

# MECHANICAL & AERONAUTICAL ENGINEERING (MAE)

College of Engineering

## MAE 207 – Engineering Experimentation & Uncertainty Analysis (4 units)

*Course Description:* Design and analysis of engineering experiments with emphasis on measurement standards, data analysis, regressions and general and detailed uncertainty analysis, including statistical treatment of experimental data intervals, propagation of bias and precision errors, correlated bias approximations, and using jitter programs.

*Prerequisite(s):* EME 108; EME 109.

*Learning Activities:* Lecture 3 hour(s), Discussion 1 hour(s).

*Enrollment Restriction(s):* Open to Graduate students.

*Grade Mode:* Letter.

## MAE 210A – Advanced Fluid Mechanics & Heat Transfer (4 units)

*Course Description:* Development of differential equations governing continuity, momentum and energy transfer. Solutions in laminar flow for exact cases, low and high Reynolds numbers and lubrication theory. Dynamics of inviscid flow.

*Prerequisite(s):* ENG 103; ENG 105; EME 165.

*Learning Activities:* Lecture 3 hour(s), Discussion 1 hour(s).

*Grade Mode:* Letter.

## MAE 210B – Advanced Fluid Mechanics & Heat Transfer (4 units)

*Course Description:* Study of stability and transition to turbulence. Introduction to the physics of turbulence. Modeling of turbulence for numerical determination of momentum and heat transfer.

*Prerequisite(s):* MAE 210A.

*Learning Activities:* Lecture 3 hour(s), Discussion 1 hour(s).

*Grade Mode:* Letter.

## MAE 211 – Fluid Flow & Heat Transfer (4 units)

*Course Description:* Design aspects of selected topics such as: heat conduction, fins; heat transport in ducts, boundary layers and separated flows; heat exchangers.

*Prerequisite(s):* ENG 103; ENG 105; EME 165; or equivalent.

*Learning Activities:* Lecture 3 hour(s), Discussion 1 hour(s).

*Grade Mode:* Letter.

## MAE 212 – Biomedical Heat & Mass Transport Processes (4 units)

*Course Description:* Application of principles of heat and mass transfer to biomedical systems related to heat exchange between the biomedical system and its environment, mass transfer across cell membranes and the design and analysis of artificial human organs.

*Prerequisite(s):* EME 165; EBS 125; ECH 153; or the equivalent.

*Learning Activities:* Lecture 3 hour(s), Discussion 1 hour(s).

*Cross Listing:* BIM 212.

*Grade Mode:* Letter.

## MAE 216 – Advanced Thermodynamics (4 units)

*Course Description:* Study of topics important to energy conversion systems, propulsion and other systems using high temperature gases. Classical thermodynamics and quantum statistical mechanics of nonreacting and chemically reacting gases, gas mixtures, and other substances.

*Prerequisite(s):* ENG 105.

*Learning Activities:* Lecture 3 hour(s), Discussion 1 hour(s).

*Grade Mode:* Letter.

## MAE 217 – Combustion (4 units)

*Course Description:* Review of chemical thermodynamics and chemical kinetics. Discussion of reacting flows, their governing equations and transport phenomena; detonations; laminar flame structure and turbulent combustion.

*Prerequisite(s):* ENG 103; ENG 105; EME 106.

*Learning Activities:* Lecture 3 hour(s), Lecture/Discussion 1 hour(s).

*Enrollment Restriction(s):* Restricted to graduate students.

*Grade Mode:* Letter.

## MAE 218 – Advanced Energy Systems (4 units)

*Course Description:* Review of options available for advanced power generation. Detailed study of basic power balances, component efficiencies, and overall powerplant performance for one advanced concept such as a fusion, magnetohydrodynamic, or solar electric powerplant.

*Prerequisite(s):* ENG 103; ENG 105; or the equivalent.

*Learning Activities:* Lecture 3 hour(s), Discussion 1 hour(s).

*Grade Mode:* Letter.

## MAE 219 – Introduction to Scientific Computing in Solid & Fluid Dynamics (4 units)

*Course Description:* Scientific calculations with finite element and finite difference methods for multi-dimensional problems in solid and fluid dynamics are performed with examples in C, C++, FORTRAN, and MATLAB script files. Derivation of the basic equations of motion in finite volume form with applications to elasticity, waves.

*Prerequisite(s):* ENG 103; ENG 104.

*Learning Activities:* Lecture 3 hour(s), Laboratory 3 hour(s).

*Grade Mode:* Letter.

## MAE 220 – Mechanical Vibrations (4 units)

*Course Description:* Multiple degrees of freedom; damping measures; Rayleigh's method; vibration absorbers; eigenvalues and modeshapes; modal coordinates; forced vibrations; random processes and vibrations; autocorrelation; spectral density; first passage and fatigue failure; nonlinear systems; phase plane.

*Prerequisite(s):* ENG 122.

*Learning Activities:* Lecture 4 hour(s).

*Grade Mode:* Letter.

## MAE 222 – Advanced Dynamics (4 units)

*Course Description:* Dynamics of particles, rigid bodies and distributed systems with engineering applications; generalized coordinates; Hamilton's principle; Lagrange's equations; Hamilton-Jacobi theory; modal dynamics orthogonality; wave dynamics; dispersion.

*Prerequisite(s):* ENG 102.

*Learning Activities:* Lecture 4 hour(s).

*Grade Mode:* Letter.

**MAE 223 – Multibody Dynamics (4 units)**

*Course Description:* Coupled rigid-body kinematics/dynamics; reference frames; vector differentiation; configuration and motion constraints; holonomicity; generalized speeds; partial velocities; mass; inertia tensor/theorems; angular momentum; generalized forces; comparing Newton/Euler, Lagrange's, Kane's methods; computer-aided equation derivation; orientation; Euler; Rodrigues parameters.

*Prerequisite(s):* ENG 102.

*Learning Activities:* Lecture 4 hour(s).

*Cross Listing:* BIM 223.

*Grade Mode:* Letter.

**MAE 225 – Spatial Kinematics & Robotics (4 units)**

*Course Description:* Spatial kinematics, screw theory, spatial mechanisms analysis and synthesis, robot kinematics and dynamics, robot workspace, path planning, robot programming, real-time architecture and software implementation.

*Prerequisite(s):* MAE 222; C Language.

*Learning Activities:* Lecture 3 hour(s), Laboratory 3 hour(s).

*Cross Listing:* BIM 225.

*Grade Mode:* Letter.

**MAE 226 – Acoustics & Noise Control (4 units)**

*Course Description:* Description of sound using normal modes and waves; interaction between vibrating solids and sound fields; sound absorption in enclosed spaces; sound transmission through barriers; applications in design, acoustic enclosures and sound walls, room acoustics, design of quiet machinery.

*Prerequisite(s):* ENG 122.

*Learning Activities:* Lecture 4 hour(s).

*Grade Mode:* Letter.

**MAE 228 – Introduction to BioMEMS (4 units)**

*Course Description:* Ideal for beginning graduate or advanced undergraduate students interested in microelectromechanical systems (MEMS) topics related to biological applications. Covers topics from various disciplines related to BioMEMS: mechanical, electrical, biomedical, chemical engineering, and materials science.

*Prerequisite(s):* B.S. engineering discipline or consent of instructor.

*Learning Activities:* Lecture 3 hour(s), Discussion 1 hour(s).

*Grade Mode:* Letter.

**MAE 229 – Design & Analysis of Micro-Electromechanical Systems (4 units)**

*Course Description:* Mechanical design of micro-electromechanical systems (MEMS). Device modeling: lumped parameter models; energy methods; nonlinearities; electrical and mechanical noise sources. Actuation and measurement methods: capacitive, piezoresistive, thermal, piezoelectric, and optical techniques. Review of basic electronics: bridge circuits, amplitude modulation; lock-in detection.

*Prerequisite(s):* (ENG 045 or ENG 045Y); ENG 100; ENG 104; and consent of instructor. ENG 122 recommended.

*Learning Activities:* Lecture 4 hour(s).

*Grade Mode:* Letter.

**MAE 232 – Skeletal Tissue Mechanics (3 units)**

*Course Description:* Overview of the mechanical properties of the various tissues in the musculoskeletal system, the relationship of these properties to anatomic and histologic structure, and the changes in these properties caused by aging and disease. Tissues covered include bone, cartilage and synovial fluid, ligament and tendon.

*Prerequisite(s):* ENG 104B.

*Learning Activities:* Lecture 3 hour(s), Laboratory 1 hour(s).

*Cross Listing:* BIM 232.

*Grade Mode:* Letter.

**MAE 234 – Design & Dynamics of Road Vehicles (4 units)**

*Course Description:* Analysis and numerical simulation of road vehicles with on design applications.

*Prerequisite(s):* EME 134.

*Learning Activities:* Lecture 4 hour(s).

*Grade Mode:* Letter.

**MAE 237 – Analysis & Design of Composite Structures (4 units)**

*Course Description:* Modeling and analysis methodology for composite structures including response and failure. Laminated plate bending theory. Introduction to failure processes. Includes discussion of aerospace structural analysis.

*Prerequisite(s):* ENG 104; or equivalent.

*Learning Activities:* Lecture 3 hour(s), Discussion 1 hour(s).

*Grade Mode:* Letter.

**MAE 239 – Advanced Finite Elements & Optimization (4 units)**

*Course Description:* Introduction to advanced finite elements and design optimization methods, with application to modeling of complex mechanical, aerospace and biomedical systems. Application of states of the art in finite elements in optimum design of components under realistic loading conditions and constraints.

*Prerequisite(s):* ENG 180 or EAD 115 or MAT 128C.

*Learning Activities:* Lecture 4 hour(s).

*Cross Listing:* BIM 239.

*Grade Mode:* Letter.

**MAE 240 – Computational Methods in Nonlinear Mechanics (4 units)**

*Course Description:* Deformation of solids and the motion of fluids treated with state-of-the-art computational methods. Numerical treatment of nonlinear dynamics; classification of coupled problems; applications of finite element methods to mechanical, aeronautical, and biological systems.

*Prerequisite(s):* EAD 115 or MAT 128B or ENG 180.

*Learning Activities:* Lecture 4 hour(s).

*Cross Listing:* BIM 240.

*Grade Mode:* Letter.

### **MAE 245 – Micro- & Nano-Technology in Life Sciences (4 units)**

*Course Description:* Survey of biodevice design from engineering and biological perspectives; micro-/nano-fabrication techniques; surface science and mass transport; essential biological processes and models; proposal development skills on merging aforementioned themes.

*Prerequisite(s):* Graduate standing or consent of instructor.

*Learning Activities:* Lecture/Discussion 4 hour(s).

*Cross Listing:* ECH 245, EMS 245, EEC 245.

*Grade Mode:* Letter.

### **MAE 248 – Advanced Turbomachinery (4 units)**

*Course Description:* Preliminary aerodynamic design of axial and radial flow compressors and turbines. Design of diffusers. Selection of turbomachine and configurations and approximations to optimum dimensions and flow angles. Introduction to through flow analysis. Rotating stall and surge, and aeromechanical considerations.

*Prerequisite(s):* ENG 103; ENG 105.

*Learning Activities:* Lecture 3 hour(s), Discussion 1 hour(s).

*Grade Mode:* Letter.

### **MAE 250A – Advanced Methods in Mechanical Design (4 units)**

*Course Description:* Applications of advanced techniques of solid mechanics to mechanical design problems. Coverage of advanced topics in stress analysis and static failure theories with emphasis in design of machine elements. Design projects emphasizing advanced analysis tools for life cycle evaluation.

*Prerequisite(s):* EME 150A; EME 150B; or the equivalents or consent of instructor.

*Learning Activities:* Lecture 4 hour(s).

*Grade Mode:* Letter.

### **MAE 250B – Advanced Methods in Mechanical Design (4 units)**

*Course Description:* Applications of advanced techniques of solid mechanics to mechanical design problems. Advanced topics in variational methods of mechanics with emphasis in design of machine elements. Design projects emphasizing advanced analysis tools.

*Prerequisite(s):* MAE 250A.

*Learning Activities:* Lecture 4 hour(s).

*Grade Mode:* Letter.

### **MAE 250C – Mechanical Performance of Materials (4 units)**

*Course Description:* Occurrence, mechanisms, and prediction of fatigue and fracture phenomenon. Use of stress and strain to predict crack initiation. Use of fracture mechanics to predict failure and crack propagation. Effects of stress concentration, manufacturing, load sequence, irregular loading, and multi-axial loading.

*Prerequisite(s):* Undergraduate course in stress analysis and mechanical behavior of materials.

*Learning Activities:* Lecture 4 hour(s).

*Grade Mode:* Letter.

### **MAE 252 – Information Processing for Autonomous Robotics (4 units)**

*Course Description:* Computational principles for sensing, reasoning, and navigation for autonomous robots.

*Prerequisite(s):* EME 154; EME 171; ENG 006; EME 005; or equivalent programming experience to ENG 006 EME 005; MAE 154, MAE 171, or consent of instructor.

*Learning Activities:* Lecture 3 hour(s), Discussion 1 hour(s).

*Grade Mode:* Letter.

### **MAE 253 – Network Theory & Applications (4 units)**

*Course Description:* Develops the mathematical theory underlying growth, structure and function of networks with applications to physical, social, biological and engineered systems. Topics include network growth, resilience, epidemiology, phase transitions, software and algorithms, routing and search control, cascading failures.

*Prerequisite(s):* MAT 022A; MAT 022B; (STA 013 or STA 013Y or STA 120); Experience with computer software, or consent of instructor.

*Learning Activities:* Lecture/Discussion 4 hour(s).

*Cross Listing:* ECS 253.

*Grade Mode:* Letter.

### **MAE 254 – Engineering Software Design (4 units)**

*Course Description:* Principle and design of engineering software.

Advanced topics in engineering software design, applications of object-oriented programming, very high-level languages, real-time multi-thread computing and sensor fusion, Web-based network computing, graphics, and GUI in engineering.

*Prerequisite(s):* EME 005; ENG 180.

*Learning Activities:* Lecture 3 hour(s), Laboratory 3 hour(s).

*Grade Mode:* Letter.

### **MAE 255 – Computer Aided Design & Manufacturing (4 units)**

*Course Description:* Representation and processing of geometrical information in design and manufacturing. Numeric and symbolic computations. Coordinate systems and transformations. Bezier and B-spline curves and surfaces. Interpolation and approximation methods. Intersections, offsets, and blends. Path planning for machining, inspection, and robotics applications.

*Prerequisite(s):* Proficiency in a high level programming language such as Fortran, Pascal or C.

*Learning Activities:* Lecture 3 hour(s), Laboratory 3 hour(s).

*Grade Mode:* Letter.

### **MAE 256 – Sustainable Manufacturing & Design (4 units)**

*Course Description:* Definitions, methods, and dimensions of sustainability in manufacturing and product design. Emphasis on resource efficiency and life cycle engineering in the context of the production environment.

*Learning Activities:* Lecture/Discussion 4 hour(s).

*Enrollment Restriction(s):* Open to graduate students; undergraduate students allowed only with consent of instructor.

*Grade Mode:* Letter.

**MAE 258 – Hybrid Electric Vehicle System Theory & Design (4 units)**

*Course Description:* Advanced vehicle design for fuel economy, performance, and low emissions, considering regulations, societal demands and manufacturability. Analysis and verification of computer design and control of vehicle systems in real vehicle tests. Advanced engine concepts.

*Prerequisite(s):* EME 150B; graduate standing in Mechanical and Aeronautical Engineering.

*Learning Activities:* Lecture 3 hour(s), Laboratory 3 hour(s).

*Grade Mode:* Letter.

**MAE 259 – Modern Manufacturing Technologies (4 units)**

*Course Description:* Review of manufacturing processes, simulation methods, quality control, and machine tool design. Design for manufacturing and assembly and operation management are also introduced.

*Prerequisite(s):* EME 050 or equivalent is recommended.

*Learning Activities:* Lecture/Discussion 4 hour(s).

*Grade Mode:* Letter.

**MAE 262 – Advanced Aerodynamics (4 units)**

*Course Description:* Study of invicid and viscous flows about aerodynamic shapes at subsonic, transonic and supersonic conditions. Application of aerodynamic theory to design for reduced drag and increased lift.

*Prerequisite(s):* EAE 126.

*Learning Activities:* Lecture 3 hour(s), Discussion 1 hour(s).

*Grade Mode:* Letter.

**MAE 263 – Introduction to Computational Aerodynamics & Fluid Dynamics (4 units)**

*Course Description:* Introduction to numerical methods for solution of fluid flow problems. Discretization techniques and solution algorithms. Finite difference solutions to classical model equations pertinent to wave phenomena, diffusion phenomena, or equilibrium. Application to the incompressible and compressible Navier-Stokes equations.

*Prerequisite(s):* ENG 103; ENG 105; or consent of instructor.

*Learning Activities:* Lecture 3 hour(s), Discussion 1 hour(s).

*Enrollment Restriction(s):* Open to graduate students.

*Grade Mode:* Letter.

**MAE 265 – Aeroacoustics (4 units)**

*Course Description:* Introduction to acoustics, Fourier transform and sound pressure level, Green's function, Lighthill's acoustic analogy and jet noise, tailored Green's function and acoustic scattering, Ffowcs Williams and Hawkings equation and rotorcraft noise, turbulence for aeroacoustics and leading-edge noise, trailing-edge noise and wind turbine noise, duct acoustics and aircraft engine noise.

*Prerequisite(s):* ENG 103.

*Learning Activities:* Lecture 4 hour(s).

*Enrollment Restriction(s):* Restricted to graduate students.

*Grade Mode:* Letter.

**MAE 269 – Fuel Cell Systems (4 units)**

*Course Description:* Basics of electrochemistry and fuel cell engines in mobile and stationary applications. Aspects of fuel cell energy converters and their subsystems including practice with existing fuel cell and hydrogen systems on campus.

*Prerequisite(s):* EME 106; EME 109; EME 165; or equivalent courses, or consent of instructor.

*Learning Activities:* Lecture 2 hour(s), Discussion 2 hour(s).

*Enrollment Restriction(s):* Graduate or junior/senior undergraduate as a technical elective.

*Grade Mode:* Letter.

**MAE 271 – Advanced Modeling & Simulation of Mechatronic Systems (4 units)**

*Course Description:* Multiport models of mechanical, electrical, hydraulic, and thermal devices; bond graphs, block diagrams and state space equations; modeling of multiple energy domain systems; three-dimensional mechanics; digital simulation laboratory.

*Prerequisite(s):* EME 172; or equivalent.

*Learning Activities:* Lecture 3 hour(s), Laboratory 3 hour(s).

*Grade Mode:* Letter.

**MAE 272 – Theory & Design of Control Systems (4 units)**

*Course Description:* Mathematical representations of linear dynamical systems. Feedback principles; benefits and cost of feedback. Analysis and design of control systems based on classical and modern approaches, with emphasis on applications to mechanical and aeronautical systems.

*Prerequisite(s):* EME 172; or the equivalent.

*Learning Activities:* Lecture 4 hour(s).

*Grade Mode:* Letter.

**MAE 273A – Single Input Single Output (SISO) Optimal Robust Control (4 units)**

*Course Description:* Analysis and design of SISO (Single Input Single Output) feedback control systems utilizing Youla Parameterization technique. Optimal control concepts (controllability, observability, Linear Quadratic Regulator) and an introduction to Kalman filtering and robust optimal control theory for designing H<sub>2</sub>/LQG and Hinf controllers.

*Prerequisite(s):* EME 172; MAE 272; or consent of instructor. EEC 250 recommended.

*Learning Activities:* Lecture 4 hour(s).

*Enrollment Restriction(s):* Open to Graduate Students.

*Grade Mode:* Letter.

**MAE 273B – Multiple Input Multiple Output (MIMO) Optimal Robust Control (4 units)**

*Course Description:* Analysis and design of MIMO (Multiple Input Multiple Output) feedback control systems utilizing Youla Parameterization technique. Uncertainty modeling and MIMO feedback control system design using loop shaping with Hinf/H<sub>2</sub> system norm optimization techniques.

*Prerequisite(s):* MAE 272; MAE 273A; or consent of instructor.

*Learning Activities:* Lecture 4 hour(s).

*Enrollment Restriction(s):* Open to Graduate Students.

*Grade Mode:* Letter.

**MAE 275 – Guidance & Control of Unmanned Aerial Systems (4 units)**

*Course Description:* Introduction to Unmanned Aerial Systems (UAS). Challenges in guiding and controlling limited-payload small and miniature aircraft systems. Coordinate frames, kinematics and dynamics, linear design models, autopilot design, sensor models, state estimation, design model for guidance, straight-line and orbit following, and path planning.

*Prerequisite(s):* ENG 102; EME 172; or consent of instructor. Familiarity with simulation tools, such as Matlab/Simulink, expected.

*Learning Activities:* Lecture 4 hour(s).

*Enrollment Restriction(s):* Open to Graduate Students.

*Grade Mode:* Letter.

**MAE 276 – Data Acquisition & Analysis (4 units)**

*Course Description:* Application of computers for data acquisition and control. Topics include computer architecture, characteristics of transducers, hardware for laboratory applications of computers, fundamentals of interfaces between computers and experimental equipment, programming techniques for data acquisition and control, basic data analysis.

*Learning Activities:* Lecture 3 hour(s), Discussion 1 hour(s).

*Grade Mode:* Letter.

**MAE 290C – Graduate Research Conference (1 unit)**

*Course Description:* Individual and/or group conference on problems, progress, and techniques in mechanical and aeronautical engineering research.

*Prerequisite(s):* Consent of instructor.

*Learning Activities:* Discussion 1 hour(s).

*Repeat Credit:* May be repeated.

*Grade Mode:* Satisfactory/Unsatisfactory only.

**MAE 297 – SEMINAR (1 unit)**

*Course Description:* Current topics in engineering including developments in mechanical and aeronautical engineering with presentations by students, faculty, and visitors.

*Prerequisite(s):* Consent of instructor.

*Learning Activities:* Discussion 1 hour(s).

*Repeat Credit:* May be repeated.

*Grade Mode:* Satisfactory/Unsatisfactory only.

**MAE 298 – Group Study (1-5 units)**

*Course Description:* Group study.

*Learning Activities:* Variable.

*Grade Mode:* Letter.

**MAE 299 – Research (1-12 units)**

*Course Description:* Research.

*Prerequisite(s):* Consent of instructor.

*Learning Activities:* Variable.

*Grade Mode:* Satisfactory/Unsatisfactory only.

**MAE 390 – Teaching of Aeronautical Science & Engineering (1 unit)**

*Course Description:* Methods of leading discussion groups or laboratory sections, writing and grading quizzes, use of laboratory equipment, and grading laboratory reports.

*Prerequisite(s):* Meet qualifications for teaching assistant and/or associate-in in Aeronautical Science and Engineering.

*Learning Activities:* Discussion 1 hour(s).

*Repeat Credit:* May be repeated.

*Grade Mode:* Satisfactory/Unsatisfactory only.

**MAE 396 – Teaching Assistant Training Practicum (1-4 units)**

*Course Description:* Teaching assistant training.

*Prerequisite(s):* Graduate standing.

*Learning Activities:* Variable.

*Repeat Credit:* May be repeated.

*Grade Mode:* Pass/No Pass only.