### MECHANICAL ENGINEERING (ME)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Offered</th>
<th>Description</th>
<th>Prerequisites</th>
<th>Lecture + Lab + Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME F254</td>
<td>Unmanned Aircraft Systems (UAS) Investigation</td>
<td>3</td>
<td>Offered As Demand Warrants</td>
<td>Course provides an introductory analysis of unmanned air systems (UAS), including typical missions and performance expectations for various classes of UAS. Students will investigate subsystem choices for a UAS and how these affect mission performance. Course includes discussion of external factors impacting UAS design choices, including support infrastructure, flight operations and data requirements. Crosslisted with EE F254.</td>
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<tr>
<td>ME F256</td>
<td>Unmanned Aircraft Systems (UAS) Design</td>
<td>3</td>
<td>Offered As Demand Warrants</td>
<td>A multidisciplinary team of students will design, build, test and deliver an unmanned aircraft system (UAS) in support of university research mission requirements. Students will learn basic concepts related to the systems engineering design process. Graded events include team briefings, written reports, multimedia products and a finished UAS product. Prerequisites: EE/ME F254. Crosslisted with CS F254, EE F256.</td>
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<tr>
<td>ME F302</td>
<td>Dynamics of Machinery</td>
<td>4</td>
<td>Offered</td>
<td>Kinematics and dynamics of mechanisms. Analysis of displacements, velocities, accelerations, and forces in linkages, cams and gear systems by analytical, experimental and computer methods. Design applications. Prerequisites: ES F301 (may be taken concurrently); ES F210.</td>
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<td>3 + 0 + 0</td>
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<tr>
<td>ME F308</td>
<td>Instrumentation and Measurement</td>
<td>3</td>
<td>Offered</td>
<td>Principles of measurement, instrumentation, Laplace transform, Fourier series, transfer function, steady-state response, calibration, and errors. Signal filtering and amplification, data acquisition, recording, and processing. Methods and devices for measuring strain, force, torque, displacement, velocity, acceleration, pressure, fluid flow properties, and temperature. Mechatronics, sensors, actuators, and controls. Prerequisites: ES F331.</td>
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<tr>
<td>ME F313</td>
<td>Mechanical Engineering Thermodynamics</td>
<td>3</td>
<td>Offered</td>
<td>Investigation and design of power and refrigeration cycles (Rankine, Brayton, Otto, and Diesel), compressible flow (isentropic, shock waves, and flow in ducts with friction), and combustion and gas vapor mixtures. Prerequisites: ES F346.</td>
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<tr>
<td>ME F321</td>
<td>Industrial Processes</td>
<td>3</td>
<td>Offered</td>
<td>Manufacturing processes used in modern industry. Primary and secondary manufacturing processes, casting, hot and cold forming, machining, welding and mass production tools and techniques as related to economic and efficient product design. Prerequisites: Mechanical Engineering major.</td>
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<tr>
<td>ME F334</td>
<td>Elements of Material Science/Engineering</td>
<td>3</td>
<td>Offered</td>
<td>Properties of engineering materials. Crystal structure, defect structure, structure and properties, aspects of metal processing, heat treatment, joining, testing and failure analysis for engineering applications and design. Prerequisites: CHEM F105X.</td>
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<tr>
<td>ME F402</td>
<td>Advanced Mechanical System Design</td>
<td>3</td>
<td>Offered As Demand Warrants</td>
<td>Advanced analysis of two- and three-dimensional multi-body mechanical systems. Rigid body system formulation and deformable body system formulation. Application of CAE software for rigid body and large deformable body systems. Prerequisites: ME F302; ME F408. Stacked with ME F602.</td>
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<tr>
<td>ME F403</td>
<td>Machine Design</td>
<td>3</td>
<td>Offered</td>
<td>Design and analysis of machines by analytical, experimental and computer methods. Identification of requirements and conceptual design of mechanical systems, detailed design of components, strength, life, reliability, and cost analysis. Prerequisites: ES F331.</td>
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<tr>
<td>ME F405</td>
<td>Computer Aided Design</td>
<td>3</td>
<td>Offered As Demand Warrants</td>
<td>Introduction to principles of computer aided design and engineering. Applications of software and hardware in solid modeling, design analysis, motion analysis, rapid prototyping, and interface between computer aided design and computer aided manufacturing. Prerequisites: Senior standing.</td>
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<td>1.5 + 4.5 + 0</td>
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<tr>
<td>ME F406</td>
<td>Computer Aided Manufacturing</td>
<td>3</td>
<td>Offered As Demand Warrants</td>
<td>Introduction to computer aided manufacturing (CAM). This includes the principles of computer aided process planning (CAPP) and an introduction to computer numerical control (CNC) tools used in manufacturing. Emphasis will be on methodology with hands-on applications of computer software and specific machine tools. Prerequisites: ME F321; senior standing.</td>
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<td>1.5 + 4.5 + 0</td>
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ME F408  Mechanical Vibrations
3 Credits
Offered Fall
Modeling of vibratory mechanical systems with single and multiple
degrees of freedom. Study of free and forced vibrations with or without
damping by lumped-parameter methods and finite element analysis.
Vibrations of rotor systems and vibration stability.
Prerequisites: ES F210, ES F301.
Lecture + Lab + Other: 3 + 0 + 0

ME F409  Controls
3 Credits
Offered As Demand Warrants
Analysis and design of control systems. Block diagrams, transfer
functions and frequency analysis. Closed loop systems and system
stability. Industrial controllers and system compensation.
Prerequisites: ME F408.
Lecture + Lab + Other: 3 + 0 + 0

ME F414  HVAC Systems Optimization (a)
3 Credits
Offered As Demand Warrants
Design of thermal and heating, ventilation, and air-conditioning (HVAC)
systems with emphasis on economic considerations and optimization.
Concepts of thermodynamics, fluid mechanics and heat transfer will
be integrated under a design framework. A semester long project is
conducted to design a thermal system, perform system simulations, and
to optimize the design based on economic and technical considerations.
Prerequisites: ES F341; ES F346.
Lecture + Lab + Other: 3 + 0 + 0

ME F415  Thermal Systems Laboratory (W)
3 Credits
Offered Spring
Testing and evaluation of components and energy systems such as
pumps, fans, engines, heat exchangers, refrigerators and heating/power
plants.
Prerequisites: ME F308 (may be taken concurrently); WRTG F111X;
ES F341; ME F313; ME F441.
Lecture + Lab + Other: 1.5 + 4.5 + 0

ME F416  Design of Mechanical Equipment for the Petroleum Industry (a)
3 Credits
Offered As Demand Warrants
Design, selection and operation of equipment used in production and
processing of crude oil and gas. Instrumentation and control systems
used with mechanical equipment.
Prerequisites: ES F341; ES F346.
Lecture + Lab + Other: 3 + 0 + 0

ME F431  Intermediate Mechanics of Materials
3 Credits
Offered As Demand Warrants
Applications of Hooke’s law and energy method to thin-walled beams
and shafts, and analysis of stress and strain under combined loading.
Introduction to fatigue and fracture of elastic materials. Applications to
engineering problems.
Prerequisites: ES F331.
Lecture + Lab + Other: 3 + 0 + 0

ME F440  Introduction to Microfluidics
3 Credits
Offered As Demand Warrants
Overview of basic concepts and principles of fluids at the micron scale;
introduction to the design and fabrication of microfluidic devices.
Prerequisites: ES F341 (may be taken concurrently); PHYS F123X (for
Math and non-Physics science major); PHYS F211X (for Engineering,
Math and Physics major); junior standing.
Stacked with ME F640.
Lecture + Lab + Other: 3 + 0 + 0

ME F441  Heat and Mass Transfer
3 Credits
Offered Fall
Application of heat and mass transfer concepts to engineering problems
including steady state and transient conduction, numerical analysis of
heat transfer problems, laminar and turbulent free and forced convection,
and black body and real surface radiation.
Prerequisites: ES F301; ES F341; ES F346.
Lecture + Lab + Other: 3 + 0 + 0

ME F443  Fluid Mechanics and Heat Transfer Characteristics of
Nanofluids
3 Credits
Offered As Demand Warrants
Description of nanofluids, nanostructured materials and dispersion
in base fluids. Thermophysical properties: density, viscosity, thermal
conductivity and specific heat. Theoretical equations and empirical
correlations for properties. Principles of measurements of properties.
Fluid dynamic losses and pumping power required for nanofluid flow
in heat transfer systems. Experimental methods of determining the
convective heat transfer coefficient of nanofluids. Practical application
to heat exchangers in industries. Nanofluids flows in mini- and
microchannels.
Prerequisites: ES F341; ME F441; senior standing.
Stacked with ME F643.
Lecture + Lab + Other: 3 + 0 + 0

ME F450  Theory of Flight
3 Credits
Offered Fall
Airfoil theory in subsonic flow. Performance, stability and control of
aircraft. Aircraft design.
Prerequisites: ES F341 (may be taken concurrently); ES F346.
Lecture + Lab + Other: 3 + 0 + 0

ME F451  Aerodynamics
3 Credits
Offered Spring
Aerodynamics of non-lifting and lifting airfoils in incompressible
irrotational flow, wings of finite span, the Navier-Stokes equations,
boundary layers, numerical methods, supersonic and transonic flow past
airfoils, rocket aerodynamics, rocket drag.
Prerequisites: ES F341 (may be taken concurrently); ES F301; ES F346.
Lecture + Lab + Other: 3 + 0 + 0
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| ME F452     | Introduction to Astrodynamics                    | 3       | Fall      | Geometry of the solar system, detailed analysis of two-body dynamics and introduction to artificial satellite orbits; Hohmann transfer and patched conics for lunar and interplanetary trajectories. Elements of orbit determination.  
**Prerequisites:** ES F208 or ES F210.  
**Corequisites:** ES F301.  
**Lecture + Lab + Other:** 3 + 0 + 0 |
**Prerequisites:** ME F313 (may be taken concurrently); ES F341.  
**Lecture + Lab + Other:** 3 + 0 + 0 |
| ME F458     | Energy and the Environment                       | 3       | As Demand Warrants | Overview of basic concepts of energy supply, demand, production of heat and power impacts of energy use on the environment. Extensive discussion of mitigation technologies and strategies for meeting energy needs while preserving environmental quality.  
**Prerequisites:** CHEM F106X; ES F346 or equivalent; MATH F252X; PHYS F211X.  
**Stacked with ME F658.**  
**Lecture + Lab + Other:** 3 + 0 + 0 |
| ME F464     | Corrosion Engineering                            | 3       | As Demand Warrants | Principles and forms of corrosion and factors that affect it. Methods of testing and measurement, control and prevention are examined.  
**Prerequisites:** ME F334.  
**Lecture + Lab + Other:** 3 + 0 + 0 |
| ME F486     | Senior Design                                    | 1       | Fall      | Offered: Fall  
The course is focused on pursuing the design of a real or simulated project which is selected jointly by students, project advisors and/or the instructor. Emphasis will be on the design of practical engineering systems and/or components which integrate engineering knowledge and skills that students have acquired. The principles of design process will be introduced in lecture. Each design team is to generate design concepts, select the best concept and work towards completing a design.  
**Prerequisites:** ME F441 (may be taken concurrently); COJO F131X or COJO F141X; WRTG F211X, WRTG F212X, WRTG F213X or WRTG F214X; senior standing.  
**Lecture + Lab + Other:** 1 + 0 + 0 |
| ME F487     | Design Project                                   | (O, W)  | Spring    | A real or simulated engineering design project selected jointly by student and instructor. Emphasis on design of practical mechanical engineering systems and/or components which integrate students' engineering knowledge and skills.  
**Prerequisites:** ME F486.  
**Lecture + Lab + Other:** 3 + 0 + 0 |
| ME F601     | Finite Element Analysis in Engineering           | 3       | As Demand Warrants | Formulation of the finite element method. Applications to problems of engineering in solid mechanics, fluid mechanics and heat transfer. Use and development of codes for computer solution of problems.  
**Prerequisites:** Graduate standing in engineering; ES F201; MATH F302.  
**Lecture + Lab + Other:** 3 + 0 + 0 |
| ME F602     | Advanced Mechanical System Design                | 3       | As Demand Warrants | Advanced analysis of two- and three-dimensional multi-body mechanical systems. Rigid body system formulation and deformable body system formulation. Application of CAE software for rigid body and large deformable body systems.  
**Prerequisites:** ME F302; ME F408.  
**Stacked with ME F402.**  
**Lecture + Lab + Other:** 3 + 0 + 0 |
| ME F608     | Advanced Dynamics                                | 3       | As Demand Warrants | Kinematics and kinetics of rigid bodies, introduction to analytical mechanics, Lagrange's equations and Hamiltonian mechanics. Applications to engineering problems.  
**Prerequisites:** ES F210; MATH F302; graduate standing in engineering.  
**Lecture + Lab + Other:** 3 + 0 + 0 |
| ME F609     | Advanced Vibrations                              | 3       | As Demand Warrants | Analysis of discrete and continuous vibrations via energy methods, free and forced response of linear systems, stability criteria, and introduction to random and nonlinear vibration. Applications to engineering problems.  
**Prerequisites:** MATH F302; ME F408; graduate standing in engineering.  
**Lecture + Lab + Other:** 3 + 0 + 0 |
| ME F617     | Power Analysis                                   | 3       | As Demand Warrants | Fundamentals of power generation including piping, pumps, fuels and combustion, steam generators, condensers, deaerators, evaporators, feedwater treatment and heating, regeneration, fuel handling, heat balance, equipment, economics, and plant layout.  
**Prerequisites:** ME F313.  
**Lecture + Lab + Other:** 3 + 0 + 0 |
| ME F631     | Advanced Mechanics of Materials                  | 3       | As Demand Warrants | Theories of elasticity and plasticity for small and large deformations. Applications to engineering problems.  
**Prerequisites:** ES F331; graduate standing in engineering.  
**Lecture + Lab + Other:** 3 + 0 + 0 |
ME F634  Advanced Materials Engineering
3 Credits
Offered As Demand Warrants
Atomic bonding, crystal structure, crystal imperfections, phases and interfaces, microstructures, phase diagrams, phase transformation, transport and diffusion, metal deformation, fracture of materials, deterioration of materials, electronic and physical properties of materials. 
Prerequisites: ME F334; MATH F302; graduate standing in engineering.
Lecture + Lab + Other: 3 + 0 + 0

ME F640  Introduction to Microfluidics
3 Credits
Offered As Demand Warrants
Overview of basic concepts and principles of fluids at the micron scale; introduction to the design and fabrication of microfluidic devices.
Prerequisites: ES F341 (may be taken concurrently); PHYS F123X (for Math and non-Physics science major); PHYS F211X (for Engineering, Math and Physics major); junior standing.
Stacked with ME F440.
Lecture + Lab + Other: 3 + 0 + 0

ME F641  Advanced Fluid Mechanics
3 Credits
Offered As Demand Warrants
Introduction to viscous flows, laminar boundary layers, turbulent boundary layers, turbulent jets and wakes, applications to heat transfer and drag.
Prerequisites: ES F341; graduate standing in engineering.
Lecture + Lab + Other: 3 + 0 + 0

ME F642  Advanced Heat Transfer
3 Credits
Offered As Demand Warrants
Heat conduction in two and three dimensions under steady and transient conditions. Free and forced convection in internal and external flows. Radiation from black and gray surfaces and gas-filled enclosures. Both analytical and numerical methods are covered.
Prerequisites: ME F441; graduate standing in engineering.
Lecture + Lab + Other: 3 + 0 + 0

ME F643  Fluid Mechanics and Heat Transfer Characteristics of Nanofluids
3 Credits
Offered As Demand Warrants
Prerequisites: ES F341; ME F441; graduate standing.
Stacked with ME F443.
Lecture + Lab + Other: 3 + 0 + 0

ME F656  Aerospace Systems Engineering
3 Credits
Offered Fall Odd-numbered Years
A multidisciplinary team of students will perform a preliminary design study of a major aerospace system. Design considerations will include requirements for project management, aerospace vehicle design, power, attitude control, thermal control, communications, computer control and data handling. The students will present their final design in a written report and a public seminar.
Prerequisites: Graduate standing.
Cross-listed with EE F656.
Lecture + Lab + Other: 3 + 0 + 0

ME F658  Energy and the Environment
3 Credits
Offered As Demand Warrants
Basic concepts of energy supply, demand, production of heat and power impacts of energy use on the environment. Extensive discussion of mitigation technologies and strategies for meeting energy needs while preserving environmental quality.
Recommended: CHEM F106X; ES F346; MATH F252X; PHYS F211X; graduate standing.
Stacked with ME F458.
Lecture + Lab + Other: 3 + 0 + 0

ME F685  Arctic Heat and Mass Transfer (a)
3 Credits
Offered As Demand Warrants
An introduction to the principles of heat and mass transfer with special emphasis on application to problems encountered in the Arctic such as ice and frost formation, permafrost, condensation and heat loss in structures.
Prerequisites: graduate standing.
Lecture + Lab + Other: 3 + 0 + 0

ME F687  Arctic Materials Engineering (a)
3 Credits
Offered As Demand Warrants
A study of engineering material performance at low temperatures.
Prerequisites: Graduate standing.
Lecture + Lab + Other: 3 + 0 + 0

ME F698  Non-thesis Research/Project
1-9 Credits
Lecture + Lab + Other: 0 + 0 + 0

ME F699  Thesis
1-9 Credits
Lecture + Lab + Other: 0 + 0 + 0