

# Mechanical Engineering

*Professors: Colbaugh, Gerity, Lyons*

*Associate Professors: Reilly (Chair of the Department), Sarkodie-Gyan, Walling*

*Adjunct Faculty: Abernathy, Anderson, Baty, Cooper, Marcy, Meason, Melof, Ostergren, William*

*Emeritus Faculty: Miller, Oravec*

**Degrees Offered: B.S. in Mechanical Engineering; B.S. in Engineering Mechanics; M.S. in Engineering Mechanics**

The Department of Mechanical Engineering at New Mexico Tech administers the following programs:

- Bachelor of Science in Mechanical Engineering
- Bachelor of Science in Engineering Mechanics
- Master of Science in Engineering Mechanics
  - Specialization in Explosives Engineering
  - Specialization in Advanced Mechanics
  - Specialization in Mechatronics Systems Engineering

## Undergraduate Programs

### Bachelor of Science in Mechanical Engineering

Mechanical Engineering is considered to be one of the cornerstone engineering disciplines and is perhaps the broadest of all engineering disciplines. Mechanical engineers are found in every sector of our technology-based economy. Mechanical engineers find careers in (to name just a few): electric power generation and distribution; petroleum exploration, production and refining; automotive, truck and bus manufacturing; light and heavy rail transportation and manufacturing; agricultural equipment manufacturing; commercial and industrial construction industries; aeronautical design and manufacturing; national defense industries; semiconductor manufacturing; biomedical technology; petrochemical process industries; basic materials extraction and refining industries.

The undergraduate mechanical engineering program is very broad in its scope, yet it contains sufficient depth to ensure competency in the discipline. Mechanical engineering students must take a heavy load of science and mathematics as prerequisites for their engineering science courses.

Mechanical engineers in industry must be able to interact with many engineering disciplines, so they are required to take courses in other engineering disciplines. Also, because mechanical engineers design and manufacture components and systems, they are required to take courses that emphasize the engineering design/definition process. The mechanical engineering graduate engineer should be well equipped to undertake a professional engineering career in any technology that he or she chooses.

The mechanical engineering program at New Mexico Tech offers the students hands-on laboratory experience in fluid mechanics, solid mechanics, vibrations and mechatronics. Junior and senior mechanical engineering students work on year-long design projects that range from the SAE Mini Baja® competition vehicles to biomedical instruments.

*Minimum credit hours required—134*

*In addition to the General Degree Requirements (page 48), the following courses are required:*

- ES 110 (2), 111 (3), 201 (3), 216 (3), 302 (3), 303 (3), 316 (3), 332 (3), 347 (3), 350 (3)
- MENG 300 (2), 304 (3), 305 (3), 381 (1), 382 (1), 405 (2), 405L (1), 421 (3), 431 (3), 441 (3), 451 (3), 481 (2), 482 (2), 483 (2) & 483L (1)

- MATE 202 & 202L (4)
- MATH 231 (4), 332 (3), 335 (3)
- Technical Electives: Six hours from upper-division courses outside the department chosen by the student with the faculty advisor's approval. The courses must provide an understanding of the process of mathematical modeling coupled with computer usage.

Students may pursue *either* a B.S. in Mechanical Engineering *or* a B.S. in Engineering Mechanics. Students may not receive both degrees. Prior to graduation, students must declare to the Registrar on the *Intent to Graduate* form which degree title will be imprinted on their diploma and transcript.

Courses used for the degree, including the general degree requirements (page 48), may not be taken on an S/U basis. Credit for MATH 103, college algebra, and MATH 104, trigonometry, is not allowed for mechanical engineering students.

All engineering majors must take the Fundamentals in Engineering (FE) exam as a requirement for graduation. Passing this exam is a major step in the process of attaining professional registration. It is **strongly** recommended that the exam be taken in semester 7, before the graduation semester (semester 8).

It is strongly recommended that all Mechanical Engineering students follow the sample curriculum and, in particular, complete ES 216 (fluid mechanics) prior to enrolling in ES 347 (thermodynamics).

### Sample Curriculum for the Bachelor of Science in Mechanical Engineering

#### Semester 1

- |                            |                            |
|----------------------------|----------------------------|
| 3                          | ENGL 111 (college English) |
| 4                          | MATH 131 (calculus)        |
| 4                          | CHEM 121 & 121L (general)  |
| 2                          | ES 110 (intro.)            |
| 3                          | Social Science             |
| <hr style="width: 100%;"/> |                            |
| 16                         | Total credit hours         |

#### Semester 2

- |                            |                            |
|----------------------------|----------------------------|
| 3                          | ENGL 112 (college English) |
| 4                          | MATH 132 (calculus)        |
| 5                          | PHYS 121 & 121L (general)  |
| 3                          | ES 111 (computer engr.)    |
| <hr style="width: 100%;"/> |                            |
| 15                         | Total credit hours         |

#### Semester 3

- |                            |                              |
|----------------------------|------------------------------|
| 3                          | ENGL 341 (technical writing) |
| 4                          | MATH 231 (calculus)          |
| 4                          | CHEM 122 & 122L (general)    |
| 3                          | ES 201 (statics)             |
| 3                          | Humanities                   |
| <hr style="width: 100%;"/> |                              |
| 17                         | Total credit hours           |

#### Semester 4

- |                            |                                      |
|----------------------------|--------------------------------------|
| 3                          | MATH 335 (applied analysis)          |
| 5                          | PHYS 122 & 122L (general)            |
| 4                          | MATE 202 & 202L (intro to materials) |
| 3                          | ES 216 (fluid mechanics)             |
| 3                          | ES 302 (strength of materials)       |
| <hr style="width: 100%;"/> |                                      |
| 18                         | Total credit hours                   |

#### Semester 5

- |                            |                                |
|----------------------------|--------------------------------|
| 3                          | MATH 332 (vector analysis)     |
| 3                          | ES 303 (dynamics)              |
| 3                          | ES 316 (engineering economics) |
| 3                          | ES 347 (thermodynamics)        |
| 1                          | MENG 381 (junior design)       |
| 3                          | Social Science                 |
| <hr style="width: 100%;"/> |                                |
| 16                         | Total credit hours             |

*Semester 6*

2	MENG 300 (mechanics lab)
3	MENG 304 (advanced strength of materials)
3	MENG 305 (engineering analysis)
1	MENG 382 (junior design)
3	ES 332 (electrical circuits)
3	ES 350 (heat & mass transfer)
3	Humanities
<hr/>	
18	Total credit hours

*Semester 7 (Take FE exam)*

2	MENG 405 (system dynamics & controls)
1	MENG 405L (controls and instrumentation)
3	MENG 451 (machine design)
2	MENG 481 (senior design)
3	MENG 483 & 483L (mechatronics)
3	Technical Elective
3	Social Science
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17	Total credit hours

*Semester 8*

3	MENG 421 (finite element analysis & design)
3	MENG 431 (fluid/thermal systems)
3	MENG 441 (dynamics & vibration)
2	MENG 482 (senior design)
3	Technical Elective
3	Humanities/Social Science
<hr/>	
17	Total credit hours

## Bachelor of Science in Engineering Mechanics

The Bachelor of Science in Engineering Mechanics prepares students for a successful career in many engineering fields such as aerospace, petroleum, mining, environmental, manufacturing, and electrical. Students study specific topics such as solid mechanics, materials engineering, dynamics, thermodynamics, electrical engineering, and fluid mechanics along with more general courses in engineering science, engineering design, and engineering economics to obtain a broad engineering education. These courses include the humanities and social sciences and of course, a study of chemistry, physics, and mathematics. With this broad education, the Engineering Mechanics graduate is prepared to enter industry and attack the engineering problems faced by society. An alternative approach is to enter graduate school for further study in engineering, business, or law.

New Mexico Tech engineering students take many of the engineering science and design courses offered by this department. The topics include mechanics, thermodynamics, unit operations, economics, engineering drawing, fluid mechanics, basic computer skills, and basic electrical engineering. The courses are taught by faculty members drawn from all Tech engineering departments and the business administration department.

*Minimum credit hours required—134*

*In addition to the General Degree Requirements (page 48), the following courses are required:*

- ES 110 (2), 111 (3), 201 (3), 216 (3), 302 (3), 303 (3), 316 (3), 332 (3), 347 (3), 350 (3)
- MENG 300 (2), 304 (3), 305 (3), 381 (1), 382 (1), 405 (2), 405L (1), 421 (3), 431 (3), 441 (3), 451 (3), 481 (2), 482 (2), 483 (2) & 483L (1)
- MATE 202 & 202L (4)
- MATH 231 (4), 332 (3), 335 (3)
- Technical Electives: Six hours from upper-division courses outside the department chosen by the student with the faculty advisor's approval. The courses must provide an understanding of the process of mathematical modeling coupled with computer usage.

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Courses used for the degree, including the general degree requirements (page 48), may not be taken on an S/U basis. Credit for MATH 103, college algebra, and MATH 104, trigonometry, is not allowed for engineering mechanics students.

All engineering majors must take the Fundamentals in Engineering (FE) exam as a requirement for graduation. Passing this exam is a major step in the process of attaining professional registration. It is **strongly** recommended that the exam be taken in semester 7, before the graduation semester (semester 8).

It is strongly recommended that all Engineering Mechanics students follow the sample curriculum and, in particular, complete ES 216 (fluid mechanics) prior to enrolling in ES 347 (thermodynamics).

### Sample Curriculum for the Bachelor of Science in Engineering Mechanics

*Semester 1*

3	ENGL 111 (college English)
4	MATH 131 (calculus)
4	CHEM 121 & 121L (general)
2	ES 110 (intro.)
3	Social Science
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16	Total credit hours

*Semester 2*

3	ENGL 112 (college English)
4	MATH 132 (calculus)
5	PHYS 121 & 121L (general)
3	ES 111 (computer engr.)
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15	Total credit hours

*Semester 3*

3	ENGL 341 (technical writing)
4	MATH 231 (calculus)
4	CHEM 122 & 122L (general)
3	ES 201 (statics)
3	Humanities
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17	Total credit hours

*Semester 4*

3	MATH 335 (applied analysis)
5	PHYS 122 & 122L (general)
4	MATE 202 & 202L (intro to materials)
3	ES 216 (fluid mechanics)
3	ES 302 (strength of materials)
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18	Total credit hours

*Semester 5*

3	MATH 332 (vector analysis)
3	ES 303 (dynamics)
3	ES 316 (engineering economics)
3	ES 347 (thermodynamics)
1	MENG 381 (junior design)
3	Social Science
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16	Total credit hours

*Semester 6*

2	MENG 300 (mechanics lab)
3	MENG 304 (advanced strength of materials)
3	MENG 305 (engineering analysis)
1	MENG 382 (junior design)
3	ES 332 (electrical circuits)
3	ES 350 (heat & mass transfer)
3	Humanities
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18	Total credit hours

**Semester 7 (Take FE exam)**

2	MENG 405 (system dynamics & controls)
1	MENG 405L (controls and instrumentation)
3	MENG 451 (machine design)
2	MENG 481 (senior design)
3	MENG 483 & 483L (mechatronics)
3	Technical Elective
3	Social Science
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17	Total credit hours

**Semester 8**

3	MENG 421 (finite element analysis & design)
3	MENG 431 (fluid/thermal systems)
3	MENG 441 (dynamics & vibration)
2	MENG 482 (senior design)
3	Technical Elective
3	Humanities/Social Science
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17	Total credit hours

## Graduate Program

### Department Requirements for the Master of Science in Engineering Mechanics

The Master of Science in Engineering Mechanics is available to students with an engineering degree in any field. However, students must demonstrate a competence in mathematics and the basic undergraduate mechanics courses offered in a typical engineering mechanics or mechanical engineering curriculum.

The Mechanical Engineering Department administers the Master of Science in Engineering Mechanics degree for those students wanting to pursue an advanced degree in engineering mechanics. There are currently three areas of specialization for this degree:

- Specialization in Explosives Engineering
- Specialization in Advanced Mechanics
- Specialization in Mechatronics Systems Engineering

Students may move from one specialization to another without the loss of any credits.

### Specialization in Explosives Engineering

The Master of Science degree in Engineering Mechanics with Specialization in Explosives Engineering may be earned with or without thesis. The student must have a B.S. degree in an engineering or science discipline as a prerequisite for this program.

#### Thesis Option

In addition to the three core advanced mechanics courses—EM 521 (3), Elastic Stability; EM 531 (3), Mechanics of Viscous Fluids; EM 541 (3), Vibrations of an Elastic Continuum—the student must complete at least 12 credit hours from the following: ChE 475 (3), Explosives Surety; EM 546, Detonation Theory; EM 549 (3), Shock Wave Theory; EM 550 (3), Advanced Explosives Engineering; EM 553 (3), Computer Modeling of Detonation; EM 589 (3), Introduction to Explosives Engineering.

In addition, the student must take three hours of senior- or graduate-level courses that are approved by the student's advisory committee. The student must also take a minimum of six credit hours in EM 591, Thesis. In all cases the student must complete a minimum of 12 credit hours of 500-level courses. The student must also prepare and submit a thesis to his/her advisory committee for approval in accordance with the general requirements of the graduate school. The minimum credit hour requirement for the Specialization in Explosives Engineering with thesis is 30 credit hours.

### Independent Study Option

In addition to the three core advanced mechanics courses EM 521 (3), Elastic Stability, EM 531 (3), Mechanics of Viscous Fluids, EM 541 (3), Vibrations of an Elastic Continuum, the student must take EM 546 (3), Detonation Theory; EM 549 (3), Shock Wave Theory; EM 589 (3), Introduction to Explosives Engineering. The student must take an additional nine credit hours of senior- or graduate-level courses with the approval of the student's advisory committee. The student is also required to submit a research report to his/her advisory committee on a topic pertinent to the field of explosive science/engineering. The student must take three credit hours of EM 590, Independent Study. EM 591, Thesis cannot be taken for credit by students in this option. The minimum credit hour requirement for the Specialization in Explosives Engineering with independent study option is 30 credit hours.

### Specialization in Advanced Mechanics

Students pursuing this degree program must have a B.S. degree in an engineering discipline. The Master of Science in Engineering Mechanics with Specialization in Advanced Mechanics may only be earned with a thesis in accordance with the general requirements of the graduate school. The student is required to take a minimum of 12 credit hours of 500-level courses of which nine credit hours must be the core advanced mechanics courses EM 521 (3), Elastic Stability; EM 531 (3), Mechanics of Viscous Fluids; EM 541 (3), Vibrations of an Elastic Continuum.

In addition, the student must take an additional 12 credit hours of senior- or graduate-level classes that are approved by the student's advisory committee. The student must take a minimum of six credit hours of EM 591, Thesis. The student must also prepare and submit an acceptable thesis to his/her advisory committee for approval in accordance with the general requirements of the Graduate School. The minimum credit hour requirement for the Specialization in Advanced Mechanics is 30 credit hours.

### Master of Science in Engineering Mechanics With Specialization in Mechatronic Systems Engineering (MSE)

The Master of Science in Engineering Mechanics with Specialization in Mechatronics Systems Engineering may be earned with or without thesis. The student must have a B.S. degree in an engineering or science discipline as a prerequisite for this program. The synergy of this program suggests the accommodation of a wide variety of students (from computer science, mechanical engineering, electrical engineering, etc.) to this specialization; hence, the study program may be designed to accommodate each student's academic background.

#### Requirements

A minimum of 30 credit hours is required for the Master of Science in Engineering Mechanics with Specialization in Mechatronic Systems Engineering.

- Core Classes—at least 12 credit hours from the following: EM 548/EE 548, Manipulator Based Robotics; EM 554/EE 554, Embedded Control Systems; EM 567/CS 567, Smart Engineering Systems I; EM 568/CS 568, Smart Engineering Systems II; EM 570, Advanced Mechatronics; EM 572, Sensor Technology; EM 574, Electrical Measurements of Non-Electrical Quantities; EM 576, Biomedical Mechatronics
- Graduate Seminar—2 credit hours, EM 585/CS 585, Research Methods in Mechatronics Systems Engineering
- Elective Courses—Suitable courses for a graduate program in Mechatronics Systems Engineering, which may include, but are not limited to, advanced engineering or advanced computer science courses.
- Thesis (6 credit hours) or Independent Study (3 credit hours)—  
A student must prepare and submit a thesis to his/her advisory committee for approval in accordance with the general requirements of the graduate school, or complete an independent study with accompanying report.

## Engineering Science Courses:

The major content of these courses is directed toward the fundamental core subjects of engineering.

### ES 110, Introduction to Engineering, 2 cr, 1 cl hr, 3 lab hrs

Corequisite: MATH 103

Introduction to structure and ethics in the engineering profession. The concept of problem solving. Introduction to engineering analysis and design, graphical communication, basic computer skills. Manual and CAD engineering graphics.

### ES 111, Computer Programming for Engineers, 3 cr, 2 cl hrs, 3 lab hrs

Corequisite: MATH 131

Engineering computer problem solving using a high-level programming language. Algorithm and program development and documentation. Emphasis is placed on programming logical and concise solutions to a variety of problems drawing from engineering disciplines of mechanics, civil, electrical, industrial, and economics.

### ES 201, Statics, 3 cr, 3 cl hrs

Prerequisites: PHYS 121

Corequisite: MATH 231

Forces and moments acting on rigid bodies in equilibrium, distributed forces including hydrostatic forces, friction, moment of inertia, and problem solution by computer.

### ES 216, Engineering Fluid Mechanics, 3 cr, 3 cl hrs

Prerequisite: ES 201

Corequisite: MATH 231

Fundamentals of fluid mechanics including fluid statics, velocity of continuous media, continuity, and momentum balance. Introduction of laminar and turbulent flows, similitude, dimensionless analysis, Bernoulli's equation, friction factor, introduction to pump and compressor selection.

### ES 302, Mechanics of Materials, 3 cr, 3 cl hrs

Prerequisite: ES 111 or CS 111; ES 201 passed with grade C or better; MATH 231

Relationships between external forces acting on deformable bodies and the stresses and strains produced; tension, compression, torsion, shear, bending, and problem solution by computer. Failure criteria. Design of members and systems.

### ES 303, Engineering Dynamics, 3 cr, 3 cl hrs

Prerequisite: ES 111 or CS 111; ES 201 passed with grade C or better; MATH 335

Kinematics and kinetics of particles, systems of particles, and rigid bodies; momentum and energy methods; and problem solution by computer.

### ES 305, Engineering Analysis, 3 cr, 3 cl hrs

Prerequisites: ES 216, 302; MATH 335; or consent of instructor

Solution of linear systems of equations using Gaussian elimination and matrix methods. Scalar and vector fields; gradient; divergence; curl; line, surface and volume integrals; Green's theorem and Stokes' theorem. Solutions to partial differential equations from heat transfer, mechanical vibrations, and fluid mechanics using separation of variables, series and Laplace transforms. Computational techniques using MATLAB. (Same as MENG 305)

### ES 316, Engineering Economics, 3 cr, 3 cl hrs

Prerequisite: ES 111

Professional ethics. Economic decision-making for engineering alternatives. Use of compound interest and depreciation calculations to compare the relative economy of investments and procedures. The application of economic principles such as return on investment, leverage, and present worth to engineering problems. Use of PC computer programs. This course is not available for social science credit.

### ES 332, Electrical Engineering, 3 cr, 3 cl hrs

Prerequisites: PHYS 122; MATH 335

Analysis of steady state linear circuits, balanced three-phase power, transformers. Electromechanical energy conversion. Semiconductor devices and applications.

### ES 347, Thermodynamics, 3 cr, 3 cl hrs

Prerequisites: CHEM 122; MATH 132; ES 111

Corequisites: ES 216; PHYS 122; MATH 231

Introduction of the first and second laws of thermodynamics and their applications to engineering power cycles. Carnot cycle, Rankine cycle, refrigeration cycle, Otto cycle, and Diesel cycle.

### ES 350, Heat and Mass Transfer, 3 cr, 3 cl hrs

Prerequisite: ES 347

Corequisite: MATH 335

Fundamentals of heat transfer, steady- and unsteady-state conduction, convection and radiation. Fundamentals of mass transfer, steady and unsteady state, diffusion, and convection. Dimensionless analysis, equipment.

### ES 405L, Instrumentation, Measurement, and Process Control Laboratory, 1 cr, 3 lab hrs

Prerequisite: ES 111; MATH 335

Laboratory exercises involving instrumentation and design of basic control systems. (Same as MENG 405L)

### ES 489, Special Topics in Engineering Science, 3 cr, 3 cl hrs

### ES 491, Directed Study, cr to be arranged

## Mechanical Engineering Courses:

The major content of these courses is directed toward the core subjects of engineering.

### MENG 300, Mechanics Laboratory, 2 cr, 6 lab hrs

Prerequisites: ES 216, 302; ENGL 341

Experiments in solid and fluid mechanics, testing methods, and measurement techniques. Tension, compression, buckling, and bending of various common structural materials. Basic fluid properties, buoyancy, major and minor friction losses in pressure conduits, positive displacement and centrifugal pumps.

### MENG 304, Advanced Strength of Materials, 3 cr, 3 cl hrs

Prerequisite: ES 302 passed with C or better

Unsymmetrical loading of beams, shear flow and shear center in thin-walled beams, curved beams, thin plates, thick walled cylinders, stress concentrations, thermal stresses, impact loads, and vibration loads. Applying energy methods to various solid mechanics and beam problems.

### MENG 305, Engineering Analysis, 3 cr, 3 cl hrs

Prerequisites: ES 216, 302; MATH 335; or consent of instructor

Solution of linear systems of equations using Gaussian elimination and matrix methods. Scalar and vector fields; gradient; divergence; curl; line, surface and volume integrals; Green's theorem and Stokes' theorem. Solutions to partial differential equations from heat transfer, mechanical vibrations, and fluid mechanics using separation of variables, series and Laplace transforms. Computational techniques using MATLAB. (Same as ES 305)

### MENG 405, Dynamic Systems and Controls, 2 cr, 2 cl hrs

Prerequisites: ES 332; MENG 305; MATH 335 or consent of the instructor

Corequisite: MENG 405L or ES 405L

A practical survey course examining the basic components of instrumentation, measurement, and process control systems common to the field of engineering. Sensing and measurement (temperature, pressure, flow rate, level, stress-strain, concentration, etc.), signal generation and data acquisition, control loops and controllers, and process control theory.

### MENG 405L, Instrumentation, Measurement, and Process Control Laboratory, 1 cr, 3 lab hrs

Prerequisite: ES 111; MATH 335

Laboratory exercises involving instrumentation and design of basic control systems. (Same as ES 405L)

### MENG 421, Finite Element Analysis and Design, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: MENG 304 passed with grade C or better; MENG 305; ES 350

Introduction to finite element analysis for structural, heat transfer, and fluid-flow systems. Use of computer-aided design (CAD) to address engineering design problems. Laboratory devoted to CAD operations and its use in complex design problems.

**MENG 483, Mechatronics, 2 cr hr, 2 cl hr***Prerequisites: ES 111; MATH 335; MENG 305**Corequisite: MENG 405, 451; EE 341 for EE majors or consent of instructor*

This course is an in-depth examination of the field of mechatronics, which is a consolidation of computer science (software), electrical engineering (microprocessor control), and mechanical engineering (machine design). Topics covered include: system analysis/ control theory, robotics, dynamic systems and control, elements of mechatronics systems, modeling and simulation of mechatronic systems and computer aided mechatronics.

**MENG 483L, Mechatronics Lab, 1 cr hr, 3 cl hr***Corequisite: MENG 483*

This is a hands-on lab where the student will design and build a simple mechatronics system. The student will learn the principles of instrumentation and sensors as they relate to the robotic control. The student will also learn the programming methods for the microprocessor controller.

**MENG 489, Special Topics in Mechanical Engineering, 3 cr, 3 cl hrs****MENG 491, Directed Study, cr to be arranged**

## Mechanical Engineering Design Courses:

*The major content of these courses is directed toward the practice of engineering design and the ethical, economic, and societal issues that are part of the profession of engineering.*

**MENG 381, Junior Engineering Design Clinic I, 1 cr, 3 lab hrs***Prerequisites: ES 216, 302; MATH 335; PHYS 122 & 122L; ENGL 341; junior standing**Corequisite: MATH 332*

An academic-year-long engineering design project. Organized and directed by a faculty member. Weekly intensive workshops in specialized design topics pertinent to actual design project. Junior-level students are under the direct supervision of the faculty members and the senior-level students assigned to the project.

**MENG 382, Junior Engineering Design Clinic II, 1 cr, 3 lab hrs***Prerequisite: MENG 381*

A continuation of MENG 381 academic-year-long engineering design project.

**MENG 431, Fluid and Thermal Systems Design I, 3 cr, 3 cl hrs***Prerequisites: MENG 305; ES 350; MATH 335*

Advanced dimensional analysis. Design and synthesis of systems based on application of incompressible fluid flow, heat transfer, design optimization theories, and economics. Design problems to include complex pressure conduit and pipe networks, heat exchangers, dynamic and positive displacement pumps, and hydraulic motors.

**MENG 441, Dynamics and Vibrations in Structural Design, 3 cr, 3 cl hrs***Prerequisites: MENG 305; ES 303; MATH 332, 335*

Definition of various dynamic loads. Design and synthesis of structural systems and machine members subject to impact and periodic load conditions. Seismic and blast loads on structures. Relevant failure criteria for dynamically loaded systems in structural and mechanism design.

**MENG 451, Design of Machine Elements, 3 cr, 3 cl hrs***Prerequisites: ES 303; MENG 304, 305, 381, 382; MATE 202 and 202L*

Principles of design and failure analysis of mechanical machine elements such as fasteners, shafts, columns, and gears. Design of mechanical drives such as roller chains, belts, speed reducers, and hydraulic transmissions.

**MENG 481, Senior Engineering Design Clinic I, 2 cr, 6 lab hrs***Prerequisite: MENG 382**Corequisite: MENG 451*

An academic-year-long engineering design project. Organized and directed by a faculty member. Senior-level students are under the direct supervision of the faculty member. Weekly intensive workshops in specialized design topics pertinent to actual design projects. Topics include costing of capital equipment, cost of materials and labor, design optimization concepts, as well as specialized topics. Formal reports, fabrication drawings, and cost estimates prepared and submitted to faculty and outside industrial reviewers. Formal presentation to reviewing group.

**MENG 482, Senior Engineering Design Clinic II, 2 cr, 6 lab hrs***Prerequisite: MENG 481*

A continuation of MENG 481 academic-year-long engineering design project.

## Engineering Mechanics Courses:

*The major content of these courses is directed toward a Master of Science degree in Engineering Mechanics.*

**EM 515, Theory of Elasticity, 3 cr, 3 cl hrs***Prerequisite: Graduate standing or consent of the instructor*

An introduction to tensor analysis, analysis of stress, balance laws, infinitesimal and finite theories of motion, strain and rotation tensors, compatibility equations, constitutive equations, materials symmetry, uniqueness of the solution, solution of two-dimensional elasticity problems. Airy stress function, application of complex variable technique in elasticity, three-dimensional elasticity problems, energy methods, bending theory of plates. (Same as ME 515)

**EM 517, Advanced Finite Element Method, 3 cr, 3 cl hrs***Prerequisite: Graduate standing or consent of the instructor*

An introduction to the numerical analysis calculus of variation, weak form of a differential equation, weighted residual techniques, solution of one-dimensional problems by the finite element method, bending problems, Lagrange and Hermite interpolation functions, isoparametric elements, numerical integration, two-dimensional problems, solution of Poisson and Laplace equations, triangular and quadrilateral elements, elasticity problems, theorem of minimum potential energy stiffness matrix, examples. (Same as ME 517)

**EM 520, Fracture Mechanics, 3 cr, 3 cl hrs***Prerequisite: Graduate standing or consent of the instructor*

An introduction to the theory of elasticity, singular stress fields, Westergaard method, complex variable technique, stress intensity factor, fracture energy, numerical and experimental methods in determination of stress intensity factor, fracture toughness, J-integral Elasto-plastic fracture. (Same as ME 520)

**EM 521, Elastic Stability, 3 cr, 3 cl hrs***Prerequisite: MENG 304 or consent of the instructor*

Classical theory of elastic stability for beams, plates, and shell structures. Geometric non-linear equations for thin-walled structures. Linear, linearized, and non-linear solutions of problems. Approximate analytic methods and numerical methods for problem solving.

**EM 531, Mechanics of Viscous Fluids, 3cr, 3 cl hrs***Prerequisite: MENG 431 or consent of the instructor*

Fundamental laws of motion for a viscous fluid. Navier-Stokes equation. Laminar fluid flow, turbulent boundary layer topics. Compressible and incompressible flow problems.

**EM 541, Vibrations in an Elastic Continuum, 3 cr, 3 cl hrs***Prerequisites: ES 302, 303; MENG 441; or consent of instructor*

Analysis of single and multi degree-of-freedom systems for time dependent loads, including periodic and impact loads. Thin-walled structures—beams, plates, and shells. Dynamic stability of thin-walled structures.

**EM 545, Introduction to Explosives Engineering, 3 cr, 3 cl hrs**

*Prerequisites:* CHEM 122 and 122L; PHYS 122 and 122L; ES 111 or CS 111; or consent of instructor

Introduction to the broad field of explosives science and technology. Basic organic chemistry, decomposition reactions, properties of explosives, thermodynamics of explosives, shock wave theory, detonation theory, initiators, Gurney equations, blast effects and demolition. Students will submit a semester-long research report.

**EM 546, Detonation Theory, 3 cr, 3 cl hrs**

*Prerequisites:* EM 549, EM/ME 550 or consent of instructor

Development of classical detonation model for full order detonation of secondary explosives. Ideal versus non-ideal detonation. Burn-rate models for pyrotechnics. The concept of deflagration to detonation transition. (Same as ME 556)

**EM 548, Manipulator Based Robotics, 4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisite:* MENG 405 or equivalent or consent of instructor

Fundamentals of the multi-disciplinary field of robotics. Emphasis is placed on understanding how to model and control robotic manipulators while providing an appreciation of the importance of sensing to robotic applications. Topics include: forward, inverse, and motion kinematics; dynamic modeling; position, velocity, and force control. Shares lecture/lab with EE 448, but is graded separately, and additional graduate-level work is required. (Same as EE 548)

**EM 549, Shock Wave Theory, 3 cr, 3 cl hrs**

*Prerequisites:* MATH 335 or consent of instructor

An in-depth study of the propagation of shock waves in various media. The derivation and application of the Rankine-Hugoniot jump equations. The concept of the rarefaction wave and various wave interactions. Derivation and application of the Mie-Grüneisen equation of state. The differential form of the conservation equations, as well as some numerical solutions for simple cases. Several current hydrocodes. (Same as ME 549)

**EM 550, Advanced Explosives Engineering, 3 cr, 3cl hrs**

*Prerequisites:* MATH 335 or consent of instructor

The detonation of non-ideal explosives, equation of state for porous media, shaped charge effect and explosively formed projectiles. Shock compaction of powders, explosive welding and experimental methods used in the evaluation of explosives and their applications. The dynamic fracture of ductile and brittle materials. (Same as ME 550)

**EM 553, Computer Modeling of Detonations, 3 cr, 3 cl hrs**

*Prerequisites:* EM 549, 550; or consent of instructor

Introduction to hydrodynamic modeling applied to explosives. Numerical methods for modeling shock physics, detonation, and material response. Finite difference, finite element and smoothed particle hydrodynamic methods, equation of state and strength models, and numerical fracture and fragmentation. (Same as ME 553)

**EM 554, Embedded Control Systems, 4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisites:* EE 308 or EE 443 or MENG 405 or equivalent or consent of instructor

Micro-controller or microcomputer based embedded control systems. A comparative survey of currently available embedded computers/controllers including SBC's, PIC's, basic-stamps, and single-chip computer solutions. Real time operating systems including real-time LINUX, and hard real-time process requirements. Projects will include the implementation of an embedded real-time control solution. (Same as EE 554)

**EM 567, Smart Engineering Systems, 3 cr, 3 cl hrs**

*Prerequisites:* MATH 254, 382; CS 344; or equivalent; or consent of instructor

Artificial neural networks, with emphasis on multiplayer feedback networks, self-organizing networks, and Hopfield-style networks. Learning algorithms. Introduction to fuzzy systems and evolutionary computing. Engineering applications of soft computing. (Same as CS 567)

**EM 568, Smart Engineering Systems II, 3 cr, 3 cl hrs**

*Prerequisites:* MATH 254, 382; CS 344; or equivalent; or consent of instructor

Overview of the major paradigms of soft computing: neural networks, fuzzy systems, and evolutionary computing. In-depth coverage of selected topics in each area as relevant to intelligent systems. Recent advances in the field, and case studies of intelligent systems. Coursework includes a large-scale project. (Same as CS 568)

**EM 570, Advanced Mechatronics, 3 cr, 3 cl hrs**

*Prerequisite:* MENG 405 or EE 443 or equivalent or consent of instructor

The theory, design, manufacture and use of instrumentation and control in the various sciences. The use of electrical and electronic instruments and equipment to measure, monitor and/or record physical phenomena. Measurements of force, mass dimension, strain; displacement, velocity, and acceleration; tensile, impact and comprehensive strength; temperature and thermal properties; time and frequency; thrust and torque; pressure vacuum and flow; electrical quantities; photo-optics and radiation.

**EM 572, Sensor Technology, 3 cr, 3 cl hrs**

*Prerequisites:* ES 332 and MENG 405, or EE 443 or equivalent, or consent of instructor

The operating principles and properties of sensors/transducers for the measurement of physical quantities in the mechanical domain, as well as the associated interface circuits. Focus is on commercially available sensors, but where appropriate, recent trends toward miniaturization, integration, and higher quality performance will be addressed.

**EM 574, Electrical Measurements of Non-Electrical Quantities, 3 cr, 3 cl hrs**

*Prerequisites:* ES 332 and MENG 405, or EE 443 or equivalent, or consent of instructor

This course is particularly reliant on advances in scientific knowledge. Establishment of units and scales of measurement, their development, realization, maintenance and dissemination, as well as the performance of traceable measurements. Hence, this course serves a key factor of modern manufacture through automation, which both enhances productivity and ensures consistent quality. The demand for improved and assured quality means ever better instrumentation. Focus on the course will be on measurement science, design principles for instrument systems, electrical measurements of thermal quantities, electrical measurements of mechanical quantities, electrical measurements of optical quantities, and electrical measurements of chemical quantities.

**EM 576, Biomedical Mechatronics, 3 cr, 3 cl hrs**

*Prerequisites:* MENG 405 or EE 443 or ES 332 or equivalent or consent of instructor

This course will give students direct experience with computational tools used to create simulations of human movement. Lectures and labs cover animation of movement; kinematic models of joints; forward dynamic simulation; computational models of muscles, tendons, and ligaments; creation of models from medical images; control of dynamic simulations; collision detection and contact models. The course is intended as an introduction to medical device design for graduate engineering students because the class will have a significant design and prototyping emphasis.

**EM 581, Directed Study, cr to be arranged****EM 585, Graduate Seminar—Mechatronics, 2 cr**  
(Same as CS585)**EM 586, Advanced Topics in Engineering Science, 2 - 3 cr each semester****EM 590, Independent Study, cr to be arranged****EM 591, Thesis (master's degree), cr to be arranged**

## Staff Teaching & Research Interests

- Anderson—Structural Mechanics including Blast and Seismic Effect, Energy Systems; Nuclear Reactors, Heat Pipes and Fuel Cells
- Baty—Computer Modeling and Simulation
- Colbaugh—Mechanical Engineering, Management
- Gerity—Robotics, System Integration, Technology Turnkey and Licensing
- Lyons—Drilling Mechanics, Structural Mechanics, Structural Vibrations
- Meason—Electromagnetic Directed Energy, Nuclear Engineering, EW/EO/EM Effects, Environmental Monitoring of Natural and Man-made Radionuclides
- Melof—Energetic Materials, Synthesis of Explosives, Explosives Chemistry
- Miller—Finite Element Analysis, Explosive Synthesis of Materials, High-temperature Systems
- Oravec—Rock Mechanics, Instrumentation, High Precision Displacement Measurements
- Ostergren—Mechanics of Materials, Structural Analysis, Machine Design, Propulsion and Power Systems
- Reilly—Fluid-Thermal Systems, Heat Exchangers, Propulsion System Optimization, Combustion Kinetics, Applied Mathematics
- Sarkodie-Gyan—Image Analysis, Robotics and Automation, Vibration and Isolation Systems, Soft Computing (Genetic Algorithms, Neural Computing, Fuzzy Systems), Machine Vision and Pattern Recognition, Biomedical Engineering, Systems Theory
- Walling—Air Blast Loading of Structures, Seismic Response of Structures, High Velocity Impact of Hardened Structures, Mitigation of Effects of Explosive Detonations
- Willian—Engineering Management, Sensor Systems, Weapons Intern Instructor