351. Mechanical Engineering Analysis
Fall, Winter. 4(4-0) MTH 315, 
CPS 120 or concurrently.
Application of analytical and numerical methods to the solution of problems encountered in mechanical engineering.

352. Introduction to Systems and Control
Winter, Spring. 4(4-0) Approval of department.
Modeling of a variety of physical systems, using state-variable concepts. Time and frequency response of low-order linear systems. Primary applications to mechanisms and hydraulics.

406. Automotive Engines
Spring. 3(3-3) 310,
Analysis of internal combustion engines for vehicular propulsion.

410. Thermomechanical Continua
Fall. 3(3-0) MTH 311; MTH 324
Thermomechanical continua including energy principles, formulation and solution of boundary value problems, the use of elasticity, plasticity, and viscoelasticity, Dynamic response of mechanical systems via Hamilton's Principle; Euler-Lagrange equations. Rayleigh, Ritz, and Galerkin approximations.

411. Heat Transfer I
Fall. 3(3-0) 311; MTH 215

412. Heat Transfer II
Winter. 3(3-0) 333, 411
Natural and forced convection based on boundary layer theory. Heat transfer in fluids with phase change. Heat exchangers, mass transfer.

414. Energy Conversion
Winter. 3(3-0) 312
Fundamental principles of energy conversion systems. Direct energy conversion. Thermoelectric, photovoltaic, nuclear, fuel cells, marine, hydrokinetic, and other methods of power generation.

417. Propulsion
Spring. 3(3-0) 333

421. Machine Design I
Fall. 4(3-3) MTH 211
Analysis and synthesis of mechanical systems, fatigue resistance, stress concentration; elasticity; non-linear elements.

422. Machine Design II
Winter. 3(3-2) 431
Analysis and synthesis of elements of systems; hydrodynamic theory of lubrication; contact stresses; finite and infinite life design factors.

424. Dynamics of Machines
Winter. 3(3-0) 350
Analysis of static and dynamic forces in rigid body systems; balancing of rotating and reciprocating system elements; inertial guidance; critical speeds.

432. Aerodynamics
Winter. 3(3-0) 333
Fundamental of fluid mechanics, potential flows about bodies and fields, compressible flow, perturbation methods, viscous flow, boundary layers on airfoils, transition, turbulence, separation, aerodynamics of wings and bodies.

436. Cooling Processes
Spring. 3(3-0) 312
Thermodynamic principles applied to the design of cooling systems in range of normal temperatures to ultra-low cryogenic temperature conditions. Psychrometric principles as applied to air conditioning and evaporating systems.

442. Industrial Engineering
Winter, Spring. 4(3-2) 280; MGT 302
Theory and techniques used by industry in planning for manufacturing. Process selection and design, work methods planning, production time standards, materials handling, and plant layout planning.

451. Modeling of Physical Systems
Fall. 3(3-0) 322
Modeling of physical and engineering devices as multidimensional bond graph representation of multiport systems; application to mechanical, hydraulic, electrical, and transducer components.

452. Analysis of Physical Systems
Winter. 3(3-0) 451
Systematic formulation of state-space equations for multiport models; analytical methods for linear systems, including time and frequency response characteristics based on matrix methods. Systems containing rigid bodies.

455. Mechanical Vibrations
(325.) Winter. 4(4-0) MTH 206
Oscillatory phenomena for linear systems with one and two degrees of freedom, non-linear systems, time varying systems with deterministic excitation, and time invariant systems with non-deterministic excitations.

458. Control Theory
(426.) Spring. 3(3-0) 352
Closed-loop control systems; application of transfer function analysis; design for a definite degree of stability, on-off controllers.

463. Mechanical Engineering Projects
Spring. 3(3-4) 332, 411

471. Flight Dynamics
Fall. 3(4-0) MTH 206
Particle and rigid body dynamics, vacuum trajectories, orbit theory, aerodynamic forces, propulsion, longitudinal, directional and lateral stability and control, dynamics stability and control, range, speed, payload, and altitude performance.

499. Senior Problems
Fall, Winter, Spring, Summer. 1 to 6 credits. May re-enroll for a maximum of 12 credits. Approval of department.

812. Heat and Mass Transfer
Fall. 4(4-0) Graduate students. Not open to students with credit in 411, 412
811. Convective Heat Transfer
Winter. 3(3-0) 412; MTH 421.
Analysis of convective transfer of heat, mass, and momentum in boundary layers and induced flows. Heat transfer with phase change of fluids.

814. Radiative Heat Transfer
Spring. 3(3-0) 812.

815. Advanced Classical Thermodynamics
Fall of odd-numbered years. 3(3-0) 313; MTH 422 or 424 or concurrently.
Posttreatment of the laws of thermodynamics. Equilibrium and maximum entropy postulates. Development of formal relationships. Principles for general systems. Applications to chemical, magnetic, electric and elastic systems.

817. Conductive Heat Transfer
Fall. 3(3-0) 411, 351.

818. Parameter Estimation
Spring. 3(3-0). May re-enroll for a maximum of 6 credits. 351.

823. Theory of Vibrations I
Fall. 4(4-0) 455. Interdepartmental with the Metallurgy, Mechanics and Materials Science Department.
Discrete and continuous parameter systems with linear and non-linear characteristics. Variational principles; equations of motion. Matrices; quadratic forms; self-adjoint operators; eigenvalues. Trajectory and random excitation. Theory developed through physical problems.

826. Kinematics of Machines II
Fall. 3(3-0) 420.

827. Machine Design III
Spring. Summer. 3(3-0) 431.
Strain energy method for analyzing statically indeterminate machine members. Theories of failure, fatigue, use of statistics in selection of tolerances for parts in mass production. Optimization design.

828. Machine Design IV
Winter. 3(3-0) 421.
Application of design theory to the synthesis of complete mechanical and hydraulic systems. Stress waves due to impact loading. Critical speed.

832. Refrigeration
Spring. 3(3-0) 436.
Characteristics of refrigerants; application details pertaining to comfort cooling, food refrigeration, and ultra-low temperature units; refrigeration controls, and control systems.

834. Low Temperature Thermal Analysis
Winter of odd-numbered years. 3(3-0) 436.
Low temperature environments and thermal transport fluids. Cryogenic systems; space simulation, super insulation, vacuum technology, ultra low temperature physical phenomena with helium and magnetic cooling systems.

841. Advanced Gas Dynamics
Spring. 3(3-0) 423; MTH 322 or 432 or 424 or approval of department.

842. Inviscid Fluids
Spring. 3(3-0) MTH 810; MTH 322 or 423.
Kinematically, dynamical equations; potential flows, transformations; Helmholtz flows; added masses, forces and moments; vortex motion; wave motion.

843. Turbulence
Winter, Summer. 4(4-0) MTH 810 or approval of department.
Reynolds equations; turbulence energy equations; turbulence structure descriptions; correlation and spectrum functions, mean, micro and time scales; basic elements of isotropic turbulence, phenomenological theories, hot-wire anemometry; free-shear and conduit flows.

846. Advanced Space and Orbit Ballistics
Fall of odd-numbered years. 3(3-0) MTH 306; MTH 315, 369.
Particle motion; missile trajectories; motion of a rocket; orbits; effects of oblateness on satellite orbit; orbital lifetimes; rendezvous transfer in earth-moon system; optimization; low thrust space propulsion systems; trip to Mars.

852. Mechanical and Aero-Space Optimization
Winter. 3(3-0) MTH 424.
Elementary fundamentals of calculus of variations, maximum principle. Optimization techniques applied to fluids, gas dynamics, optimization of airflow shapes, fuel consumption, heat transfer, wave propagation in solids and physical properties in plasmas.

873. Thermal Stresses
Spring of odd-numbered years. 3(3-0) MTH 422; MTH 810; or approval of department.
Thermomechanical behavior of continuous; thermoelectric, thermoviscoelastic and thermoplastic models; coupled and uncoupled thermomechanical behavior, thermally induced vibrations; instability and instability; thermal shock; thermomechanical ablation.

899. Research
(EGR 899). Fall, Winter, Spring, Summer. Variable credit. Approval of department.

917. Statistical Thermodynamics and Kinetic Theory of Gases
Fall of even-numbered years. 3(3-0) 313; MTH 422 or 422; or approval of department.

920. Theory of Vibrations II
(MMM 904.) Winter of odd-numbered years. 4(4-0) MTH 422; 823 or approval of department. Interdepartmental with and administered by the Metallurgy, Mechanics and Materials Science Department.

921. Theory of Vibrations III
(MMM 903.) Spring of odd-numbered years. Summer. 4(4-0) MTH 920 or approval of department. Interdepartmental with and administered by the Metallurgy, Mechanics and Materials Science Department.

923. Wave Motion in Continuous Media I
Winter of even-numbered years. 4(4-0) MTH 422; MTH 810; or approval of department.

924. Wave Motion in Continuous Media II
Spring of even-numbered years. 4(4-0) 923.
Continuation of 923.

925. Mechanical Engineering Problems
Fall, Winter, Spring, Summer. Variable credit. May re-enroll for a maximum of 9 credits. Approval of department.
Analysis of advanced engineering problems involving design, thermodynamics, fluid dynamics, gas dynamics, space.

930. Seminar
Fall, Winter, Spring. 1 credit. May re-enroll for a maximum of 3 credits in master's program. 6 credits in doctoral program. Open to graduate students of all colleges and departments.
Recent developments in space orbit theory, theory of space propulsion, magnetohydrodynamics, re-entry phenomena, ionosphere, space radiation phenomena, design of space vehicles, and developments in the field pertinent to space technology such as external environmental conditions, internal environmental conditions, effects upon space vehicle construction, etc.

941. Advanced Gas Dynamics II
Fall of odd-numbered years. 3(3-0) 841.
Convective flows, blunt bodies in supersonic flows, three-dimensional transonic flows, hodograph methods, characteristics, unsteady phenomena, physical gas dynamics.

942. Viscous Fluids
Fall of even-numbered years. 3(3-0) MTH 910 or CHE 841.
Exact solutions of Navier-Stokes equations, i.e., Orr-Sommerfeld Motion, Laminar Jet, Converging Channel, etc.; Hydrodynamic Stability including free convection, surface tension, gravitational and free-surface instabilities, and Tollmien-Schlichting waves.
952. Slip and Free (Newtonian) Molecular Flows
Spring. 3(3-0) 412, 432.
Distribution function; Boltzmann equation; solutions of Fokker-Planck type; slip flow; drag coefficient; heat transfer; free molecule flow; elastic and inelastic reflections; flow around bodies; resistance coefficient; heat; obstruction; meteors.

953. Plasma Dynamics (Magnetohydrodynamics)
Winter. 3(3-0) 422, PHY 491.
Fundamental equations of hydrodynamics; Maxwell equations; continuum; channel flow; boundary layer; shock; Alfven wave propagation; one and two fluid theories; discrete particle approach; plasma oscillations; flow around bodies and in nozzles; space propulsion systems.

954. Ion Flow Dynamics
Spring. 3(3-0) 953.
Continuation of 953 as applied to the ion flow; extension of the neutral flow turbulence into electromagnetic turbulence, and method of characteristics applied to the ion flow dynamics.

999. Research (ECR 999)
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

MEDICAL TECHNOLOGY M T

College of Human Medicine
College of Osteopathic Medicine
College of Veterinary Medicine

201. Medical Technology
Fall. 1(1-0) Approval of school.
Relationship of medical technology to medicine and research, and the necessary interaction with other paramedical sciences.

401. Seminar in Medical Technology
Fall. 1 credit. Seniors.
Acquaints students with the operation and administration of a hospital, the philosophy and understanding of the entire profession of medical technology.

MEDICINE MED

College of Human Medicine

590. Special Problems in Medicine
Fall, Winter, Spring, Summer. 1 to 6 credits. May re-enroll for a maximum of 12 credits. Human Medicine students.
Each student will work under direction of a staff member on an experimental, theoretical or applied problem.

605. Senior Medical Clerkship
Fall, Winter, Spring, Summer. 17 credits. Prerequisite: clerkship, third year Human Medicine students.
Based in community hospitals, this clerkship will stress interviewing skills, history, physical examination, along with problem solving and therapy, and care of the whole patient leading to independence in patient management.

METALLURGY, MECHANICS AND MATERIALS SCIENCE MMM

College of Engineering

205. Mechanics I
Fall, Winter, Spring, Summer. 4(4-0) MTH 214 or concurrently.

206. Mechanics II
Fall, Winter, Spring, Summer. 4(4-0) MTH 215 or concurrently.
Dynamics of rigid bodies in general motion, plane motion, rotation, statics, variational methods.

211. Mechanics of Deformable Solids
Fall, Winter, Spring, Summer. 4(4-0) or Statics; MTH 215.
Deformable solids, stress and strain, principal axes, material behavior (elastic, plastic, viscoelastic, temperature dependent). Boundary value problems, torsion, beams. Stability, columns.

215. Materials Testing Laboratory
Fall, Winter, Spring, Summer. 1(0-3) Physical properties of engineering materials, resistance to primary types of static loading.

230. Introduction to Materials Science
Fall. 4(4-0) Sophomores.
A qualitative survey of metals, ceramics, and polymers, and the relationship of electronic, molecular, and crystal structure to the physical, mechanical, thermal, electrical and magnetic properties.

304. Dynamics
Fall. 4(4-0) Statics; MTH 215 or concurrently.
Dynamics of particles and rigid bodies for those students who have had Statics.

320. Analytical Mechanics I
Fall. 3(3-0) MTH 215, PHY 289.
Measures of point motion, initial notation, vector space and time transformations. Newton's, Lagrange's and Hamilton's equations. Motions of point objects; limiting wave forms.

321. Analytical Mechanics II
Winter. 3(3-0) 320.
Schrödinger's equation. Particle motions in various potentials; hydrogen-like atoms and molecules. Continuum models of particle systems; tensor properties, rigid and elastic solids, transfer of heat and electricity, flow relations.

322. Analytical Mechanics III
Spring. 3(3-0) 321.
Quantum and statistical models of particle systems; the Maxwell-Boltzmann, Einstein-Bohr and Fermi-Dirac distributions; analysis of ideal atomic, electron and photon gases; properties of dense gases and liquids; thermal, elastic and electrical properties of crystals.

340. Materials Chemistry I
(440.) Fall. 4(4-0) CEM 153.
An integrated treatment of the physical chemistry of metals and other engineering materials is presented by 340, 341 and 342. Physical-chemical systems; thermodynamics and thermodynamics; equilibrium; solutions and phase equilibrium; electrochemistry; corrosion; reaction kinetics in condensed phases; diffusion; surface phenomena.

341. Materials Chemistry II
(441.) Winter. 4(4-0) 340 or approval of department.
Continuation of 340.

342. Materials Chemistry III
(442.) Spring. 4(4-0) 341.
Continuation of 340, 341.

360. Physical Metallurgy I
Fall. 4(4-0) CEM 153 or approval of department.
Relationship of properties of microstructure as affected by solidification transformations in heterogeneous systems, cold work, recrystallization, and grain growth. Emphasis on the important commercial metals and alloys.

361. Physical Metallurgy II
Winter. 4(4-0) 360.
Continuation of 360.

362. Physical Metallurgy III
Spring. 4(4-0) 360, 361.
Continuation of 360, 361.

370. Metals and Alloys I
Fall, Winter. 4(3-3)
Principles of physical metallurgy applied to engineering metals and alloys.

371. Metals and Alloys II
Winter. 3(3-0) 370.
Continuation of 370.

372. Metals and Alloys III
Spring. 3(3-0) 371.
Continuation of 371.

380. Physical Metallurgy Laboratory I
Fall. 1(0-3) 360 or concurrently.
First of an integrated sequence of laboratory courses designed to illustrate the parallel theory courses. Introduction to metallography, pyrometry, and testing of metals.

381. Physical Metallurgy Laboratory II
Winter. 1(0-3) 380; 381 concurrently.
Continuation of 380.

382. Physical Metallurgy Laboratory III
Spring. 1(0-3) 381; 362 concurrently.
Continuation of 381.

400. Special Problems
Fall, Winter, Spring, Summer. 1 to 3 credits. May re-enroll for a maximum of 9 credits. Approval of department. Individualized reading and research.

404. Dynamics of Mechanical Systems
Fall. 3(3-0) 206.

411. Mechanics of Deformable Solids II
Spring. 3(3-0) 311.
Continuation of 311. Unsymmetrical bending.