Mechanical Engineering

Professor: Ford
Associate Professors: Bakhtiyarov, Ghosh, Lim, Ostergren, Yilmaz, Zagrai (Chair of the Department)
Assistant Professors: Grow, Hargather, Kimberley, Ryu, Wei
Visiting Assistant Professor: Wei
Adjunct Faculty: DeChant, Dinwiddie, Fakhimi, Field, Higgins, Kennedy, Langley, Marcy, A. K. Miller, O'Malley, Rivera, Romero, Ruff, Stofleth, Stone, Westpfahl
Emeritus Faculty: A. Miller

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

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

- Bachelor of Science in Mechanical Engineering
- Master of Science in Mechanical Engineering
  - Specialization in Explosives Engineering
  - Specialization in Fluid and Thermal Sciences
  - Specialization in Mechatronics Systems and Robotics
  - Specialization in Solid Mechanics

Program Educational Objectives

The Department of Mechanical Engineering at New Mexico Tech will produce Bachelor of Science graduates who are independent thinkers, taking ownership in identifying problems and determining effective solution strategies in a timely manner. Following working experience after graduation, they will:

1. Be employed successfully in government laboratories, graduate schools, industry, or other areas of the profession
2. Have an understanding of the importance of life-long learning such that they seek personal and professional growth.
3. Have achieved a noteworthy level of workplace responsibility.

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 and thermal sciences, mechanics of materials, vibrations, mechatronics, dynamic systems and controls, instrumentation, and measurement. Junior and senior mechanical engineering students work on design projects for two years that range from the Baja SAE® vehicles to aerospace aircraft design.

Minimum credit hours required—136
In addition to the General Education Core Curriculum (page 7 with MENG 341 substituted for ENGL 341), the following courses are required:

- ES 111 (3), 201 (3), 216 (3)*, 302 (3), 303 (3), 316 (3), 332 (3), 347 (3), 350 (3)
- MENG 110 (1), MENG 110L (1), MENG 302L (1), 304 (3), 305 (3) 351L(1), 352L (1), 341(3), 381 (2), 382 (2), 405 (2), 405L (1), 421 (3), 431 (3), 441 (3), 451 (3), 481 (3), 482 (3), 483 (2) & 483L (1)
- MATE 202 & 202L (4)
- MATH 131 (4), MATH 132 (4), MATH 231 (4), MATH 335 (3) , MATH 337 (3)
- Technical Electives: Three hours from upper-division courses chosen by the student with the faculty advisor's approval.

* or MENG 216(3)

Credit for MATH 103, pre-calculus, and MATH 104, trigonometry, is not allowed for mechanical engineering students.

Courses used for the degree, including the General Education Core Curriculum, may not be taken on an S/U basis except for two courses in Humanities and/or Social Science.

Mechanical 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.

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	MENG110 & 110L (intro.)
3	Social Science
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.)
3	Humanities
18	Total credit hours

Semester 3

3 Social Science
4 MATH 231 (calculus)
4 CHEM 122 & 122L (general)
3 ES 201 (statics)
4 MATE 202 & 202L (intro to materials)
18 Total credit hours

Semester 4

3 MATH 335 (ordinary differential equations)
5 PHYS 122 & 122L (general)
3 MATH 337 (engineering math)
3 MENG 216/ES 216 (fluid mechanics)
3 ES 302 (mechanics of materials)
1 MENG 302L (mechanics of materials lab)
18 Total credit hours

Semester 5

3 MENG 305 (engineering analysis)
3 ES 303 (dynamics)
3 MENG 304 (advanced strength of materials)
3 ES 347 (thermodynamics)
2 MENG 381 (junior design)
3 MENG341 (mechanical engineering tech writing)
17 Total credit hours

Semester 6

3 ES 332 (electrical circuits)
3 MENG 421 & 421L (finite element analysis & design)
1 MENG 351L (fluids lab)
1 MENG 352L (instrumentation and measurements lab)
2 MENG 382 (junior design)
3 ES316 (engineering economics)
3 ES 350 (heat & mass transfer)
16 Total credit hours

Semester 7 (Take FE exam)

2 MENG 405 (dynamic systems & controls)
1 MENG 405L (dynamics systems & controls lab)
3 MENG 451 (machine design)
3 MENG 481 (senior design)
3 MENG 441 (dynamics & vibration)
3 Humanities
3 Social Science
18 Total credit hours

Semester 8

3 MENG 431 (fluid/thermal systems)
3 MENG 483 & 483L (mechatronics)
3 MENG 482 (senior design)
3 Technical Elective

3 Humanities/Social Science
15 Total credit hours

Minor in Mechanical Engineering

Minimum credit hours required – 18
The following courses are required:
At least eighteen (18) credit hours of ES or MENG courses and/or labs beyond those required for major. These courses and labs are subject to the approval of the Mechanical Engineering Minor Advisor.

Minor in Aerospace Engineering

Minimum credit hours required – 18
The following courses are required:
AE 311, Aerodynamics I, 3 cr, 3 cl hrs
AE 412, Aerospace Systems, 3 cr, 3 cl hrs
AE Elective, 3 cr, 3 cl hrs
One course from:

- AE 313, Orbital Mechanics, 3 cr, 3 cl hrs
- AE 414, Aerospace Structures, 3 cr, 3 cl hrs

Two courses from:

- AE 313, Orbital Mechanics, 3 cr, 3 cl hrs
- AE 318, Experimental Methods in Aerodynamics, 2 cr, 2 cl hrs
- AE 318L, Experimental Methods in Aerodynamics Lab, 1 cr, 3 lab hrs
- AE 414, Aerospace Structures, 3 cr, 3 cl hrs
- AE 415, Aerodynamics II, 3 cr, 3 cl hrs
- AE 416, Aircraft Flight Dynamics and Controls, 3 cr, 3 cl hrs
- AE 417, Aerospace Propulsion, 3 cr, 3 cl hrs
- AE 418, Structural Dynamics in Aerospace Engineering, 3 cr, 3 cl hrs

Minor in Biomedical Engineering

Minimum credit hours required – 19
The following courses are required:
BIOL 111, 111L, General Biology, 4 cr, 3 cl hrs, 2 lab hrs
BIOL 331, Cell Biology, 3 cr, 3 cl hrs
BIOL 351, Physiology I, 3 cr, 3 cl hrs
BIOL 352, Physiology II, 3 cr, 3 cl hrs
Two courses from:

- MATE 351, Introduction to Polymeric Materials, 3 cr, 3 cl hrs
- MENG 460, Introduction to Biomedical Engineering, 3 cr, 3 cl hrs
- MENG 465, Biorheology, 3 cr, 2 cl hrs, 3 lab hrs
- MATE 516, Biomimetic Materials, 3 cr, 3 cl hrs
- CHE 473, Polymer Materials Engineering, 3 cr, 3 cl hrs
- MENG 576, Biomedical Mechatronics, 3 cr, 3 cl hrs
- MENG 489, Special Topics in Biomedical Engineering, 3 cr, 3 cl hrs

Senior Design Project:

Students, who are interested in a minor in Biomedical Engineering, will do their Junior/Senior Design Project in the Biomedical Engineering field. This is an opportunity for them to implement their learning in the mechanical engineering and life sciences fields to tackle a particular problem in the biomedical

engineering field.

Minor in Explosives Engineering

Minimum credit hours required – 18

The following courses are required:

EXPL 311/MENG ~~545~~445, Introduction to Explosives Engineering, 3 cr, 3 cl hrs

EXPL 412/MENG 549, Wave Propagation, 3 cr, 3 cl hrs

EXPL Elective, 3 cr, 3 cl hrs (subject to the approval of the Explosives Engineering Minor Advisor)

One course from:

- EXPL 314, Theory and Application of Pyrotechnic, 3 cr, 3 cl hrs
- EXPL 413/MENG ~~589~~513, Impact Dynamics, 3 cr, 3 cl hrs

Two courses from:

- EXPL 314, Theory and Application of Pyrotechnic, 3 cr, 3 cl hrs
- EXPL 316, Energetic Material Chemistry, 3 cr, 3 cl hrs
- EXPL 317, Energetic Material Safety, 3 cr, 3 cl hrs
- EXPL 320, Explosives Technology and Applications, 3 cr, 3 cl hrs
- EXPL 413/MENG ~~589~~513, Impact Dynamics, 3 cr, 3 cl hrs
- EXPL 414/ChE 475, Explosives Surety, 3 cr, 3 cl hrs
- EXPL 415/MENG553, Computer Modeling of Detonations, 3 cr, 3 cl hrs
- EXPL 418, Shock Physics and Structural Response to Blast, 3 cr, 3 cl hrs
- EXPL 419, Experimental and Diagnostic Techniques, 3 cr, 3 cl hrs

Graduate Program

Department Requirements for the Master of Science in Mechanical Engineering

The Mechanical Engineering Department administers the Master of Science in Mechanical Engineering degree for those students wanting to pursue an advanced degree in mechanical engineering. The degree may be earned with a thesis or independent study option. Students selecting the independent study option must complete one additional three credit elective course. There are currently four areas of specialization for this degree:

- Specialization in Explosives Engineering
- Specialization in Fluid and Thermal Sciences
- Specialization in Mechatronics Systems & Robotics
- Specialization in Solid Mechanics

Students must take MENG 585 each semester offered if the student is in residence. Distance-education students and part-time on-campus students are required to take two semesters of MENG 585. Only one credit of MENG 585 may be used to fulfill degree requirements. MENG 585 must be taken for a letter grade if used to fulfill degree requirements.

Requirements

A minimum of 30 credit hours is required for the Master of Science in Mechanical Engineering .

- Core Specialization Courses—at least 12 credit hours from the selected specialization listed below:
  - *Specialization in Explosives Engineering core classes:* MENG ~~545~~445, Introduction to Explosives Engineering; MENG 546, Detonation Theory, MENG 549, Wave Propagation; MENG 550, Advanced Explosives Engineering; MENG 575, Advanced Engineering Mathematics.
  - *Specialization in Fluid and Thermal* Sciences core classes: MENG 556, Compressible Fluid Flow; MENG 575, Advanced Engineering Mathematics; MENG 577, Advanced Fluid Mechanics; MENG 578, Advanced Thermodynamics; MENG 579, Advanced Heat Transfer; MENG 580,

Computational Fluid Dynamics and Reactive Flow.

- *Specialization in Mechatronics Systems and Robotics core classes:* MENG 541, Vibrations in Elastic Continuum; MENG 544/EE 544, Modern Control Theory; MENG 548/EE 548, Manipulator Based Robotics; MENG 551, Sensor Technology; MENG 575, Advanced Engineering Mathematics; MENG 576, Biomedical Mechatronics.
- *Specialization in Solid Mechanics core classes:* MENG 504, Advanced Mechanics of Materials; MENG 515, Theory of Elasticity; MENG 516, Plates and Shells; MENG 517, Advanced Finite Element Method; MENG 520, Fracture Mechanics; MENG 524, Continuum Mechanics; MENG 541, Vibration in an Elastic Continuum; MENG 583, Engineering Mechanics of Composite Structures.

- Elective Courses—6 credit hours of graduate level MENG courses. The advisory committee may allow for a maximum of 3 credits of out-of-department graduate level coursework hours to apply to the elective course requirement.
- Out-of-Department courses—6 credit hours of approved upper-division or graduate course work from another department. The advisory committee may determine that a student's previous academic experience has provided breadth and may recommend modification of this requirement.
- MENG 591, Thesis (6 credit hours) or MENG 590, 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.

Aerospace Engineering Courses

AE 311, Aerodynamics I, 3 cr, 3 cl hrs

Prerequisites: MENG 216/ES 216

Fundamental concepts of aerodynamics, equations of compressible flows, irrotational flows and potential flow theory, singularity solutions, circulation and vorticity, Kutta-Joukowski theorem, thin airfoil theory, finite wing theory, slender body theory, subsonic compressible flow and Prandtl-Glauert rule , supersonic thin airfoil theory, introduction to performance, basic concepts of airfoil design

AE 313, 313D, Orbital Mechanics, 3 cr, 3 cl hrs

Prerequisites: PHYS 122 or 132, MATH 332 or MENG 305

This is a first upper-division course covering the Newtonian mechanics of orbits. Applications include ballistic missiles, satellites, and lunar and interplanetary orbits. (Same as PHYS 313.)

AE 318, Experimental Methods in Aerodynamics, 2 cr, 2 cl hrs

Prerequisite: ES 216/MENG 216

Experimental approach to problem solving and validation of theoretical/computational methods. Uncertainties in measurement. Review of fundamental equations of fluid dynamics, properties of gases and liquids, similarity laws. Wind tunnels, water channels, simulation of phenomena in processing equipment. Pressure sensors, including optically-reactive surface paint. Measurement of skin friction by direct force sensors, Preston and Stanton-tubes, diffusion analogies, liquid crystals. Flow visualization with laser light sheet; Schlieren, shadowgraph and interferometric methods. Future trends; flow control, impact of microelectronic sensors and actuators.

AE 318L, Experimental Methods in Aerodynamics Lab, 1 cr, 3 lab hrs

Corequisite: AE318

Laboratory demonstrations and exercises using available instrumentation in Mechanical Engineering Department.

AE 412, 412D, Aerospace Systems, 3 cr, 3 cl hrs

Prerequisites: ES 111; MATH 335; MENG 305
Corequisites: MENG 405, 451; EE 341 for EE majors or consent of instructor

The course explores formulation, development and implementation of a comprehensive approach to the design, analysis, and life-cycle cost management of highly complex, often adaptive systems. An appreciation for the strength of integrated, multidisciplinary skills, within a structured framework for concept development is a desired outcome of the course. A number of case studies are examined as leading examples for completion of a final class project in systems conceptualization and development management.

AE 414, 414D, Aerospace Structures, 3 cr, 3 cl hrs
Prerequisites: MENG 304, MENG 305

Behavior, analysis and design of discrete and continuous plates and shells, membrane and bending behavior, numerical methods of solution, Composite structures, Macro-mechanics to Structural design and development. Development of analytical procedures for determining material properties. Effective experimental methods and prediction of structural behavior.

AE 415, 415D, Aerodynamics II, 3 cr, 3 cl hrs
Prerequisites: AE 411

The course is covering advanced aerodynamic theories and their application. Includes airfoil shape, drag, velocity, lift, thrust, stability and control. Also included are advanced principles of performance including airplane capabilities and limitations, performance design criteria, load factors, weight and balance, comparative analysis of aircraft and aircraft certification.

AE 416, 416D, Aircraft Flight Dynamics and Controls, 3 cr, 3 cl hrs
Prerequisites: ES 332, MATH 254 or equivalent, MATH 335, MENG405, AE 411, AE 412

The application of aerodynamic surfaces to determine the trajectory and the attitude of flight vehicles involves knowledge of the forces and moments applied to the vehicle from the surrounding media in subsonic, transonic and supersonic flow regimes. Methods of either specifying, or estimating the performance parameters of a flight vehicle, operating in a particular velocity range are introduced, including the critical factors in determining the size, shape and placement of control surfaces, and the forces or torques required to reliably and accurately position such surfaces in desired states. Time-domain methods are taught for simulating flight vehicles and synthesizing robust, stable control schemes.

AE 417, 417D, Aerospace Propulsion, 3 cr, 3 cl hrs
Prerequisites: ES 216/MENG 216, ES 347

Aerospace propulsion can be classified into four categories: propeller, jet, ramjet and rocket propulsion. Among them gas turbine engines and jet propulsion are the essentials for modern aircraft. In this course, the fundamentals of different propulsion systems will be first introduced. Then the course focus will be on gas turbine engines. The material can be divided into four parts: (1) review of thermodynamics and compressible flow; (2) one-dimensional gas dynamics analysis of gas engine performance; (3) analysis and performance of air breathing propulsion system; and (4) the analysis and design of gas turbine engine components, e.g. inlets, nozzles, turbomachinery (compressors, turbines, turbofan, turbopropeller) and combustors. Further, the fundamentals of ramjet and rocket propulsion will be also discussed in this course.

AE 418, Structural Dynamics in Aerospace Engineering, 3 cr, 3 cl hrs
Prerequisites: MATH 231, ES 302, ES 303, AE 414.

This course explores structural dynamic topics covering a broad range of aerospace applications. Vibration of single and multi-degree-of-freedom systems is reviewed in the context of modeling the

aerospace structural systems. Essential structural elements – bars, beams, and plates are addresses in the dynamics of continuous systems section. Structural response to transient, shock, and random loads is discussed and practical aspects of dynamic testing are presented.

AE 420, 420D, Compressible Fluid Flow, 3 cr, 3 cl hrs

Prerequisites: ES 216, ES 347, ES 350, MATH 335

Explanation of the physical phenomena encountered in compressible flow by providing practical applications and examples. Provide the knowledge and understanding of the basic fundamentals of compressible flow and gas dynamics.

AE 489, 489D, Special Topics in Aerospace Engineering, 3 cr, 3 cl hrs

AE 491, Directed Study, cr to be arranged

Explosives Engineering Courses:

EXPL 189 - Beginning Explosives Engineering, 2 cr, 2 cl hrs

Prerequisites: none

This course will introduce the student to the subjects of pyrotechnics and explosives and encompasses subjects including basic combustion chemistry, the physical chemistry of energetic materials, and some test instrumentation. This course also will include a design project.

EXPL 189 - Beginning Explosives Engineering Lab, 3 lab hrs

Prerequisites: none

This course is based primarily in the laboratory, however, two days will be spent at the Energetic Materials Research and Testing Center working with high explosives

EXPL 311, Introduction to Explosives Engineering, 3 cr, 3 cl hrs

Prerequisites: ES 216, ES 302 and ES 347; or consent of instructor~~CHEM 122 and 122L; PHYS 122 and 122L; ES 111 or CS111; ES347 or ES350; 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.

EXPL 314 Theory and Application of Pyrotechnic, 3 cr, 3 cl hrs

Prerequisite: EXPL 311

Fundamentals of basic concepts of pyrotechnic. Thermo-mechanical/chemical aspects of pyrotechnics, formulation and mixing of pyrotechnic mixtures, application of pyrotechnic including illumination, tracers, incendiaries, delays, etc.

EXPL 316 Energetic Material Chemistry, 3 cr, 3 cl hrs

Prerequisite: EXPL 311

An introduction to the chemical aspect of energetic materials. Based on basic/advanced chemical and thermo-chemical concepts and dynamics, understand the characteristic and typical properties of energetic materials.

EXPL 317 Energetic Material Safety, 3 cr, 3 cl hrs

Prerequisite: EXPL 311

Development of the concept of detonation process or Detonation-Deflagration Transition (DDT) mechanics. Analysis of the thermo-dynamic behavior of explosives, hydro hot-spot theory, shock initiation, explosives cook-off, explosive sensitization.

EXPL 320 Explosives Technology and Applications, 3 cr, 3 cl hrs

Prerequisite: EXPL 311

Focus on the application of explosives mechanics. Fundamentals of explosive welding/cutting, shaped charges, explosive-driven flux-compression generators, spallations, explosives initiation methods, explosives applied testing methods, etc.

EXPL 412, Wave Propagation, 3 cr, 3 cl hrs

Prerequisites: EXPL 311 and MATH 335; or consent of instructor

An in-depth study of the propagation of 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-Gruneisen equation of state. The differential form of the conservation equations, as well as some numerical solutions for simple cases. Shares lecture with ME/MENG 549, with additional expectations for graduate credit.

EXPL 413 Impact Dynamics, 3 cr, 3 cl hrs

Prerequisites: EXPL 412

A specialized but very important branch of engineering mechanics deals with the collision of multiple bodies throughout a broad range of relative velocities. The physical phenomenon during impact and subsequent response of each of the bodies is dependent on the mechanical material properties of each, the impact velocities, and the relative size and orientation of each of the bodies. Impact response is most easily categorized based on the impact velocity (relative approach velocity of two bodies), ranging from elastic response with little change in temperature at low velocities, through plastic deformation and/or fracture at higher velocities, to physical state changes of bodies or a portion of a body at hyper-velocity impacts (> 1 km/sec).

EXPL 414 Explosives Surety, 3 cr, 3 cl hrs

Prerequisite: Upper class standing or consent of instructor

An introduction to explosives and other energetic materials. The basic chemical compositions, properties and environmental effects of commercial, military, and improvised explosives and some pyrotechnics will be compared. The basic physics of shock waves and detonation. Explosive effects, blast detection, tagging and environmental issues. Case studies or recent bombings will be used to describe a variety of terrorist approaches. Safety in handling of explosive materials and classifications for transportation and storage. (Same as ChE 475.)

EXPL 415 Computer Modeling of Detonations, 3 cr, 3 cl hrs

Prerequisite: EXPL 412; or EXPL 311 and MENG 421: or consent of instructor.

Introduction to the numerical/hydrocode modeling of detonation behaviors. Focus on the area of detonation initiation, behavior of heterogeneous explosives, explosive/propellant performances, experiment interpretations, and numerical expressions of explosives relate theories.

EXPL 418 Shock Physics and Structural Response to Blast, 3 cr, 3 cl hrs

Prerequisite: EXPL 412 or consent of instructor

An in-depth study of structural behaviors on blast and vibration. Structure damage prediction/estimation, blasting shockwave mitigation methods/concepts, shockwave propagation/properties on structures, structure failure criteria.

EXPL 419 Experimental and Diagnostic Techniques, 3 cr, 3 cl hrs

Prerequisite: EXPL 412

An introduction to the explosive testing date acquisition systems. Basic concepts of the measurement of detonation product properties and characteristics of detonation process. Analysis of material properties under high pressure shock compression, and data interpretations

EXPL 419L Explosives Testing and Diagnostic Techniques Laboratory, 1cr., 3 cl. hrs
Prerequisite: MENG ~~545~~445 or EXPL 311 and EXPL 412 or consent of instructor.
Co-requisite: EXPL 419

An introduction to the explosive testing data acquisition systems. Basic concepts of explosives initiation and the measurement/characterization of detonation effects. Experimental analysis of energetic materials and explosives devices utilizing various state-of-art testing equipment. Ultra-high speed camera, VISAR, shock measurement systems, etc. Analysis of material properties under high-pressure shock compression, and data interpretations.

EXPL 489, Special Topics in Explosives Engineering, 3cr., 3 cl. Hrs

EXPL 491 Directed Study, cr to be arranged

Mechanical Engineering Courses:

MENG 110, 110L Introduction to Mechanical Engineering, 2 cr, 1 cl hr, 3 lab hrs
Corequisites: MATH 103 or higher; MENG 110 and 110 L are co-requisites of each other

A broad overview of mechanical engineering, including an introduction to mechatronics, explosives, thermal and fluid sciences, solid and structural mechanics. Practical hands-on experience using the Mechanical Engineering department's computer-based applications software and lab equipment.

MENG 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.

MENG 302L, Mechanics of Materials Laboratory, 1 cr, 3 lab hrs
Corequisite: ES 111, ES 302

Experiments in mechanics of materials, testing methods, and measurement techniques.

MENG 304, Advanced Strength of Materials, 3 cr, 3 cl hrs
Prerequisites: 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 111, ES 216/MENG 216, ES 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. (Same as ES 305)

MENG 341, Mechanical Engineering Technical Writing, 3 cr, 3 cl hrs
Prerequisites: ENGL 111 and 112 or the equivalent passed with a grade of C or better.
Corequisites: MENG 381.

This course is designed to offer instruction in theory and practice of effective technical communication, particularly as applied to Mechanical Engineering and the junior/senior design clinic. Students who successfully complete this course should be able to plan, organize, draft, revise, and edit technical communication that is professional in content and appearance and appropriately designed for

its intended audience.

MENG 351L, Fluid and Thermal Sciences Laboratory, 1 cr, 3 lab hrs
Prerequisites: ES 216/MENG 216, ES 347, MENG 341
Corequisites: ES 350
Experimental analysis of fluid flow, heat transfer and thermodynamic systems. CFD tools are used for visualization, validation and comparisons with experimental data. A final project in the field of fluid and thermal sciences is required for each laboratory group. Laboratory reports are presented in oral and written formats.

MENG 352L, Instrumentation and Measurement Laboratory, 1 cr, 3 lab hrs
Prerequisites: ES111, MATH 132
An introduction to a variety of programming and simulation environments, such as Matlab, Simulink, and LabView. Conduct experiments using instrumentation in conjunction with data acquisition software and hardware, to develop programs simulating systems and reducing data. The underlined direction of this course will be to simulate, observe, and record natural phenomena in the world of mechanical engineering.

MENG 381, Junior Engineering Design Clinic I, 2 cr, 1 cl hr, 3 lab hrs
Prerequisites: ES 216/MENG 216, ES 302; MATH 335; PHYS 122 & 122L; junior standing
Corequisite: MENG 341
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, 2 cr, 1 cl hr, 3 lab hrs
Prerequisite: MENG 341; MENG 381
A continuation of MENG 381 academic-year-long engineering design project.

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, Dynamic Systems and Controls Laboratory, 1 cr, 3 lab hrs
Prerequisite: ES 111; MATH 335
Laboratory exercises involving instrumentation and design of basic control systems.

MENG 421, 421D, Finite Element Analysis and Design, 2 cr, 2 cl hrs
Prerequisites: MENG 304 passed with grade C or better, Math 337 or consent of instructor
Introduction to the theory of finite element analysis for structural and heat transfer analysis. Use of finite element analysis in engineering design.

MENG 421L, Finite Element Analysis and Design Lab, 1 cr, 3 lab hrs
Corequisites: MENG 421
Application of finite element computer codes to solve complex engineering design problems.

MENG 431, 431D, 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, 441D, Dynamics and Vibrations in Structural Design, 3 cr, 3 cl hrs

Prerequisites: MATH 335 and MENG 305.
ES 332 recommended

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 445, 445D, Introduction to Explosives Engineering, 3 cr, 3 cl hrs

Prerequisites: ES 216, ES 302 and ES 347; 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.

MENG 451, 451D, Design of Machine Elements, 3 cr, 3 cl hr

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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 460, 460D, Introduction to Biomedical Engineering, 3 cr, 3 cl hrs

Prerequisite: Sophomore classification or consent of instructor

An overview of research in biomedical engineering, biomechanics, biocompatibility, tissue engineering, biomedical instrumentation, and moral and ethical issues.

MENG 465, Biorheology, 3cr, 2 cl hrs, 3 lab hrs

Prerequisite: MENG 351L or consent of instructor

Concepts of rheology. Rheology of body fluids. Different rheological models of fluids and applications in diagnosis and treatment of diseases. Laboratory experiments of plasma and blood rheological characterization (viscosity, elasticity, plasticity, etc.).

MENG 481, Senior Engineering Design Clinic I, 3 cr, 1 cl hr, 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, 3 cr, 1 cl hr, 6 lab hrs

Prerequisite: MENG 481

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

MENG 483, 483D, Mechatronics, 2 cr hr, 2 cl hr

Prerequisites: MENG 352L, MENG 405/405L, and MENG 441; or consent of instructor
Corequisite: MENG 451 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 484L, Design Clinic Lab, 1 cr, 3 lab hrs

Prerequisites: ES or MENG-110, ES or MENG-110L

Corequisites: MENG-381 or consent of the instructor

The Design Clinic Lab Course will introduce students to critical skills important in the engineering design and verification process. Weekly sessions will be conducted in specialized topics pertinent to the design process. Topics include Computer Aided Engineering (CAE), Computer Aided Design (CAD) using Solidworks, mechanical drawing layout, mechanical assemblies, clearances and tolerances, analytical modeling, concepts in machining of components, and the joining of components.

MENG 485, Advanced Design Clinic, 3 cr, 1 cl hrs, 6 lab hrs

Prerequisites: MENG 482

Enables students to enhance their understanding of the engineering design and verification process for mechanical design projects. Weekly seminars in specialized topics pertinent to the design process. Students focus on developing best practices for completing mechanical design projects. These best practices are used to improve the performance of design clinic project teams. Students participate in design project teams, contributing as senior technical members and/or advisers. Students contribute to the formal reports and oral presentations of these teams.

MENG 489, 489D, Special Topics in Biomedical Engineering, 3 cr, 3 cl hrs

MENG 491, 491D, Directed Study, cr to be arranged

Graduate Courses:

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

MENG 504, 504D, Advanced Mechanics of Materials, 3 cr, 3 cl hrs

Prerequisite: MENG 304 or equivalent or consent of instructor

Development of advanced mechanics of materials principles and techniques for use in engineering design and problem solving. Topics include material yielding, torsion, unsymmetrical bending of beams, shear stresses in thin-walled structures, curved beams, beams on elastic foundations, axisymmetric thin-walled shells and thick-walled cylinders, column stability, stress concentrations, and material failure behavior under steady and cyclic loading.

MENG 513, Impact Dynamics, 3 cr, 3 cl hrs

Prerequisites: Graduate Standing or Consent of Instructor

A specialized but very important branch of engineering mechanics deals with the collision of multiple bodies throughout a broad range of relative velocities. The physical phenomenon during impact and subsequent response of each of the bodies is dependent on the mechanical material

properties of each, the impact velocities, and the relative size and orientation of each of the bodies. Impact response is most easily categorized based on the impact velocity (relative approach velocity of two bodies), ranging from elastic response with little change in temperature at low velocities, through plastic deformation and/or fracture at higher velocities, to physical state changes of bodies or a portion of a body at hyper-velocity impacts (> 1 km/sec).

MENG 515, 515D, 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)

MENG 516, 516D, Plates and Shells, 3 cr, 3 cl hrs
Prerequisites: MENG 305, MENG 451 or approval of the instructor.
Behavior, analysis and design of discrete and continuous plates and shells, membrane and bending behavior, numerical methods of solution.

MENG 517, 517D /ME 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)

MENG 519, 519D, Adaptive Structures, 3 cr, 3 cl hrs
Prerequisites: MENG 305, Pre/Corequisite MENG 589 or approval of the instructor
Adaptive structures with embedded intelligent sensors and actuators, self-monitoring and self healing characteristics, biological system/ structures.

MENG 520, 520D, 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)

MENG 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.

MENG 522, Mechanics of Inelastic Continuum, 3 cr, 3 cl hrs
Prerequisites: MENG 515, MENG 524 or approval of the instructor
Modeling systems that yield inelastic equations, coupled with methods for their solutions and analysis. Development of insight into the fundamental behavior of inelastic systems.

MENG 523, Engineering Mechanics of Cellular Structures, 3 cr, 3 cl hrs
Prerequisites: MENG 305, Pre/Corequisite MENG 589 or approval of the instructor
Cellular structures with combinations of mechanical, energy-absorption, thermal and acoustic/vibration characteristics and their implementation in diverse applications.

MENG 524, 524D, Continuum Mechanics, 3 cr, 3 cl hrs
Prerequisites: MENG 515, Pre/Corequisite MENG 517 or approval of the instructor
Matrix, indicial and direct notation, tensor calculus, deformation analysis; general principles of stress, curvilinear coordinates.

MENG 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.

MENG 541, 541D, 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.

MENG 544, 544D, Modern Control Theory, 3 cr, 3 cl hrs
Prerequisites: MENG 405 or consent of instructor
Designing and analyzing modern control systems that can be devised from dealing exclusively in the time domain. Methods of expanding control concepts from simple single-input single-output processes to full multi-input multi-output, continuous and discrete, linear and nonlinear systems will be explored. Students will submit a semester-long research paper.

MENG 545 changed to MENG 445
~~**MENG 545, 545D, Introduction to Explosives Engineering, 3 cr, 3 cl hrs**~~
~~*Prerequisites: ES 216, ES 302 and ES 347; 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.~~

MENG 546, 546D, Detonation Theory, 3 cr, 3 cl hrs
Prerequisites: MENG 549 or consent of instructor. MENG 556 recommended.
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 546)

MENG 547, 547D, Theory and Application of Pyrotechnics, 3 cr, 3 cl hrs
Prerequisites: MENG ~~545~~445 or consent of instructor
Fundamentals of basic concepts of pyrotechnic. Thermo-mechanical/chemical aspects of pyrotechnics, formulation and mixing of pyrotechnic mixtures, application of pyrotechnic including illumination, tracers, incendiaries, delays, etc.

MENG 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)

MENG 549, 549D, Wave Propagation, 3 cr, 3 cl hrs

Prerequisites: MENG ~~545~~445 and MATH 335; or consent of instructor

An in-depth study of the propagation of 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-Gruneisen equation of state. The differential form of the conservation equations, as well as some numerical solutions for simple cases. Shares lecture with EXPL 412, with additional expectations for graduate credit. (Same as ME 549)

MENG 550, 550D, Advanced Explosives Engineering, 3 cr, 3cl hrs

Prerequisites: MENG 549 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)

MENG 551, 551D, Optimal Control Systems, 3 cr, 3 cl hrs

Prerequisites: ES 332, MATH 254 or equivalent, MATH 335, MENG 405

Formulation of stochastic dynamic systems models, combined with optimal full-state and reduced-state estimators are introduced. Various cost functionals are defined and used to design real-time control algorithms that produce specific desired system responses. Mathematical measures of control robustness are defined which allow the student to gain an appreciation for predicting and measuring system stability margins under sub-optimal conditions.

MENG 552, 552D, Explosives Technology and Applications, 3 cr, 3 cl hrs

Prerequisites: MENG ~~545~~445 or consent of instructor

Focus on the application of explosives mechanics. Fundamentals of explosive welding/cutting, shaped charges, explosive-drives flux compression generators, spallations, explosives initiation methods, explosives applied testing methods, etc. Students will submit a semester-long research report.

MENG 553, 553D, Computer Modeling of Detonations, 3 cr, 3 cl hrs

Prerequisites: MENG 519 or consent of instructor. MENG 517 is recommended.

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)

MENG 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)

MENG 555, Shock Physics and Structural Response to Blast, 3 cr, 3 cl hrs

Prerequisites: MENG 549 or consent of instructor

An in-depth study of structural behavior during blast and vibration. Structure damage prediction/estimation, blasting shockwave mitigation methods/concepts, shockwave

propagation/properties on structures, structure failure criteria. Students will submit a semester-long research report.

MENG 556, 556D Compressible Fluid Flow, 3 cr, 3 cl hrs
Prerequisites: ES 216/MENG 216, ES 347, ES 350, MENG 431, MATH 335
Explanation of the physical phenomena encountered in compressible flow by providing practical applications and examples. Provide the knowledge and understanding of the basic fundamentals of compressible flow and gas dynamics.

MENG 557, Multiphase Flow, 3 cr, 3 cl hrs
Prerequisites: MENG 431 or equivalent or consent of the instructor
Selected topics in multiphase flows with emphasis on engineering applications. Topics include basic two-phase flow equations, pressure drop in two-phase flow, gas-liquid, gas-solid and liquid-solid two-phase flows.

MENG 558, 558D, Non-Newtonian Fluid Mechanics, 3 cr, 3 cl hrs
Prerequisite: consent of the instructor
This course offers the specific techniques and understanding necessary for being able to compute and understand issues associated with non-Newtonian fluid dynamics. Issues of rheology and analytic techniques are covered.

MENG 559, Theory and Design of Internal Combustion Engines, 3 cr, 3 cl hrs
Prerequisites: ES 347, ES 350, MENG 304, MENG 421, or consent of the instructor
Thermodynamic analysis and performance characteristics of spark ignition and compression ignition engines. Effects of thermodynamics, heat transfer and combustion on engine power, efficiency and emissions. Design of internal combustion engines; stress analysis, kinematics and dynamics of the crank mechanism, design of piston, connecting rod and crankshaft.

MENG 560, 560D, Principles of Combustion, 3 cr, 3 cl hrs
Prerequisites: ES 347 or consent of the instructor
Covers the fundamentals of combustion. Topics include chemical reactions, calculation of adiabatic flame temperature, chemical kinetics and flammability limit, characteristics of premixed, diffusion, laminar and turbulent flames.

MENG 567, 567D, Smart Engineering Systems, 3 cr, 3 cl hrs
Prerequisites: MATH 254, 382; CSE 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.

MENG 568, Smart Engineering Systems II, 3 cr, 3 cl hrs
Prerequisites: MATH 254, 382; CSE 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.

MENG 570, 570D, 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.

MENG 571, Haptic Systems, Teleoperation, & Virtual Reality, 3 cr, 3 cl hrs

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

Haptic and virtual-reality interfaces are designed with the sensing, control, and actuation capabilities of both humans and robots in mind. This course provides a practical introduction to select aspects of these capabilities. Mathematical formulations fundamental to the course will be derived. Students' ability to comprehend and synthesize the often dense and technical content of research papers will be improved through frequent reading and discussion assignments. Students will design computer algorithms throughout the semester that will culminate in a final programming project.

MENG 572, 572D, 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.

MENG 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.

MENG 575, 575D, Advanced Engineering Mathematics, 3 cr, 3 cl hrs

Prerequisites: MENG 305 or consent of the instructor

A comprehensive study of applied mathematics. Vector analysis, tensors and Eigenvalue problems. Analytical solutions to linear ordinary and partial differential equations. Separation of variables, boundary value problems, and Laplace and Fourier transforms. Numerical analysis of non-linear ordinary and partial differential equations with emphasis on engineering applications. Complex Analysis; complex numbers, Cauchy-Riemann equations and conformal mapping.

MENG 576, 576D, 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.

MENG 577, 577D, Advanced Fluid Mechanics, 3 cr, 3 cl hrs

Prerequisites: MENG 431 or equivalent

Corequisite: MENG 575

Fundamental concepts and analysis of Fluid Mechanics. Derivation of the partial differential

equations governing the conservation of mass, momentum and energy. Introduction to potential flows. Exact solutions of the Navier-Stokes equations. Laminar and turbulent boundary layers. Compressible and incompressible flow problems.

MENG 578, 578D, Advanced Thermodynamics, 3 cr, 3 cl hrs
Prerequisites: ES 347 or consent of the instructor
The first and second laws of thermodynamics. Clapeyron relation, availability concepts and analysis, equations of state, non-reacting mixtures and thermodynamics of chemical reactions.

MENG 579, 579D, Advanced Heat Transfer, 3 cr, 3 cl hrs
Prerequisites: ES 350 or consent of the instructor
Covers analytical and numerical techniques in conduction, convection, radiation with emphasis on combined heat transfer.

MENG 580, 580D, Computational Fluid Dynamics and Reactive Flow, 3 cr, 3 cl hrs
Prerequisites: MENG 560, MENG 577 or consent of the instructor
Introduction to Computational Fluid Dynamics and application of CFD tools to thermal and fluid flow problems. Coupling of fluid flow with combustion chemistry. Discussion of combustion modeling, importance of the mixing intensity, heterogeneous and homogeneous chemical reactions, and application of computer analysis to chemically reacting flow problems.

MENG 581, Directed Study, cr to be arranged

MENG 582, 582D, Nondestructive Evaluation and Structural Health Monitoring, 3 cr, 3 cl hrs
Prerequisites: MENG 304, MENG 305, MATH 335 or consent of instructor.
This multi-disciplinary course introduces key physical concepts in elasticity, material science, acoustics, optics, and electromagnetics applied to system condition monitoring, material characterization, structural damage detection and failure prevention. A broad spectrum of nondestructive evaluation (NDE) methods and emerging structural health monitoring (SHM) technologies is discussed including the ultrasonic inspection, vibration monitoring, acoustic emission, radiography, eddy currents, electrical and magnetic testing. Examples of practical NDE/SHM applications in scientific research and industrial practice are presented.

MENG 583, 583D, Engineering Mechanics of Composite Structures, 3 cr, 3 cl hrs
Prerequisites: MENG 305, Pre/Corequisite MENG 523 or consent of the instructor
Composite structures, Macro-mechanics to Structural design and development. Development of analytical procedures for determining material properties, effective experimental methods and prediction of structural behavior.

MENG 585, 585D, Graduate Seminar, 1 cr

MENG ~~586~~589, ~~586~~589D, Advanced Topics in Mechanical Engineering ~~Science~~, 2 - 3 cr each semester
Prerequisites: ~~MENG 549 or~~ consent of the instructor

MENG 589 moved to MENG 513
~~**MENG 589, Impact Dynamics, 3 cr, 3 cl hrs**~~
~~*Prerequisites: ES 303, ES 305, MENG 305 or equivalent*~~
~~A specialized but very important branch of engineering mechanics deals with the collision of multiple bodies throughout a broad range of relative velocities. The physical phenomenon during impact and subsequent response of each of the bodies is dependent on the mechanical material properties of each, the impact velocities, and the relative size and orientation of each of the bodies. Impact response is most easily categorized based on the impact velocity (relative approach velocity of two bodies), ranging from elastic response with little change in temperature at low velocities, through~~

~~plastic deformation and/or fracture at higher velocities, to physical state changes of bodies or a portion of a body at hyper-velocity impacts (> 1 km/sec).~~

MENG 590, Independent Study, cr to be arranged

MENG 591, Thesis (master's degree), cr to be arranged

Faculty Teaching & Research Interests

Abernathy – Energetic Materials Testing and Computational Analysis
Bakhtiyarov—Non-Newtonian Fluid Mechanics, Heat and Mass Transfer, Rheology, Multiphase Flows, Instrumentation, Fluidized Beds, Porous Medium Flows, Nanotechnology, Self-Healing Materials, Tribology, Turbulence
Cooper - Explosives Technology, Explosives Engineering
Dinwiddie - Dynamic Antenna Modeling
Fakhimi - Geomechanics, Numerical Modeling
Ford – Written and Oral Communication, Teamwork, Communication Pedagogy, Leadership
Field – Structural Dynamics, Random Vibration, Applied Probability, Computational Modeling, Model Validation, and Robust Control
Fortner—Energetic Materials: Initiation, Applications, and Systems
Ghosh—Macro Behavior of Composites, Biomechanics, Finite Element Analysis, Experimental Mechanics and Instrumentation, Structural Health Monitoring and Restoration, Construction Materials and Project Management
Grow – Robotics, Biomedical & Surgical Devices, Haptics, Dynamic Modeling
Hargather – Shock and Gas Dynamics, Experimental Thermal-Fluid Dynamics, High-Speed Gas Dynamics, Thermal Convection Problems
Kennedy - Basic Science and Applications of Explosives, Microdetonics and Initiation of Detonation in Explosives
Kimberley – Solid Mechanics, Impact Studies, Dynamic Behavior of Materials
Lim-Energetic Materials, Explosives Technology, Linear and Conical Shaped Charges
Marcy—General Aviation, Conceptual Design
Meason – Explosives Technology
Miller, A. —Finite Element Analysis, Explosive Synthesis of Materials, High-Temperature Systems
Miller, A.K. —System Dynamics, System Modeling and Simulation, Actuators and Actuator Controls
Ostergren—Mechanics of Materials, Structural Analysis, Machine Design, Propulsion and Power Systems
Rivera – Energetic Materials, Explosives Technology
Romero—Energetic Materials, Shock Phenomena, High Energy Physics
Ruff – Mechanics of Materials, Instrumentation
Ryu – Mechanics of Materials, Smart Materials and Structures, Continuum Mechanics, Sustainable Infrastructures, Structural Health Monitoring, Advanced Sensing Technologies, Autonomous Composites, Multifunctional Materials, Nanomaterials and Nanocomposites, Optics and Optoelectronics
Stofleth – Instrumentation and Measurements, Explosives Technology
Wei – Thermal-Fluid Science, Wall-Bounded Flow, Flow Instabilities, Enhancing or Reducing Heat Transfer Coefficients, Turbulent Mixing, and Fluid Drag.
Westpfahl - Dynamics of Spiral and Dwarf Galaxies

Yilmaz - Computational Fluid Dynamics, Combustion and Chemical Kinetics, Rocket Propellants, Internal Combustion Engines, Alternative Fuels, Renewable Energy

Zagrai---Structural Dynamics and Acoustics, Intelligent Systems and Structures, Sensor Networks, Structural Health Monitoring and Nondestructive Evaluation.