The course covers the design of machine elements such as screws and joints, mechanical springs, bearings, gears, and shafts. Applications are covered through case studies and a team project.  
**Prerequisites:** MECH 320 and MECH 340. Annually.

MECH 421  **Manufacturing Processes I**  2.1; 3 cr.
A course on traditional material removal processes, CNC machining, and non-traditional material removal processes. Assembly processes such as welding, brazing, soldering, and fastening are also covered with an emphasis on process capabilities and limitations, relative cost, and guidelines for process selection. This course examines the behavior of materials under processing conditions and design for manufacturing guidelines, and involves hands-on exercises in a machine shop environment.  
**Prerequisite:** MECH 340. Annually.

MECH 430  **Instrumentation and Measurements**  2.1; 3 cr.
A course on general concepts of measurement systems; classification of sensors and sensor types; interfacing concepts; data acquisition, manipulation, transmission, and recording; introduction to LABVIEW; applications; team project on design, and implementation of a measuring device.  
**Prerequisites:** MECH 230 and PHYS 211. Annually.
MECH 431  **Control Systems**  3 cr.
This course is intended to provide students with the tools that enable them to model and control physical systems. It includes the following: modeling of physical systems; transfer function and block diagrams; time-domain analyses; root-locus; frequency-domain methods; stability analysis; design of PID controllers and dynamic compensators via the root locus and frequency methods. **Prerequisites:** MECH 230 and EECE 210. Annually.

MECH 431L  **Control Systems Laboratory**  1 cr.
This course involves a series of hands-on experiments on modeling and design of control systems using Matlab, Simulink, and Labview. The course also includes a team project. **Prerequisite:** MECH 430.

MECH 500  **Approved Experience**  0 cr.
An eight week professional training course in mechanical engineering.

MECH 501  **Final Year Project I**  1 cr.
A supervised project in groups of normally three students aimed at providing practical experience in some design aspects of mechanical engineering. Students are expected to complete a literature survey, to critically analyze, and to acquire the necessary material needed for their intended end product. **Prerequisite:** discretion of adviser. Annually.

MECH 502  **Final Year Project II**  5 cr.
A course in which the student integrates his/her acquired knowledge to deliver the product researched and planned in MECH 501. **Prerequisite:** MECH 501. Annually.

MECH 503  **Special Topics in Mechanical Engineering**  3 cr.

MECH 510  **Modeling Design of Thermal Systems**  2.1; 3 cr.
A course on the analysis, modeling, and design of engineered systems involving applications of thermodynamics, economics, heat transfer, and fluid flow. Selection of components in fluid- and energy-processing systems to meet system performance requirements. System simulation and optimization techniques. Use of modern computational tools to model thermal performance characteristics of components and systems. **Prerequisites:** MECH 314 and MECH 412.

MECH 511  **Intermediate Fluid Mechanics**  3 cr.
A course that deals with potential flow and boundary layer analysis; lift and drag; flow separation; the use of computational techniques to solve boundary layer problems; viscous internal channel flow and lubrication theory; one-dimensional compressible flow in nozzles and ducts; normal shock waves and channel flow with friction or heat transfer; fluid machinery including pumps and hydraulic turbines. **Prerequisites:** MECH 314 and MECH 412.

MECH 512  **Internal Combustion Engines**  2.1; 3 cr.
A course that examines the fundamentals of internal combustion engine design and operation, with emphasis on fluid/thermal processes. Topics include analysis of the respiration, combustion, and pollutant formation processes; heat transfer and friction phenomena; engine types and performance parameters; thermo-chemistry of fuel-air mixtures; the use of engine cycle models for performance predictions; and social implications of motorization. **Pre- or corequisites:** CHEM 202, MECH 414, and MECH 430.

MECH 513  **Air Conditioning**  3 cr.
A course on human thermal comfort and indoor air quality; solar radiation; heating and cooling load calculations in buildings; air conditioning systems; air and water distribution systems; computer-based calculations. **Prerequisite:** MECH 412.
MECH 514  **Gas Turbines**  3 cr.
A course that introduces the thermodynamic and aerodynamic theory forming the basis of gas turbine design: shaft power cycles; gas turbine cycles for aircraft propulsion; turbofan and turbojet engines; design and analysis of centrifugal and axial flow compressors and turbines. **Prerequisites:** MECH 314 and MECH 414.

MECH 515  **Steam Turbines**  3 cr.
A course that deals with impulse and reaction steam turbines, steam turbine cycles, flow of steam in nozzles, design aspects of turbines stage losses and efficiency, velocity diagrams; and impulse and reaction blading velocities; nucleation, condensation, and two-phase phenomena in flowing steam; boiler room and its various equipment; the complete steam power plants; governors, electric generator, and power transmission lines. **Pre- or corequisites:** MECH 314 and MECH 414.

MECH 516  **Aerodynamics**  3 cr.
A course on theoretical and empirical methods for calculating the loads on airfoils and finite wings by application of classical potential theory, thin airfoil approximations, lifting line theory, and panel methods; wings and airplanes; application of linearized supersonic flow to supersonic airfoils; performance and constraint analysis; longitudinal stability and control. **Pre- or corequisites:** MECH 314 and MECH 414.

MECH 517  **Energy Efficient Buildings**  3 cr.
A course on integrated design process for low energy buildings. The course introduces mechanical and architecture students to an integrated design approach to low energy buildings, and to consideration of energy efficiency at all stages of design. The course defines and correlates the function of various building elements which effect low energy sustainability and make an environmentally friendly building. It also introduces participants to ecological criteria to impart an understanding of the building’s role within the ecosystem. Students are exposed to hands-on experience in energy audit, interpretation of energy audit data, and performance of life cycle analysis for new and existing buildings. The multi-disciplinary background of students is a model for professional practice that promotes communication and understanding of architectural design processes by engineers and the understanding of the impact of architectural design on issues related to building loads, comfort, and building thermal response by the architect. **Pre- or corequisite:** MECH 310 or PHYS 210 or consent of instructor. **Annually.**

MECH 520  **Product Design and Development**  3 cr.
A course that covers modern tools and methods for product design and development. Teams of students conceive, design, and prototype a new physical product. Topics include identifying customer needs, product planning, product specifications, concept generation, industrial design, product architecture, product development economics, and design-for-manufacturing. **Alternate years. Prerequisites:** MECH 332 and MECH 420. **Annually.**

MECH 521  **Manufacturing Processes II**  2.1; 3 cr.
A course on heat treatments, deformation, phase-change, and particulate consolidation processing of metals; fabrication processing of non-metallic engineering materials such as ceramics, polymers, and composites; emphasis on process capabilities and limitations, relative cost, and guidelines for process selection; the behavior of materials under processing conditions; design for manufacturing guidelines. This course emphasizes hands-on training exercises. **Prerequisite:** MECH 340.
MECH 522  Mechanical CAD/CAE/CAM  3 cr.
A course that seeks to expose the senior ME students to the realm of computer-aided design (CAD), computer-aided engineering (CAE), and computer-aided manufacturing (CAM). This course teaches the students to harness the power of these powerful tools in the solution of various problems of mechanical engineering. The course utilizes several commercially available software packages. Prerequisites: MECH 320, MECH 432, and MECH 520. Annually.

MECH 530  Mechatronics System Design  2.1; 3 cr.
A course that discusses mechatronics; data; numbering systems, architecture of the 8-bit Motorola MC68HC11 microcontroller, assembly language programming, A/D and D/A conversion; parallel I/O, programmable timer operation, interfacing sensors and actuators, applications; a team project on design and implementation of a mechatronic system. Prerequisites: EECE 312 and MECH 430.

MECH 531  Mechanical Vibrations  3 cr.
A course on free and forced response of non-damped and damped system; damping vibration absorption; response of discrete multi-degree of freedom systems; modal analysis; vibration measurement, case studies, vibration analysis with Matlab and Simulink. Prerequisite: MECH 230.

MECH 532  Dynamics and Applications  3 cr.
This course examines the dynamics of particles and rigid bodies moving in three dimensions. Topics include Lagrange's equations of motion for particles, rotations of rigid bodies, Euler angles and parameters, kinematics of rigid bodies, and the Newton-Euler equations of motion for rigid bodies. The course material will be illustrated with real-world examples such as gyroscopes, spinning tops, vehicles, and satellites. Applications of the material range from vehicle navigation to celestial mechanics, numerical simulations, and animations. Prerequisites: MECH 230 elementary course on Newtonian dynamics or consent of instructor.

MECH 540  Selection and Properties of Materials  3 cr.
A course that reviews the mechanical behavior of materials. Topics covered include structure-property relationships in materials; continuum mechanics and tensor notation; theorems of elastic, plastic, viscoelastic behavior of materials; elements of creep, fatigue, and fracture mechanics. Prerequisite: MECH 340. Annually.

MECH 550  Computer Applications in Mechanical Engineering  3 cr.
A course dealing with the application of numerical techniques to the solution of a variety of mechanical engineering problems involving systems of linear or non-linear algebraic equations, systems of ordinary differential equations of the initial and boundary value types, systems of ordinary differential equations, and partial differential equations of the parabolic, elliptic, and hyperbolic types. Engineering applications are introduced through a number of case study problems. Prerequisite: MATH 202.
Graduate Programs

Master of Engineering (ME), Specialization: Mechanical Engineering

General Information
The Department of Mechanical Engineering offers a graduate program leading to the degree of Master of Engineering: major, mechanical engineering. Students may choose to major in any of the following concentration areas:

• Thermal and Fluid Sciences
• Design, Materials, and Manufacturing
• Mechatronics

The student is encouraged to select a concentration area of great personal interest. The master’s degree requires a minimum of 21 credit hours of course work and a thesis worth 9 credits. Research is a somewhat time consuming process; however, between 20 and 24 months are usually required to complete the master’s degree. The student and graduate adviser, in coordination with the thesis committee, develop a plan of study tailored to the student’s specific interest and background. It is advisable that this plan be developed no later than the first month of the second semester of graduate work. The required 21 course credit hours and thesis are distributed as follows:

• A mandatory three-credit course in applied mathematics. The math course or math oriented course offered by other departments must be approved by the graduate student adviser; acceptable courses include, but are not limited to the following:
  
  MECH 630 Finite Element Methods in Mechanical Engineering
  MECH 663 Computational Fluid Dynamics
  MECH 764 Advanced Topics in Computational Fluid Dynamics
  ENMG 604 Deterministic Optimization Models
  MATH 307 Topics in Analysis
  MATH 351 Topics in Applied Mathematics

• At least two advanced fundamental mechanical engineering three-credit courses from two different concentrations, which are not in the same concentration selected by the student, and as approved by the graduate thesis adviser. The following is a list of recommended courses by concentration:

  - Thermal and Fluid Sciences: MECH 701, MECH 760, MECH 761, MECH 762
  - Design, Materials, and Manufacturing: MECH 624, MECH 720, MECH 721
  - Mechatronics: MECH 740, MECH 643, MECH 645
• Four technical courses (12 credit hours). Of these 12 credit hours, a minimum of nine must be completed in the major area of mechanical engineering concentration to achieve greater depth in that area. It is advisable to make the selection in connection with thesis work. A maximum of three credit hours may be completed in other engineering graduate programs subject to approval by the graduate adviser. A student may not register more than once in MECH 796, Special Projects in Mechanical Engineering. The following is a list of recommended mechanical engineering technical courses by concentration.

Thermal and Fluid Sciences: MECH 602, MECH 603, MECH 604, MECH 606, MECH 607, MECH 609, MECH 663, MECH 665, MECH 701, MECH 760, MECH 761, MECH 762, MECH 764


Mechatronics: MECH 628, MECH 633, MECH 634, MECH 641, MECH 642, MECH 643, MECH 644, MECH 645, MECH 740. Due to the multidisciplinary nature of this area of concentration, one, or a maximum of two, three-credit course(s) may be selected from EECE 632S, EECE 636S, EECE 691C, EECE 692C, or EECE 694C as part of the mechatronics concentration technical electives. These courses are offered by the electronic devices and system graduate program in the electrical and computer engineering department.

• Seminar Course: MECH 797 (zero credit). Students must register for the course once per year.
• Thesis: MECH 799 (equivalent to nine credit hours) based on independent research.

Requirements

A student applying for admission to a graduate program is only eligible if s/he has a bachelor of engineering degree with a mechanical engineering major or the equivalent. A student must also satisfy the requirements of the University and the Faculty of Engineering and Architecture for admission to graduate study, as specified in the relevant sections of the university catalogue (see pp.621, 622).

Doctor of Philosophy (PhD), Specialization: Mechanical Engineering

General Information-Doctor of Philosophy

The PhD graduate curriculum offers students opportunities to develop levels of expertise and knowledge consistent with a career of technical leadership. The doctoral program emphasizes the acquisition of advanced knowledge and the fostering of individual experience of significant intellectual exploration.

The PhD program in Mechanical Engineering will be offered pending final approval by the New York State Education Department. For admission and graduation requirements, refer to the faculty and department webpages.
Course Descriptions

MECH 602  Energy Conservation and Utilization  3 cr.
A course that deals with methods for reduction of losses and gains from a building envelope; energy conservation in cooling, heating, air-handling, and plumbing systems; energy management program.  Prerequisites: MECH 310, MECH 412.  Alternate years.

MECH 603  Solar Energy  3 cr.
A course discussing the fundamentals of solar radiation; collectors and concentrators; energy storage; estimation and conversion formulas for solar radiation.  Prerequisite: MECH 412.  Alternate years.

MECH 604  Refrigeration  3 cr.
A course on fundamental concepts and principles; cold storage; functions and specifications of refrigeration equipment; applications.  Prerequisite: MECH 412.  Alternate years.

MECH 606  Aerosol Dynamics  3 cr.
This course covers the physical and chemical principles that underlie the behavior of aerosols—collections of solid or liquid particles suspended in gases, such as clouds, smoke, and dust—and the instruments used to measure them.  Topics include: aerosol particle characterization; transport properties and phenomena in quiescent, laminar, and turbulent flows; gas- and particle-particle interactions; and applications to human respiratory tract deposition and atmospheric pollution.  Prerequisite: MECH 314, MECH 414, MECH 412, or consent of instructor.  Alternate years.

MECH 607  Micro Flows Fundamentals and Applications  3 cr.

MECH 609  Experimental Methods in Fluid Dynamics  3 cr.
This is a graduate level course aimed at introducing students to experimental methods used to measure fluid flow quantities such as pressures, forces, and velocities.  The course starts with an introduction to what and why we measure, and uncertainty analysis and measurement error estimation.  Some basic techniques for data reduction and data post-processing are introduced.  The available fluid measurement methods are surveyed briefly, with selected applications.  Emphasis is on advance optical diagnostic techniques; namely particle image velocimetry (PIV), and laser induced fluorescence (LIF).  The theoretical foundations of these techniques are established, and the discussion extended to practical considerations including software and hardware components.  A few laboratory sessions are incorporated into the course to supplement the lectures, and make use of the instruments available in the ME department, including the open circuit wind tunnel and the PIV system.  In addition to the lectures and lab sessions, emphasis is also on the available literature.  Prior knowledge of the basic principles of fluid mechanics and fluid systems is required.  MATLAB is needed for course work.  Prerequisite: MECH 314.

MECH 622  Advanced Manufacturing Processes  3 cr.
MECH 624  Mechanics of Composite Materials  3 cr.
A course on anisotropic elasticity and laminate theory, analysis of various members of composite materials, energy methods, failure theories, and micromechanics. Materials and fabrication processes are introduced. Prerequisites: MECH 320 or CIVE 310 and MECH 340 or equivalents. Alternate years.

MECH 625  Fatigue of Materials  3 cr.
A course that deals with high cycle fatigue; low cycle fatigue; S-N curves; notched members; fatigue crack growth; cycling loading; Manson-Coffin curves; damage estimation; creep and damping. Prerequisite: MECH 320 or CIVE 310. Alternate years.

MECH 626  Metals and their Properties  3 cr.
A course that investigates ferrous and non-ferrous alloys; industrial equilibrium diagrams; heat treatment of metals; surface properties of metals; plastic deformation of metals; elements of fracture mechanics; process-structure-properties relations. Prerequisite: MECH 440. Alternate years.

MECH 627  Polymers and their Properties  3 cr.
A course on chemistry and nomenclature; polymerization and synthesis; characterization techniques; physical properties of polymers; viscoelasticity and mechanical properties; applications. Prerequisite: MECH 440. Alternate years.

MECH 628  Design of Mechanisms  3 cr.
A course involving graphical and analytical synthesis of single- and multi-loop linkage mechanisms for motion, path, and function generation through 2-3-4- and 5-precision positions; optimum synthesis of linkage mechanisms; synthesis of cam-follower mechanisms; synthesis of gear trains. Prerequisite: MECH 332. Alternate years.

MECH 630  Finite Element Methods in Mechanical Engineering  3 cr.
A course on the classification of machine components; displacement-based formulation; line elements and their applications in design of mechanical systems; isoparametric formulation; plane stress, plane strain, axi-symmetric, and solid elements and their applications; modeling considerations and error analysis; introduction to ALGOR general formulation and Galerkin approach; analysis of field problems. Prerequisites: MECH 431 and MECH 420. Alternate years.

MECH 631  Micro Electro Mechanical Systems (MEMS)  3 cr.
A course that deals with materials for micro-sensors and micro-actuators, materials for micro-structures, microfabrication techniques and processes for micromachining, computer-aided design and development of MEMS, commercial MEMS structures and systems, packaging for MEMS, future trends, and team project. Prerequisite: MECH 430. Alternate years.

MECH 633  Biomechanics  3 cr.
A course on study of the biomechanical principles underlying the kinetics and kinematics of normal and abnormal human motion. Emphasis is placed on the interaction between biomechanical and physiologic factors (bone, joint, connective tissue, and muscle physiology and structure) in skeleto-motor function and the application of such in testing and practice in rehabilitation. The course is designed for senior level undergraduate/graduate engineering students with no previous anatomy/physiology. Prerequisites: CIVE 210, MECH 320 or CIVE 310, or consent of instructor. Annually.
MECH 634  Biomaterial and Medical Devices  3 cr.
A course that examines the structure-property relationships for biomaterials and the medical applications of biomaterials and devices. The first part of the course focuses on the main classes of biomaterials, metal, ceramic, polymeric, and composite implant materials, as well as their interactions with the human body (biocompatibility). The second part of the course examines the various applications of biomaterials and devices in different tissue and organ systems such as orthopedic, cardiovascular, dermatology, and dental applications. Experts from the medical community will also be invited to discuss the various applications.  Prerequisite: MECH 340 or consent of instructor. Annually.

MECH 641  Robotics  3 cr.
A course discussing concepts and subsystems; robot architecture; mechanics of robots: kinematics and kinetics; sensors and intelligence; actuators; trajectory planning of end effector motion; motion and force control of manipulators; robot languages.  Prerequisites: MECH 431, MECH 432, and MECH 433. Annually.

MECH 642  Computer Vision  3 cr.
An introductory course on the problems and solutions of modern computer vision. Topics covered include image acquisition, sampling and quantisation; image segmentation; geometric framework for vision: single view and two-views; camera calibration; stereopsis; motion and optical flow; recognition; pose estimation in perspective images.  Prerequisites: MATH 202 and EECE 230. Alternate years.

MECH 643  Mechatronics and Intelligent Machines Engineering II  3 cr.
A course on sensors, sensor noise and sensor fusion; actuators; system models and automated computer simulation; information, perception, and cognition; planning and control; architectures, design, and development; team project.  Prerequisites: MECH 340 and MECH 530. Alternate years.

MECH 644  Modal Analysis  3 cr.
A course reviewing MDOF system vibrations, frequency response functions, damping, mobility measurement, curve fitting and modal parameter extraction, derivation of mathematical models, laboratory experiments, and projects.  Prerequisite: MECH 531. Alternate years.

MECH 645  Noise and Vibration Control  3 cr.
A course on fundamental concepts in noise and vibration; passive and active damping strategies; damping materials; control methods; applications.  Prerequisites: MECH 230, MATH 212, and MECH 531. Alternate years.

MECH 663  Computational Fluid Dynamics  3 cr.
A course that deals with discretization process in fluid dynamics; numerical approaches and applications; iterative and direct matrix methods; numerical implementation of turbulence models.  Prerequisites: MECH 314 and MECH 412. Alternate years.

MECH 665  Unsteady Gas Flow  3 cr.
A course examining equations of unsteady continuous adiabatic multidimensional flows; unsteady continuous one-dimensional flow of a perfect gas with and without discontinuities; applications; pressure exchangers.  Prerequisite: MECH 414. Alternate years.

MECH 701  Principles of Combustion  3 cr.
A course on gas-phase reaction mechanisms and thermo-chemical kinetics; theory of ignition, flame propagation, and detonation; characteristics of premixed, diffusion, laminar, and turbulent flames; combustion aerodynamics; liquid and solid fuels in practical systems; pollutant formation and reduction mechanisms.  Prerequisite: CHEM 202, MECH 414, MECH 412, or equivalents. Alternate years.
MECH 702  Pollutant Formation and Control in Combustion  3 cr.
Fundamentals of gas and condensed phase pollutant formation, measurement, and control pertaining to practical combustion systems. Topics include heat and mass transfer in reacting systems, chemical reaction kinetics, particle coagulation kinetics, and flame structure and propagation. These fundamental subjects are applied in the study of pollutant formation and control in practical systems including internal combustion engines, jet engines, and industrial boilers. Removal of gaseous and particulate pollutants from effluent streams by use of adsorption, absorption, catalytic processes, inertial separation, and electrostatic precipitators. Prerequisites: MECH 311, MECH 411, MECH 412, CHEM 202 or consent of instructor. May be repeated for credit when topics vary. Alternate years.

MECH 703  Combustion Modeling  3 cr.
Topics include chemical thermodynamics and chemical kinetics, conservation laws for reacting flow problems, diffusion controlled vs. chemistry controlled combustion, Laminar non-premixed and premixed flames and jets multi-phase combustion, detonations waves, turbulent combustion, and combustion stability. Prerequisites: CHEM 202, MECH 311, MECH 412 or equivalents. Alternate years.

MECH 720  Advanced Machine Design  3 cr.
A course that involves the analysis of stress and strain, torsion, design of axi-symmetrically loaded members, beams on elastic foundations, elastic stability, surface contact and wear, impact, and finite element applications to nonlinear problems. Prerequisite: MECH 520. Alternate years.

MECH 721  Elasticity and Plasticity  3 cr.
A course on tensor analysis, the general state of stresses, properties and deformation of solid materials, elasticity, plasticity, matrix methods, and applications. Prerequisite: MECH 320 or CIVE 310. Alternate years.

MECH 729  Spatial Mechanisms  3 cr.
A course that covers position, velocity, and acceleration analysis of spherical and spatial mechanisms; isometry; geometry of rotation axes; finite position synthesis, the 4R spherical linkage; lines and screws; the RSSR, RSSP, 4C, and 5TS spatial linkages; platform manipulators. Prerequisite: MECH 628. Alternate years.

MECH 736  Modeling Solidification Processes  3 cr.
The course seeks to impart a coherent view of solidification processes and how they are modeled. Topics for the first part of the course include: homogeneous and heterogeneous nucleation, with plane front, cellular and dendritic pattern, columnar and equiaxed grain growth. Phenomena affecting the quality of castings such as micro-segregation, constituent undercooling, macro-segregation and porosity formation are also covered. In the second part solidification models are developed and applied in the context of casting operations. The course covers: heat flow in solidification processes; thermodynamics of solidification: nucleation and growth; binary phase diagrams, phase diagram computation; microstructure evolution, constitutional undercooling; columnar and equiaxed solidification enthalpy method; mushy zone modeling; phase-field method; volume-averaging of conservation equations; multi-scale models; modeling solidification defects. Prerequisite: MECH 340, MECH 420, or consent of instructor. Alternate years.
MECH 740  Advanced Dynamics  3 cr.
A course that examines three-dimensional kinetics and kinematics, theory of rotating axis, Hamilton’s equations, Lagrange’s equation, and Euler’s equations.  Prerequisite:  MECH 230 or equivalent.  Alternate years.

MECH 746  Space Mechanisms  3 cr.
Topics covered are mobility, spatial displacements, formulation of the kinematic equation, analysis and synthesis of spherical mechanisms, analysis and synthesis of spatial mechanisms, optimum synthesis of spherical and spatial kinematic chains, and analysis of platform manipulators.  Prerequisite: MECH 628.

MECH 747  Nonlinear Finite Element Analysis  3 cr.
Governing equations and geometric and material nonlinearities; formulation of nonlinear problems; solution algorithms: vector and matrix methods; direct and iterative equations solvers; FE methods for nonlinear mechanics; element technology; numerical implementation of constitutive models; pitfalls of nonlinear analysis.  Prerequisite: MECH 630. Alternate years.

MECH 751  Simulation of Multiphase Flows  3 cr.
Multiphase flows are important to many engineering and environmental applications.  This course is intended to give an overview of the fundamentals involved in dispersed multiphase flows, and develop a working knowledge which would allow the student to numerically predict these flows.  The course examines the conservation equations for multiphase systems; discretization using the finite-volume method; pressure-based algorithms for multi-fluid flow at all speeds: mass conservation based algorithms and geometric conservation based algorithms (SIMPLE, SIMPLEC, PISO, etc.); the partial elimination and SINCE algorithms; weighted pressure correction; mutual influence of volume fractions; implicit volume fraction equations; bounding the volume fractions; numerical implementation; and, applications.  Prerequisite: MECH 663. Alternate years.

MECH 760  Advanced Fluid Mechanics  3 cr.
A course that examines fundamental concepts and principles, basic relations for continuous fluids, vorticity dynamics, Kelvin and Helmholtz theorems, Navier-Stokes equations, turbulent and oscillating flows.  Prerequisite:  MECH 314 or equivalent.  Alternate years.

MECH 761  Convection Heat Transfer  3 cr.
A course that covers fundamental modes of heat transfer; similarity between heat, momentum, and mass transfer in forced and buoyancy-driven flows; simultaneous heat, momentum, and mass transfer with phase change.  Prerequisites:  MECH 314 and MECH 412.  Alternate years.

MECH 762  Advanced Thermodynamics  3 cr.
A course on advanced thermodynamic concepts; gas mixtures and multi-phase systems; chemical reactions; thermodynamic property relations; chemical and phase equilibrium; applications.  Prerequisite: MECH 414. Alternate years.

MECH 763  Radiative Heat Transfer  3 cr.
Principles of thermal radiation and their application to engineering heat and photon transfer problems. Quantum and classical models of radiative properties of materials, electromagnetic wave theory for thermal radiation, radiative transfer in absorbing, emitting, and scattering media, and coherent laser radiation. Applications cover infrared instrumentation, global warming, furnaces, and high temperature processing.  Prerequisites: MECH 412. Alternate years.

MECH 764  Advanced Topics in Computational Fluid Dynamics  3 cr.
A course on numerical solution of compressible unsteady flows; advanced turbulence modeling; the segregated approach; the multigrid technique; introduction to multi-phase flows.  Prerequisite: MECH 663. Alternate years.
MECH 765  Advanced Finite Volume Techniques  3cr.
Linear multigrid; non-linear multigrid; mesh agglomeration: structured and unstructured grids; mesh generation: structured and unstructured grids; free surface simulation; solidification simulation. Prerequisite: MECH 411. Alternate years.

MECH 766  Turbulent Flow and Transport  3cr.

MECH 767  Heat Conduction  3 cr.
Solutions of steady and transient heat conduction problems with various boundary conditions; approximate analytical methods; application of numerical techniques; moving boundaries: problems in freezing and melting; condensation heat transfer; boiling: mechanisms and heat transfer correlations; anisotropic and composite materials. Prerequisite: MECH 412. Alternate years.

MECH 768  Transport Through Porous Media  3 cr.
The course is designed for graduate students interested in the flow of multi-phase, multi-component fluids through porous media. The course emphasizes physics of the momentum, heat and mass transport formulation and computations in multi-dimensional systems, including theoretical models of fluid flow, capillary effects, application of fractal and percolation concepts, characterization of porous materials, multiphase flow and heat transfer, turbulent flow and heat transfer, improved measurement techniques, and enhanced design correlations. Prerequisite: MECH 412. Alternate years.

MECH 769  Advanced Scientific Computing  3 cr.
High-performance scientific computing is an exciting and rapidly-changing field. In this course students will learn how to solve and visualize large-scale continuum type problems using high-performance cluster-type computing systems. Sections of the course will concentrate on discretization methods multigrid methods in a parallel computing context. Different parallel computing paradigms are introduced with emphasis on domain decomposition methods, and the practical aspects of their implementations using MPI. Prerequisite: Prior knowledge of C programming and familiarity with the UNIX operating system. Alternate years.

MECH 796  Special Projects in Mechanical Engineering  3 cr.

MECH 797  Seminar  0 cr.
A seminar that consists of weekly presentations on current research or applied projects in mechanical engineering presented by faculty, students, and invited scholars. This is a pass fail course based on attendance.

MECH 798  Special Topics in Mechanical Engineering  3 cr.

MECH 799  Thesis
Every semester.

MECH 898  Advanced Topics in Mechanical Engineering  3 cr.

MECH 899  PhD Thesis