MECH-100 Engineering Graphical Communication
Required core course

Catalog Data

Credit: 2 0 4 4
Prerequisites: None
Corequisites: None

This computer aided design and drafting course is an introduction to engineering graphics and visualization with topics to include sketching, line drawing, wire-frame section development and elements of solid modeling. Also, this course will include the development and interpretation of drawings and specifications for product realization. CAD, office, and web-based software will be used in student presentations and analysis.

Textbook(s):

References:
Giesecke, F. et al., Technical Drawing 11th, Prentice Hall, Inc.; UG Cast Tutorials

Coordinator:
Yaomin Dong, Assistant Professor of Mechanical Engineering

Instructor(s):
Yaomin Dong, Dale Eddy, Kent Eddy, Paul Zang

Course Learning Outcomes

1. To have students demonstrate the elements of 3D visualization and engineering sketching techniques. [PO’s: (c), (g), and (h)]
2. To have students demonstrate the basic structure, content and terminology of engineering drawings. [PO’s: (f), (g), and (k)]
3. To have students demonstrate the techniques and processes of elementary solid modeling and visualization. [PO’s: (c), (g), and (k)]
4. To have students demonstrate the visual and written requirements associated with product realization. [PO’s: (c), (g), and (k)]
5. To require students’ use of CAD, office, and web-based software to enable graphical project based communication. [PO’s: (c), (g), (h), and (k)]

Topics

1. Introduction to Fundamentals of Sketching
2. Introduction to Visualization and Spatial Representation
3. Three Dimensional CAD Representations And Model Construction Processes
4. Drawing Projections: Orthographic, Isometric, Sectional, Auxiliary
5. Graphical and Written Requirements for Product Realization: Dimensioning, Geometric Dimensioning & Tolerancing, and Working Drawing Requirements.
6. Introduction to Web-Based and Office Software for Graphical Communication.

Schedule:
Three sessions per week of 120 minutes, two lecture hours and four laboratory hours (after hour tutoring is also available)

Computer usage:
Five homework assignments from topics 3, 4, & 5 using Unigraphics NX software. One homework assignment from topic 6 using Web-Based software.

Laboratory projects:
One Final Project using Unigraphics NX and Office software.

Relationship to professional component:
Four Credits of Engineering Science, 100%.

Prepared by: Dale Eddy Date: 01/11/07
Revised by: Yaomin Dong Date: 04/02/09
MECH- 210 – Statics
Required core course

Catalog Data

Credit: 4 0 0 4
Prerequisite: MATH-101
Corequisites: PHYS-114, PHYS-115, MATH-102

This course deals with a discussion and application of the following fundamental concepts: (1) static force analysis of particles, rigid bodies, plane trusses, frames, and machines; (2) first and second moments of area; (3) friction; (4) internal forces; and (5) stress deflection analysis of axially loaded members. Topics covered will be (1) the static force and moment equilibrium of two and three dimensional systems; (2) resultant forces and moments due to the application of concentrated and/or distributed loads; (3) couples; (4) the center of mass and the area moment of inertia of a rigid body; (5) shear force and bending moment diagrams of a rigid body; and (6) the stress and deflection analyses of axially loaded members. Free body diagrams will be formulated in a computer-aided environment in order to enhance the students' critical thinking and problem solving capabilities. Several open-ended homework and mini projects will be assigned in order to incorporate a design experience in the course. Terms Offered: All

Coordinator:
Basem Alzahabi, Associate Professor of Mechanical Engineering

Textbook:

Course Learning Objectives

By the end of this course, you should be able to
1. Find the resultant of a system of forces [PO’s: a, e, k]
2. Draw complete and correct free-body diagrams [PO’s: e]
3. Determine the support reactions on a structure [PO’s: a, e]
4. Determine the forces in the members of a truss using: [PO’s: a, e, k]
   • The method of joints
   • The method of sections
5. Calculate the pin forces in a general frame structure [PO’s: a, e, k]
6. Locate the centroid of an area using the Composite body approach [PO’s: a, e, k]
7. Determine the internal reactions in a beam, including . . . [PO’s: a, e, k]
   • Drawing complete and correct shear force and bending moment diagrams

Topics

1. General Principles and Vector Mathematics
2. Concurrent Force Systems
3. Statics of Particles (Free Body Diagrams)
4. Rigid Bodies: Equivalent Force/Moment Systems
5. Distributed Forces: Centroids and Center of Gravity
6. Equilibrium of Rigid Bodies
7. Trusses, Frames and Machines
8. Internal Forces

Examinations & Grading

- Quizzes (5) (25%)
- 2 Exams (50%)
- Comprehensive Common Final Exam (25%)

Schedule:
Two sessions per week of 120 minutes

Relationship to professional component:
100% of Engineering Science

Prepared by: Basem Alzahabi Date: 3/29/2009
MECH-212: Mechanics of Materials (previously, Mechanics II)
Required core course

Catalog Data

Credit: 4 0 0 4
Prerequisite: MECH-210: Statics (previously, Mechanics I)

The fundamental topics of this course include: normal and shear stress and strain, Hooke’s law, Poisson’s ratio, generalized Hooke’s law, axial deformation, torsion of circular bars, angle of twist, bending of beams, flexure formula, flexural shear stress, beam deflections, combined stresses, transformation of stresses, Mohr’s circle (principal stresses), statically indeterminate problems, and columns. Homework will be assigned. Design related projects may also be assigned.

Textbook(s):

Course Coordinator:
Raghu Echempati, Professor of Mechanical Engineering

Course Learning Objectives

1. Apply the principles of Statics to determine the forces and moments on load carrying members. [PO’s: a, c, e, i]
2. Analyze the stresses in load carrying members due to axial forces, bearing forces, torsional moments, bending moments and shear forces. [PO’s: a, c, e, k]
3. Analyze the combined stresses in load carrying members due to axial forces, torsional moments, and bending moments acting together. [PO’s: a, c, e, k]
4. Determine the deflection of load carrying, members due to axial loads, torsional moments and bending moments. [PO’s: a, c, e, k]
5. Objective 5: Apply the principles learned from the objectives 1 through 4 to perform basic analysis and sizing of different structural members. [PO’s: a, c, d, e, k, p]

Topics
1. Review of Statics – Internal Forces
2. Concepts of Stress and Strain: Hooke’s Law
3. Concepts of Stress, Deformation and safety factor as applied to:
   a. Axial Loading (uniform and stepped bars), and
   b. Torsion Loading (uniform and stepped bars)
   c. Horse power calculations
   d. Applications
4. Statically Indeterminate Problems as applied to:
   a. Axial loading (uniform and stepped bars)
   b. Effect of temperature (thermal stresses) in axial loading
   c. Applications
5. Concepts of Bending Stress, deflection and safety factor as applied to:
   a. Transverse Loading (Pure Bending) (uniform section bars with concentrated as well as distributed loads)
   b. Shear Force and Bending Moment Diagrams for the above
   c. Deflection of beams for simple loading by superposition (using deflection tables)
   d. Applications
6. Transformations of stresses and Combined Loading:
   a. Mohr’s circle for plane stress and determination of principal stresses
   b. Equivalent stress using yield criterion
   c. Applications (thin-walled cylinders, crankshaft example)
7. Other suggested topics for optional coverage:
8. Effects of Stress Concentration in axial, torsion and transverse loadings
   a. Applications
9. Statically Indeterminate Problems as applied to:
   a. Torsion loading (uniform and stepped bars)
   b. Applications
10. Transverse (Flexural) Shear effect
    a. Applications
11. Strain analysis by Mohr’s principle and strain rosettes
    a. Applications
12. Euler Buckling (long slender rods)
    a. Applications
13. Simple failure theory
14. Other topics

Grading Policy:
   Homework/classwork  25%
   Quizzes/Midterms    50%
   Mini Projects       5%
   Common hour finals  20%

Schedule:
   Two sessions per week of 120 minutes

Computer usage:
   Basic Computer Skills (MathCAD/Working Model/Excel/MS-Word/or equivalent program)

Laboratory projects: May include computer based design projects

Relationship to professional component:
   Four credits of 100% Engineering Science.

Prepared by: Dr. Raghu Echempati, P.E.          Date: March 24, 2009
MECH-231L Signals for Mechanical Systems Lab  
Required core course

Catalog Data

Credits: 0 0 2 1  
Prerequisites: None  
Corequisites: EE-212

This lab complements the Electrical Engineering course, EE-212, and provides the necessary knowledge and skills of electrical engineering to non-electrical engineering majors. It teaches students how to use sensors and instruments to make meaningful measurements in mechanical and electrical systems. This lab course introduces students to: (1) the laws and methods of circuit analysis (2) sensors used in measurements of displacement, temperature, strain and fuel cell systems and (3) the amplifiers and other instrumentation used to process the signals from these sensors.

Textbook(s):  
None

References:  
Rizzoni, Giorgio, Principles and Applications of Electrical Engineering, McGraw-Hall

Coordinator:  
Brenda Lemke, Lecturer Department of Mechanical Engineering

Instructor(s):  
Brenda Lemke, Janet Brelin-Fornari, Tim Cameron

Course Learning Objectives

1. Students will demonstrate the ability to generate and condition a signal using basic measurement techniques and measuring devices [PO’s: a, k, n]  
2. Students will demonstrate the ability to operate instrumentation systems containing sensors, signal conditioning electronics, and electronic amplifiers [PO’s: a, k, n]  
3. Students will demonstrate the ability to analyze circuits containing resistors, capacitors, and inductors using Kirchoff’s Current and Voltage Laws, Node Voltage Method, Current and Voltage dividers, Superposition method and by reducing circuits to their Thevenin Equivalents [PO’s: a, b, e]  
4. Students will demonstrate a working ability in the analysis of mechanical and electrical systems using computer software including MultiSIM and LabVIEW software for simulation and data acquisition [PO’s: a, c, g, k, n]

Topics

1. Instruments used for signal generation and measurement  
2. PEM Fuel Cell system performance
3. LabVIEW programming and data acquisition
4. MultiSIM programming for DC Circuit simulation
5. DC Circuit analysis
6. AC Circuit analysis
7. Operational Amplifiers
8. Sensors used for measuring system performance

Schedule:
One session per week of 120 minutes

Computer usage:
National Instruments LabVIEW and MultiSIM software, Excel.

Laboratory projects:
One Final Self Directed Experiment.

Relationship to professional component:
One Credit of Engineering Science.

Prepared by: Brenda S. Lemke  Date: 01/08/09
MECH-300 Computer Aided Engineering
Required Core Course

Catalog Data

Credit: 2 0 4 4
Prerequisites: MECH-100, MECH-212

This is a threaded continuation of MECH-100, Engineering Graphical Communication using computer graphics and computer aided design techniques. These advanced techniques use graphics primitives, construction functions, transformations, image control, dimensioning and layers. Both two-dimensional drawing and three-dimensional wireframe, surface modeling, and simulation modeling such as FEA and kinematic motion are covered.

Textbook(s):
None

References:

Coordinator(s):
Arnaldo Mazzei, Associate Professor of Mechanical Engineering

Course Learning Objectives

1. Demonstrate and apply the fundamental principles of statics and mechanics of materials using computer aided engineering techniques such as FEA [PO’s: a, e].
2. Demonstrate and apply modern analytical techniques to mechanical systems using computer aided engineering techniques [PO’s: e, k].
3. Demonstrate the ability to use computational techniques applied to mechanical systems [PO’s: k].
4. Demonstrate the ability to communicate effectively through individual and team presentations [PO’s: g].

Prerequisites by Topic

1. Ordinary and partial derivatives
2. Center of Mass, Moment of Inertia
3. Stress and Strain
4. Mechanical properties of materials
5. Fundamental concepts in statics
6. Computer Skills
Schedule:
Three sessions per week of 120 minutes (2 hours of lecture plus 4 hours in the lab)

Computer usage:
Computer Skills (MS Word, Excel, UGS NX)

Laboratory projects:
Individual and team projects during the term.

Relationship to professional component:
Two credits (50%) Engineering Science and two credits (50%) Engineering Design.

Prepared by:
Arnaldo Mazzei

Date: 2/16/2009
MECH-310: Dynamics (formerly called Mechanics III)  
Required Core Course

Catalog data

Credit: 4 0 0 4
Prerequisites: PHYS-114, PHYS-115, MATH-102, MECH-210

This course deals with a discussion and application of the following fundamental concepts: (1) application and basis of Newtonian mechanics and physical laws; (2) a study of the kinematics and kinetics of a particle including relative and absolute motion, friction concepts; (3) additional analysis of particle dynamics using work-energy and impulse-momentum methods, analysis of impact events; (4) analysis of a system of particle using work-energy, impulse, linear and angular momentum; (5) kinematics and kinetics of rigid bodies analyzed in various reference systems; (6) additional analysis of rigid body dynamics using work-energy and impulse-momentum; (7) inertia quantities.

Textbook(s):

References:

Coordinator:
Richard Stanley, Associate Professor of Mechanical Engineering

Course Learning Objectives

1. Analyze the kinematics of a particle in order to predict its motion in standard 1-D and 2-D coordinate systems. [PO’s: a, e, m]
   1.1 Rectilinear (1-D) Motion
   1.2 Motion in the Cartesian coordinate system
   1.3 Motion in the normal-tangential coordinate system
   1.4 Motion in the cylindrical coordinate system
   1.5 Relative motion between two particles
2. Analyze a mechanical system and predict the forces acting on a particle or the motion of a particle resulting from external forces. [PO’s: a, e, m]
   2.1 Create a Free Body Diagram (FBD) of particle or a connected system or particles (i.e.a pulley system).
   2.2 Apply Newton’s Law to a FBD in any coordinate system listed in Objective 1
   2.3 Apply impulse-momentum principles and impact loading principles.
   2.4 Apply work-energy principles.
3. Analyze the kinematics of a rigid body or a connected system of rigid bodies in order to predict the motion of the body(s) and/or the motion of a point on the body(s). [PO’s: a, e, m]
   3.1 Apply kinematic principles to a rigid body in order to predict its angular motion.
3.2 Apply kinematic principles to a system of connected rigid bodies in order to predict the angular motion of any of the connected bodies by using different reference systems.

3.3 Apply kinematic principles to a system of connected rigid bodies in order to predict the linear motion of a point on any of the connected bodies by using different reference systems.

4. Analyze a mechanical system and predict the forces acting on a rigid body or the motion of a rigid body resulting from external forces. [PO’s: a, e, m]

4.1 Create a Free Body Diagram (FBD) of rigid body or a connected system of rigid bodies.

4.1 Calculate the mass moment of inertia of a rigid body.

4.2 Apply Newton’s Law to the FBD.

4.3 Apply work-energy principles.

**Topics**

1. Introduction
2. Review of Vector Mechanics, Free Body Diagrams, and Trigonometry,
3. Definitions of Particle/Rigid Body Mechanics, Newton’s Laws
4. Kinematics of a particle, relative motion, rectangular coordinates
5. Kinematics of a particle in normal-tangential and cylindrical coordinates
7. Kinetics of a particle using work-energy and impulse methods, Impact
8. Particle dynamics applications
9. Kinematics of a rigid body, relative motion
10. Kinematics of a rigid body, different reference systems
11. Kinetics of a rigid body using Newton’s Laws
12. Kinetics of a rigid body using work-energy methods
13. Planar rigid body dynamics applications

**Schedule:**

Two sessions per week of 120 minutes

**Computer usage:**

Basic Computer Skills (MathCAD/Working Model/Excel)

**Laboratory projects:**

Several open-ended projects are planned that involve parametric studies performed using computational tools.

**Relationship to professional component:**

This course is 100 % Engineering Science.

**Prepared by:**

Richard Stanley  
**Date:** 11/16/05
MECH-311: Introduction to Mechanical System Design
Required Core Course

Catalog Data

Credit: 2044
Prerequisites: MECH-100, MECH-210
Corequisites: EE-212 & MECH-231L

The objective of the course is to teach fundamentals of machine elements and mechatronics design, with an emphasis on product design and fabrication. Design, analysis and fabrication of prototype mechatronic systems and devices are completed. Mechanical design concepts including transmission methods, force and torque analysis, mechanisms and simulation is covered. Formal design processes such as brainstorming and concept-tree development are utilized. Intellectual property law pertinent to design and invention is covered. The synergistic combination of sensors, actuators and controls technologies to create functionally “smart” and adaptive devices is implemented. Sensor and actuator technologies are covered. The course culminates with an open-ended project to design and fabricate a mechatronic system using basic machining equipment and a programmable controller.

Textbook(s):
None: Reading assignments are web-based

References:
Web site http://www.kettering.edu/acad/mechatronics

Coordinator:
Dale Eddy, Staff Lecturer of Mechanical Engineering

Instructors:
Dale Eddy, Ph. X7874, Office 2-135 MC, deddy@kettering.edu
Office hours vary by term. Please consult faculty schedule.
Jeff Hargrove, Ph. X7437, Office 2-245 MC, jhargrov@kettering.edu
Office hours by appointment only.

Course Learning Objectives

1. Students will be able to integrate sensor technologies in design [PO’s: c, e]
2. Students will be able to integrate actuator technologies in design [PO’s: c, e]
3. Students will be able to design a mechanical system [PO’s: c, d, e, f, k, n, p]
4. Students will be able to fabricate a mechanical system [PO’s: d, k]
5. Students will be able to communicate design experiences [PO’s: d, f, k, n]
Topics

1. Introduction to mechatronics and mechanical design; software design tools; mechanical analysis; machine shop safety
2. Mechanical analysis; first design project introduction
3. Design fabrication; functional analysis
4. Functional testing and analysis; design project oral report
5. Intellectual properties; controller programming; formal design processes; introduction to final design project
6. Patent applications; detailed design of final project
7. Detailed design revisions, design project fabrication
8. Design project fabrication
9. Design project fabrication
10. Design project fabrication; certification and qualification
11. Design project fabrication and final competition

Schedule:
Three sessions per week of 125 minutes; lecture at the top of every session with recitation and/or laboratory to follow.

Computer usage:
UG NX, Microcontroller software development and debugging tools, MS Excel™, MS Word™, Working Model™

Laboratory projects:
Two laboratory projects teaching the integration of sensors and actuators with microcontrollers, mechanical design laboratories with fabrication, open-ended design project.

Relationship to professional component:
80% Engineering Design, 20% Engineering Science

Grading Policy: Grades are based on the following five (5) measures as follows:
- Project 1 Oral Report 10%
- Project 1 Written Report 20%
- Project 2 Patent 20%
- Project 2 Written Report 25%
- Projects 1 & 2 Logbook 25%
Midterm grades are automatically entered as incomplete (I). Final scaling of each measure based on professional behavior is completed at the conclusion of the course.

Prepared by: Jeff Hargrove, Associate Professor of Mechanical Engineering, 2/18/2003
Revised by: Bill Waldron, Assistant Professor of Mechanical Engineering, 3/15/2005
Revised by: Dale Eddy, Staff Lecturer of Mechanical Engineering, 8/9/2006 & 8/9/2008
MECH –312:  Design of Mechanical Components I  
Required Core Course

Catalog Data

Credit: 4 0 0 4
Prerequisites: MECH-210, MECH-212, and MECH-311.

This course involves application of theory and techniques learned in the mechanics courses to the concepts of mechanical component design. Through lectures and class example and homework problems the student will be introduced to design methodology. This methodology requires learning to develop and set-up a mechanical component design problem, through properly understanding and solving the problem based upon the given data, design constraints, making and verifying assumptions. Selection of the proper analytical tools as required, producibility and maintainability of the design, materials selection, safety, and cost considerations. Take-home project problems will enhance and demonstrate the type of study and research required for design. Topics to be studied include strength and fatigue considerations, shaft design, threaded fasteners, lubrication and bearings, springs, and fundamentals of gear analysis, including forces, stresses and terminology.

Textbook:

Reference:

Coordinator:
Richard E. Dippery, Jr., Ph.D., PE, Professor of Mechanical Engineering

Course Learning Objectives

1. Develop, set-up, and solve mechanical component design problems based upon given data and requirements. [PO’s: a, c, e]
2. Develop corrective action (define the cause for a problem and the design fixes) for field problems. [PO’s: a, c, d, e, g]
3. Understand the need for proper design actions via discussions of current, news worthy, design-related incidents. [PO’s: f, g, h, j]
4. Through mechanical component design homework and team-based problems develop an appreciation for design tools and the ever-changing materials, processing and analytical techniques available to design while providing an understanding of the basics of design. [PO’s: a, c, d, e, g, n]
Topics

1. Design for Static Strength/Yield Criteria
2. Fatigue Considerations in Design
3. Design of Shafts
4. Springs
5. Bearings and Lubrications
6. Threaded Fasteners
7. Gear Terminology, Gear Trains, and Gear Forces
8. Forces and Stresses in Gears

Prerequisite by Topic:

- Equilibrium and Free Body Diagrams
- Basic Stress-Strain Analysis
- Deflection Analysis
- Torsion
- Bending of Beams
- Shear-Moment Diagrams
- Materials Properties and Behavior
- Materials Processing
- Mohr’s Circle and Principal Stresses
- Common Sense

Schedule:

Two sessions per week of 120 minutes each

Computer Usage:

Basic skills using MathCAD or equivalent

Relationship to Professional Component:

Three credit hours Engineering Science
One credit hour Engineering Design

Prepared By: Richard E. Dippery, Jr., Ph.D., PE  Date: 03/20/06
MECH-320  Thermodynamics
Required Core Course

Catalog Data

Credit: 4 0 0 4
Prerequisite: PHYS-224, PHYS-225, Minimum Class Standing: SO
Corequisite: None

A study of the first and second laws of thermodynamics and their application to energy transformations during various processes. Property relations are studied for pure substances, ideal gases, mixture of ideal gases, and atmospheric air. Steam power cycles, refrigeration cycles, spark-ignition and compression-ignition engines, and turbine cycles are evaluated to determine performance parameters and energy efficiencies.

Textbook:
Fundamentals of Classical Thermodynamics by: Van Wylen, Sonntag, and Borgnakke, 7th Edition

References:

Coordinator:
Homayun Navaz, 2-133 C. S. Mott Engineering & Science Center, (810) 762-9597, hnavaz@kettering.edu.

Course Learning Objectives

Upon completion of this course, the student will be able to:
1. Identify the state and properties of a pure substance in a single or multiple phase (mixture). [PO’s: a, b, l]
2. Develop in-depth understanding of mass and energy conservation laws [PO’s: a, e, i]
   Identify, formulate, and solve problems in classical thermodynamics [PO’s: a, c, e].
3. Demonstrate a systematic and structured approach to problem solving [PO’s: a, c, e m]
4. Apply fundamental principles to analyze components of a thermodynamic cycle (turbines, compressors, etc.) [PO’s: a, b, c, e, i]
5. Apply thermodynamic laws to design a cycle or a thermodynamic system [PO’s: a, c, e, g, h, l, j, k, n]
6. Utilize thermodynamic tools to perform a preliminary design of a complex system (or cycle) [PO’s: a, c, d, k, n]
Prerequisites by Topic:
1. Electricity and Magnetism
2. Electricity and Magnetism Lab

Schedule:
Two sessions per week of 120 minutes each.

Computer Usage:
Basic computer skills (MS Word, Excel and MATLAB or equivalent

Recommended Laboratory Project:
No required laboratory. Laboratory experience is attained in the Energy Systems Lab (MECH-422)

Recommended Team Project
A team project (10%) of the final grade is assigned to students during week 6.

Relationship to Professional Component:
This course is 90% engineering science and 10% engineering design

References:

Grading:
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<tr>
<th>Component</th>
<th>Weight</th>
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<tbody>
<tr>
<td>Test 1</td>
<td>20%</td>
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<tr>
<td>Quizzes</td>
<td>10%</td>
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<tr>
<td>Test 2</td>
<td>25%</td>
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<tr>
<td>Final Project</td>
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<td>Final Exam</td>
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No prior notice for quizzes will be given.

Attendance:
Is mandatory. Any anticipated absence should be worked out with the instructor ahead of time. No make-up exam will be offered without the department’s head or the Provost’s written statement. Missing classes will significantly affect the subjective part of your final grade.

Prepared by: Homayun Navaz, Professor of Mechanical Engineering
MECH-322 Fluid Mechanics
Required Core Course

Catalog Data

Credit: 4 0 0 4
Prerequisites: MECH-320 Thermodynamics

This is a first course in Fluid Mechanics that involves the study of fluid flow in ducts and over objects. The course introduces the fundamental aspects of fluid motion, fluid properties, flow regimes, pressure variations, fluid kinematics, and methods of flow description and analysis. Presents the conservation laws in their differential and integral forms and their use in analyzing and solving fluid flow problems. In addition, the concept of using similitude and dimensional analysis for organizing test data and for planning experiments is introduced. The effects of fluid friction on pressure and velocity distributions are also discussed. The effects of compressibility (variable density) on fluid flows are also included.

Textbook:

Reference:

Coordinator:
Dr. Bassem Ramadan, Room 2-223 MC, 762-9928, bramadan@kettering.edu

Course Learning Objectives

Upon completion of this course the student will be able to:
1. Determine pressure distribution in fluids at rest and to calculate hydrostatic forces (magnitude and line of action) acting on plane and curved surfaces [PO’s: a,c,e,k].
2. Draw streamlines in a given flow and to determine pressure variations along and normal to a streamline [PO’s: a,e,k].
3. Determine the velocity and acceleration of the fluid for steady and unsteady flows [PO’s: a,e,k].
4. Apply the control volume concept to describe fluid flow through the application of conservation of mass, momentum, and energy [PO’s: a,c,e,i,k,n].
5. Apply the governing differential equations (mass and momentum) to analyze fluid flows [PO’s: a,e,k,n]
6. Plan and understand experiments, as well as understand and correlate data through the use of similitude and dimensional analysis [PO’s: a,b,e,j,k].
7. Apply the basic principles to the flow of viscous incompressible fluids in pipes, multiple pipe systems, and ducts, to determine friction losses [PO’s: a,c,e,i,j,k,l]
8. Utilize existing experimental and numerical data to analyze external flows, and to calculate drag and lift forces acting on immersed bodies [PO’s: a,e,j,k]
9. Study the effect of compressibility on steady, isentropic, one-dimensional flow of an ideal gas in a varying cross-sectional area duct [PO’s: a,e,k]

Letters in brackets are ME POs.

Prerequisites by Topic:
1. Integration and Differentiation. Dot Product and Cross Product of Vectors.
2. Statics, Dynamics, Moment of Inertia and Centroids
3. Concepts of Control Volume and System
4. Basic Computer Skills (MS Word and Excel)

Topics Covered:
10. Comprehensive Final Examination

Schedule:
Two sessions per week, 120 minutes each

Computer Usage:
Basic computer skills (MS Word, Excel)

Laboratory:
None.

Relationship to Professional Component:
This course is 25% Basic Science and 75% Engineering

Prepared by: Dr. Bassem Ramadan, Professor of Mechanical Engineering. 02/15/2009
A study of mathematical modeling of mechanical, electrical, hydraulic and multidiscipline engineering system using bond-graph-technique, yielding state space equations. Derivation of the Equations of Motion (EOM) of single Degree of Freedom (SDOF) and 2DOF using Lagrange Equation and/or Newton Second Law (NSL). Determine transfer functions and frequency transfer function response for first and second order systems. A study of linear mechanical vibrations for SDOF and 2DOF systems, and of their vibration isolation. Determine characteristic equation, stability eigenvalues of systems. Develop computer code in order to simulate, analyze real engineering systems in the time and frequency domain using MATLAB.

Textbook:

References:
Strum and Ward, Laplace Transform Solution of Differential Equations, Prentice-Hall

Coordinator:
Pinhas Barak, Professor of Mechanical Engineering

Course Learning Objectives

Upon completion of this course, “Dynamics Systems I”, the student will be able to:
1. identify system components, their symbols, terminology, attributes, constitutive equations and interactions based on a unified approach [PO’s: a, c, p]
2. model mechanical, electrical, hydraulic and multidiscipline systems using bond-graph technique [PO’s: a, b, c, e, p, s]
3. derive the Equations of Motion (EOM) in state space form from bond-graph models of mechanical, electrical, hydraulic and multidiscipline systems with Multi-Input-Multi-Output (MIMO) variables[PO’s: a, b, c, l, s]
4. derive the equations of motion of Single Degree of Freedom (SDOF) and a 2DOF mechanical system using Lagrange equation and/or Newton Second Law (NSL) [PO’s: a]
5. determine transfer functions of first and second order systems using Laplace transformation pairs from the t-domain to the s-domain [PO’s: a]
6. derive the characteristic equation of a first and second order system, solve for the eigenvalues, natural frequency (if any) and evaluate the stability of the system [PO’s: a, b, c, l, s]
7. estimate the value of a function f(t) at \( t \to 0 \), and \( t \to \infty \) using the Initial Value Theorem (IVT) and the Final Value Theorem (FVT) [PO’s: a]
8. evaluate the time response to deterministic inputs for first and second order systems [PO’s: a, b, c, e, j]
9. investigate and analyze the vibration isolation of SDOF and 2DOF mechanical systems in the time and frequency domain [PO’s: a, b, c, e, j]
10. develop a computer code to simulate and analyze and design real engineering systems using MATLAB software [PO’s: a, b, c, e, l, p, s]
11. take the second course in systems engineering entitled “MECH 430 – Dynamic Systems II” dealing with more advanced multi-domain systems and closed-loop control systems.

Schedule:
Two sessions per week of 120 minutes each.

Computer Usage:
Basic computer skills and MATLAB Professional Edition 6.5 (or higher).

Recommended Laboratory Projects:
Laboratory project #1: MATLAB. Supervised simple case study for first and second order system; 2 hours per student, up to 5% of final grade.
Laboratory project #2: Comprehensive case study using MATLAB, teams of no more than two students (to be collected), up to 10% of final grade.

Relationship to Professional Component:
This course is 90% engineering science and 10% engineering design.

Prepared by: Pinhas Barak, Professor of Mechanical Engineering, 5/17/06
MECH-350: Introduction to Bioengineering Applications
Elective

Catalog data

Credit: 4 0 0 4
Pre-requisites: BIOL-241 and/or CHEM-145, MECH-212

This course deals with a discussion and application of the following fundamental concepts: (1) basic anatomy and physiology of the overall human body; (2) basic anatomy and physiology of specific structures including brain, ears, eyes, heart, kidney, gastro-intestinal system, articular joints, and bones; (3) an appreciation of the engineering basis for current and developmental products designed to diagnose and replace these biological structures; (4) exposure to biochemistry, biomaterials, and biomechanics at a fundamental level; and (5) an understanding of current laws which govern bioengineering device manufacturing. A semester project will require the student to rigorously research an existing product or emerging technology of relevance to bioengineering and the human body.

Textbook(s):

References:
Medical Instrumentation: Application and Design, 3rd edition by Webster, John Wiley

Coordinator:
Patrick Atkinson, Associate Professor of Mechanical Engineering

Course Learning Objectives

Objective 1: Understand basic human anatomy and physiology terms and biological concepts [PO’s: a, i]
1.5 The students will be able to identify basic anatomical directions, cutting planes, and body segment motions.
1.6 The students will be able to identify the major organs of the head and abdomen.
1.7 The students will be able to understand the basic biochemical basis for macro-biological function.

Objective 2: Understand the basis for major organ function/dysfunction and diagnostic techniques using engineering concepts [PO’s: a, i, p]
2.1 The students will be able to explain the basic anatomy and physiology specific to the brain, eyes, ears, heart, kidneys, gastrointestinal system, fetal development, articular joints, and bone. Further, the students will be able to differentiate between the normal and diseased state.
2.2 The students will apply general engineering principles to explain the techniques upon which medical images are acquired.
2.3 The students will apply general engineering principles to explain basis of quantitative brain and heart signal diagnosis.

2.4 The students will be able to explain the engineering principles upon which gastrointestinal images are acquired.

2.5 The students will apply general engineering principles to explain the basis of fetal monitoring systems.

Objective 3: Understand the basis for the design of prosthetic devices designed to replace or augment failing or debilitated biological systems [PO’s: a, l]

3.1 The students will be able to explain the engineering and design basis for products which replace or augment the heart, kidneys, eyes, ears, and articular joints.

3.2 The students will be able to explain the basic principles associated with the federal requirements associated with device manufacture and implementation.

Objective 4: Research an existing or emerging technology designed to replace or augment failing or debilitated biological systems [PO’s: c, f, h, i, j, k, l]

4.1 The students will thoroughly research a topic of mutual interest to the student and class after which these findings will be presented using computer presentation tools, props, etc.

Topics

1. Introduction, basic anatomy and physiology
2. Basic anatomy and physiology (cont’d)
3. Ear function, hearing aids, inner ear accelerometer
4. Eye function, restoring sight, tissue engineering
5. Kidney function, dialysis
6. Heart function and diagnosis, pacemakers, heart valves, stent installation
7. Brain function and diagnosis: electroencephalography
8. Articular joints, arthritis, total joint arthroplasty, anterior cruciate ligament reconstruction
9. Gastrointestinal dysfunction and diagnosis
10. Fetal development and monitoring
11. Federal Drug Administration requirements

Schedule:
Two sessions per week of 120 minutes

Computer usage:
Basic computer skills such as PowerPoint presentations

Laboratory projects:
One semester research project is required on a topic of mutual interest to the student and the class.

Relationship to professional component:
This course is 100% Engineering Science.

Prepared by: Patrick Atkinson
Date: March 22, 2006
Catalog Data

Credit: 4 0 0 4  
Prerequisites: MECH-312

This course is an extension of MECH-312, Design of Mechanical Components I. Topics to be studied will include material considerations in design, deflection analysis, ethics, friction and friction components, code based design, fasteners, welded connections, and topics selected by the students. Course work will consist of lecture plus team-based homework assignments. In addition, the students will perform research on these topics and provide written and oral reports.

Textbook:

Reference:


Coordinator:
Richard E. Dippery, Jr., Ph.D., PE, Professor of Mechanical Engineering

Course Learning Objectives

1. Develop, set-up, and solve mechanical component problems based upon given data and requirements. [PO’s: a, c, d, e, f, k.]
2. Develop corrective action for manufacturing and field problems (define the cause for a problem and the design fixes). [PO’s: a, c, d, e, f, g, k]
3. Recognition of the need for an ability to engage in proper design actions via discussions of current, newsworthy, design-related incidents. [PO’s: d, g, j]
4. Through team-based research and problem solving, develop an understanding of the fundamentals of engineering research, as will be required “on-the-job” and apply it to delivering written or oral reports and discuss applications of that particular research. [PO’s: a, d, e, f, g, i, k]

Topics

1. Materials and materials considerations in design
2. Deflection analysis
3. Fastener design considerations
4. Ethics in engineering
5. Design for welding
6. Friction and friction components

**Schedule:**
Two sessions per week, two hours each

**Computer Usage:**
Basic skills using MathCAD or equivalent

**Relationship to Professional Component:**
2 hours, Engineering Science  2 hours Design

**Prepared By:** Richard E. Dippery, Jr., Ph.D., PE, Date: 3/21/06
MECH-420  Heat Transfer
Required Core Course

Catalog Data

Credit:  4 0 0 4
Prerequisite:  MECH-320
Corequisite:  MECH-322

This course addresses the principles of heat transfer by conduction, convection, radiation and energy conservation; fins; steady-state and transient problems; and analysis and selection of heat exchangers.

Textbook:

References:
None

Coordinator:
Ahmad Pourmovahed, Professor of Mechanical engineering

Course Learning Objectives

Upon completion of this course, the student will be able to:
1. Identify the three modes of heat transfer: conduction, convection and radiation for a given energy system [PO’s: a,e,k].
2. Analyze physical heat transfer problems by reducing them to workable mathematical models [PO’s: a,e,k].
3. Solve heat conduction problems in steady-state and transient conditions through application of rate equations and the conservation of energy law [PO’s: a,e,k].
4. Solve convective heat transfer problems by determining convective heat transfer coefficients and the corresponding heat transfer rate for forced and natural, external and internal convective heat transfer problems [PO’s: a,e,k]
5. Design heat exchangers and analyze their performance [PO’s: a,b,c,d,e]
6. Solve radiation heat transfer problems incorporating surface radiative properties [PO’s: a,e,k]
7. Utilize suitable numerical techniques and computer tools in the formulation and solution of open-ended heat transfer design problems in a project team setting [PO’s: a,c,d,k]

Prerequisites by Topic:
1. Partial derivatives
2. Thermodynamics and fluid mechanics principles covered in prerequisites
3. Basic computer skills (MS Word, Excel and MATLAB, or equivalents)
Topics

1. Conduction, convection, radiation basics; rate equations; energy balance and the control volume and control surface concepts
2. 1-dimensional steady-state conduction, plane and radial geometries; heat diffusion equation; boundary and initial conditions
3. Thermal resistance models, heat generation problems; design of fins
4. 2-dimensional steady-state conduction; numerical methods
5. Transient conduction problems
6. Dimensionless analysis; forced external convection problems
7. Forced internal convection problems, natural convection problems
8. Heat exchanger fundamentals; U-factor calculation; LMTD and $\varepsilon$-NTU methods
9. Heat exchanger design and analysis; phase-change heat exchangers
10. Radiation heat transfer design; effects of surface properties; view factors
11. Final examination and team design project

Schedule:
Two sessions per week of 120 minutes each.

Computer Usage:
Basic computer skills (MS Word, Excel and MATLAB or equivalent); Students use IHT and FEHT software provided with text for open-ended heat transfer design problem solving.

Recommended Laboratory Project:
No required laboratory experiences.

Prepared by: Ahmad Pourmovahed, Professor of Mechanical Engineering (10/12/07)
MECH-422 Energy Systems Laboratory  
Required Core Course  

Catalog Data  

Credit: 2044  
Prerequisites: MECH-320, MECH-322  
Corequisite: MECH-420  

A laboratory course dealing with the detailed application of the first and the second laws of thermodynamics; continuity, momentum, and energy equations; and principles of conduction, and convection to a variety of energy systems. Topics such as internal and external flows, refrigeration, psychrometrics, aerodynamic lift and drag, pump and fan performance, jet engine, road load simulation, compressible flow and shock waves, free and forced convection, heat exchangers and PEM fuel cell performance are covered. Computational fluid dynamics (CFD), automatic data acquisition, flow visualization using DPIV and a design experience are incorporated into various laboratory experiments.

Textbook:  

References:  

Coordinator:  
Ahmad Pourmovahed, Professor of Mechanical Engineering

Course Learning Objectives  

Upon completion of this course, the student will be able to:  
1. apply the fundamental principles of thermodynamics, fluid mechanics, and heat transfer [PO’s: a,e,k].  
2. apply modern measurement techniques and experimental methods to energy systems [PO’s: a,b,e].  
3. apply computational techniques to energy systems [PO’s: a,e,k].  
4. apply team working skills [PO’s: d]  
5. communicate effectively [PO’s: g]  
6. design and conduct experiments [PO’s: b,e,k]
7. analyze and interpret data [PO’s: b]
8. implement experimental results in a design process[PO’s: b,c]

Prerequisites by Topic:
1. Ordinary and partial derivatives
2. Conservation of mass, momentum, and energy
3. 2nd Law of Thermodynamic
4. Thermo-physical properties of substances
5. Fundamental concepts in external and internal flows
6. Basic Computer Skills (MS Word, Excel)

Topics
2. Design Project Initiation, Road Load Simulation
3. PEM Fuel Cell Performance
4. Centrifugal Pump
5. Fan Laws, Introduction to DPIV
6. Compressible Flow
7. Jet Engine
8. Design Projects
9. Lift, Drag & Aerodynamics
10. Cylinder Convection
11. Final examination and team design projects

Schedule:
Lecture: One session per week of 120 minutes
Lab: Two sessions per week of 120 minutes each

Computer Usage:
Basic Computer Skills (MS Word, Excel)

Prepared by:
Ahmad Pourmovahed, Professor of Mechanical Engineering (10/12/07)
MECH-430 Dynamic Systems II  
Required Core Course

Catalog Data

Credit: 2 0 4 4  
Prerequisites: MECH-330

This is a second course; follow up course, in System Dynamics. The objective of this course is to provide an understanding into basic principles and methods underlying the steady state and dynamic characterization of feedback control systems. The focus is on multi-discipline approach as in the previous course. Construction of mathematical models of systems using Bond-graphs, block diagrams and development of transfer functions and state space models is emphasized. System performance is studied mainly using computer simulation (both in time and frequency domains) software tool(s). Design of control systems is attempted using the same computer simulation tools. Introduction to some advanced topics in control systems is also provided.

Suggested Textbooks:
- Dynamic Systems Workbook, R. Chandran and R. Lundstrom, Kettering University, 2005

References:

Coordinator(s):
Ram S. Chandran, Professor of Mechanical Engineering

Course Learning Objectives

Upon completion of this course the student will be able to:
1. Model simple engineering systems involving multiple feedback loops. The system will include at least two disciplines, such as electrical-mechanical, electrical-fluid-mechanical combinations [PO’s: a, b, c, e, l].
2. Analyze the system performance in Time and Frequency domains-Laplace/inverse Laplace transform solution for simple cases, evaluate the system (response) characteristics using indices such as natural frequency, damping ratio, eigen value, time constant and band width.[ PO’s: a, b, c, e, l, n].

3. Evaluate the system performance characteristics, such as stability and speed of response based on accepted metrics in time and frequency domains [PO’s: a, b, c, e, l, n].

4. Simulate the system performance in time and frequency domains using accepted professional simulation tools, such as MATLAB/Simulink [PO’s: a, b, e, l, n]

5. Design simple controllers, such as, P, PI, PD and PID, for systems to meet certain performance objectives using the modeling and simulation tools, such as MATLAB/Simulink, detailed in the course [PO’s: a, b, c, e, k, l, m, n].

Schedule:
   Two lab. sessions per week of 120 minutes, and
   One lecture session per week of 120 minutes.

Computer usage:
   Basic computer skills (MS Word, Excel) and some familiarity with MATLAB/Simulink.

Laboratory Projects:
   Two.

Relationship to professional component:
   Three credits Engineering Science and one credit Engineering design.

Prepared by: Ram S. Chandran, Professor of Mechanical Engineering, 10/18/07
MECH-510: Analysis and Design of Mechanical Assemblies (4-0-4)
Elective

Catalog Data

Credit: 4 0 0 4
Prerequisites: MECH-300, MECH-310, MECH-312, MECH-330
Corequisites:

The main aim of this course is to integrate the concepts of kinematic & dynamic analyses to the design of machines and mechanical assemblies used in automotive, medical equipment and other applications. These include (but not limited to) the analysis and design of reciprocating engine sub-systems such as, piston cylinder mechanism, steering linkages, window and door-lock mechanisms, over-head valve linkage system, flywheel, gears & gearboxes, universal couplings and automotive differential. Synthesis of mechanism systems used in medical equipment area will also be covered. Kinematic and dynamic characteristics such as displacement, velocity, acceleration and forces are analyzed by graphical and analytical methods. CAE tools will be used to perform kinematic, dynamic and stress analyses and fatigue design of these systems using CAE tools. Temperature effects will also be included wherever appropriate in the design. Several practical design projects will be assigned during the term of this course.

Textbook:

References:

Coordinator:
Raghu Echempati, Professor of Mechanical Engineering

Course Learning Objectives

Upon completion of this course, “Analysis and Design of Machines & Mechanical Systems”, the students will be able to:
1. apply the integration of the fundamental concepts of rigid body kinematics in relative motion, solid mechanics, computer aided engineering through computational and design tools [PO’s: a, c, e, k]
2. apply fundamental mechanics principles to the kinematic, dynamic and fatigue stress analyses of mechanical components, subsystems and systems [PO’s: a, c, e, k]
3. use state-of-the-art CAE software tools to formulate, conceptualize, design, analyze, and synthesize open-ended problems pertaining to mechanical systems [PO’s: a, c, k, p]
4. develop strategies to improve the product and process design based on the results obtained [PO’s: c, d, h, i, k]

Topics

1. Introduction to analysis and design of mechanical systems
2. Kinematic and dynamic analysis of machines and mechanism systems, including real-world industrial applications
3. Analysis and design of engine mechanism system with applications
4. Analysis and design of overhead valve systems
5. Analysis and design of compound and epicyclic gear trains involving helical gears; AGMA standards
6. Analysis and design of automotive differential system using bevel and hypoid gears; AGMA standards
7. Study and design of worm gears; AGMA standards
8. Introductory kinematic synthesis and applications to medical devices
9. Materials and manufacturing considerations in design; incorporation of ASME standards
10. Review

Schedule:
   Two sessions per week of 120 minutes

Computer usage:
   PC or Unix-based software will be used

Laboratory projects:
   Several laboratory exercises that are open-ended involving computer simulation and parametric studies on the modeling and analysis of machines and mechanical systems will be assigned.

Relationship to professional component:
   This course is 50% Engineering Science, 50% Engineering Design

Prepared by: Raghu Echempati, Professor of Mechanical Engineering       Date: March 25, 2009
MECH-512: Mechanical Systems Design Project
Senior Capstone Design Elective
Catalog Data

Credit: 4 0 0 4
Prerequisites: MECH-300, MECH-312, Senior Standing

The fundamental topics of this course include: The engineering design process, ethics, teamwork, brainstorming, conceptual designs, proposal writing, project planning, project management, product attributes, design criteria, engineering targets, physical simulation, virtual simulation, analysis techniques, design synthesis, alternative designs, bill of materials, bill of process, manufacturability, product variations, product quality, design reports and presentations.

Textbook(s):
Lecture notes

References:
The Engineering Design Process, Atila Ertas and Jesse Jones, John Wiley & Sons 1993

Coordinator:
Dr. Mohamed El-Sayed, Professor of Mechanical Engineering

Course Learning Objectives

Objective 1: Creative thinking in design [PO’s: c, d, e]
1.1 Students will be able to brainstorm and think creatively to achieve alternate design solutions.

Objective 2: Teamwork and communication skills [PO’s: d, g, p]
2.1 Students will be able to form teams and work effectively with others to achieve design goals.
2.2 Student will be able to present their ideas, plans and design alternatives in written and oral formats.

Objective 3: Project planning and management. [PO’s: c, d, e, f, g, h, i, j, k, p]
3.1 Student will be able to use project planning tools to plan tasks, timing and coordinate design activities.

Objective 4: Identify product attributes and design criteria. [PO’s: a, c, e, g, h, i, j, p]
4.1 Student will be able to use systematic design process thinking to analyze the conceptualized product attributes and transfer these attributes to design criteria and engineering targets

Objective 5: Product simulation and synthesis. [PO’s: a, b, c, h, i, k, l, m, n, o, p]
5.1 Student will be able to apply their education and co-op experiences to simulate the conceptualized product in the intended environment and synthesize to achieve targets and attributes.
Topics

1. The engineering design process
2. Team formation and working in teams
3. Brainstorming and creativity in design
4. Project selection and Proposal writing
5. Project planning
6. Proposal in class presentations
7. Bill of Materials
8. Analytical and physical Simulations
9. Design analysis and Integration
10. Product synthesis and optimization
11. Writing progress reports
12. Engineering Ethics
13. Project management
14. Design progress in class presentations
15. Alternative Designs
16. Design to Cost
17. Design for Manufacturability
18. Bill of process
19. Product variations
20. Product quality
21. Writing final reports
22. Final design in class presentations

Schedule:
Two sessions per week of 120 minutes

Computer usage:
Basic Computer Skills (CAD, FE Analysis, MathCAD/Working Model/Excel/MS-Word/MS-Project/MS-PowerPoint/or equivalent programs)

Laboratory projects:
One open-ended design project.

Relationship to professional component:
This course is 100 % Engineering Design.

Prepared by: Dr. Mohamed El-Sayed                Date: 03/24/2009
MECH - 514 Experimental Mechanics
Senior Capstone Design Elective

Catalog Data

Credit: 2 0 4 4
Prerequisites: Senior II level standing in Mechanical Engineering

The primary purpose of this course is to provide fundamental knowledge in the theory and practical experience in the application of mechanical engineering measurements. Viewed as a system, consideration is given to the performance, limitations, and cost of the detection - transducing stage, the signal conditioning stage and the final termination or readout - recording stage. Sensors such as resistive, capacitive or inductive are considered for the transducing stage. Signal conditioning stage emphasizes the use of a Wheatstone Bridge circuit, operational amplifiers and digital processing. The final readout or termination stage considers visual readouts such as analog or digital meters, charts or scopes in addition to memory devices such as computer hard drives and microprocessors. Nearly 2/3 of the time is spent on an approved team project that produces experimental measurements, which adds knowledge or understanding to some theoretical concept or rhetorical inquiry. Course is structured so as to qualify as a capstone for cognate mechanical engineering students. Others may use it as a technical elective.

Textbook:

References:
2. Measurement and Instrumentation in Engineering by Francis S. Tse and Ivan E. Morse, Marcel Decker, Inc.
3. Sensors Volumes 1 thru 6, Edited by W. Gopel, J. Hesse, and J. N. Zemel, Verlagsgesellschaft mbH, Germany
5. www.vishay.com, Vishay International, Inc. Valley Forge, PA

Coordinator:
Henry Kowalski, Professor of Engineering Mechanics

Course Learning Objectives

Upon completion of this course; the students will have completed assignments that demonstrate they are capable of:
1. Identifying the three fundamental components of a measuring system. [PO’s: a, k]
2. Stating the historic allegory and subsequent legal authority to control measurements.
3. Identifying the legal standards currently in use domestically and internationally, cite their advantages, limitations and conversions. [PO’s: g, j]
4. Recognizing the importance and practicality of reporting meaningful numerical data precisely and significantly. [PO’s: b, g, n]
5. Identify error, bias, precision, uncertainty, and confidence in data representation and apply appropriate stochastic procedures to experimental data. [PO’s: a, b, e]
6. Representing data in appropriate and meaningful graphical representation. [PO’s: g]
7. Selecting appropriate software to quantify time related characteristics. [PO’s: k, m]
8. Identifying the characteristics of a first and second order measurement system. [PO’s: k, m]
9. Ascertaining the fundamental sensing principle of basic transducers. [PO’s: a, k, m]
10. Specifying either a current or typical voltage circuit for the second stage of a measuring system along with any necessary amplification, attenuation or filtering. (PO’s: a, c, k, m)
11. Specifying a measuring system’s termination state. [PO’s: a, c, k, m]
12. Write a proposal formulating a specific measuring system designed to gain an understanding that strengthens, supports, or quantifies some theory or rhetorical question. [PO’s: b, c, k, n]
13. Identify the costs, safety issues and ethical concerns associated with the measuring system designed in learning objective 12. [PO’s: j]
14. Devise and execute a timetable to implement the measurement system designed in learning objective 12 within a specific time frame and in the context of a team effort.
15. Organize and complete a schedule of activities and responsibilities to implement the measuring system designed in learning objective 12.
16. Identify and acquire needed resources including sources of pertinent information online through the Internet in order to complete the measuring system formulated in learning objective 12. [PO’s: i, j]
17. Present a formal report in electronic format of the results from the measuring system including at least the team’s observations, conclusions and recommendations. [PO’s: b, g, n]

Schedule:
Three sessions per week of 120 minutes each (1/3 of course or 10 sessions of lecture - discussion followed by 2/3 of course or 20 sessions of laboratory experiences)

Computer Usage:
PC based software - primarily Microsoft Word and Excel, and MATLAB

Laboratory project:
Group project that adds understanding to theory or a rhetorical inquiry.

Relationship to Professional component:
2/3 (67%) of the course is a capstone experience -
1 Credit of Engineering Science and 3 Credits of Engineering Design

Prepared by: Henry Kowalski Date Prepared: 1/12/05
Designing components that are safe and reliable requires efficient use of materials and assurance that failure will not occur during the operating life of the component. Even still, components do fail. In this course, students will be introduced to the techniques of designing for life and material considerations involved in that process. In addition, students will also study how to analyze those components which do fail, and evaluate safe-life and remaining life in a design through the study of real-life component design and current failures. Students will also be required to prepare technical reports wherein they discuss the problem, assumptions they have made along with verifications of the assumptions, results of analyses and evaluations, “draw” conclusions, and recommend corrective action (for example, redesign or a change in operating conditions/practices.)

Textbook:

Reference:

Coordinator:
Richard E. Dippery, Jr., Ph.D., PE, Professor of Mechanical Engineering

Course Learning Objectives

1. Develop, set-up, and solve mechanical component problems based upon life and material considerations; and, analytically evaluate failed components including recommended efforts to correct the problem. [PO’s: a, d, e, f, k, l, n.]
2. Develop corrective action for field problems. [PO’s: a, c, d, e, f, k.]
3. Develop and recognize the importance and need for proper design actions via discussions of current, newsworthy, design-related incidents. [PO’s: d, e, f, g, h, j.]

Problem solving
How components work
Basic computer techniques
Stress and life-cycle analysis
Materials processing and behavior
Common sense

**Topics Covered**

1. Stress-strain relations
2. Inelastic stresses
3. Notch effects
4. High cycle fatigue
5. Fracture mechanics
6. Low cycle fatigue
7. Variable amplitude loading
8. Cumulative damage/cycle counting

**Schedule:**
Two sessions per week, two hours each

**Computer Usage:**
Basic skills using MathCAD or equivalent

**Relationship to Professional Component:**
2 hours, Engineering Science
2 hours Design

**Prepared By:** Richard E. Dippery, Jr., Ph.D., PE

March 21, 2006
MECH-516: Introduction to Finite Element Analysis with structural Applications

Elective

Catalog Data

Credit: 4 0 0 4
Prerequisites: MECH-212, MECH-310, MECH-330

The main aim of this course is to introduce the theory of Finite Element Method with applications to simple and real world structural components. Both 1-D and 2-D formulations will be presented and discussed. Commercial F.E.A. codes such as UG, SDRC/I-DEAS, ANSYS, SolidWorks, and/or other CAE packages may be used and integrated to enhance the understanding of the theory presented. Other engineering software application programs such as MATLAB will also be used. Several practical design projects will be assigned during the term of this course.

Textbook:
Textbook (TBA); Handouts and class notes

References:

Coordinator:
Raghu Echempati, Professor Mechanical Engineering

Course Learning Objectives

Upon completion of this course, the students will be able to:
1. Apply the knowledge of Matrix Algebra, Statics, CAE and Solid Mechanics courses to a basic understanding of “What”, “Why” and “How” about the Finite Element Method and its engineering applications [POs: a, c, e]
2. Model a given physical system ready for analysis by the Finite Element Method [POs: a, c, e]
3. formulate the Finite Element equations for 1-D and 2-D finite element problems to analyze simple structures for stresses and deflections [POs: a, c, e]
4. Familiarize with the computational tools used for the FEA process [POs: a, c, k]
5. understand the solution process and the solution method used for structural, thermal and modal analyses [POs: a, c, o, ]
6. Understand the validation process to correctly interpret the results in a view to make any design changes to a component or a subsystem [POs: a, c, o, p]

Prerequisites by Topics:
1. Matrix Algebra
2. Statics and Solid Mechanics
3. Engineering materials
4. Machine Design and Introductory Finite Element Analysis
5. Dynamics (Kinematics & Kinetics, Energy Methods, Basic Vibration Theory)
6. Computer-aided engineering (solid modeling and design communication)

Topics
11. Introduction
12. The Finite Element Method
13. Element and Global Stiffness formulations
14. Plane Stress and Plane Strain
15. Plane stress Triangular Elements
16. Isoparametric Plane stress quadrilateral elements
17. Flat Plate finite elements
18. Axisymmetric finite elements
19. Large deformation mechanics, examples
20. Review

Schedule:
Two sessions per week of 120 minutes

Computer usage:
PC or Unix-based software will be used

Laboratory projects:
Several laboratory exercises that are open-ended involving computer simulation and parametric studies on the modeling and analysis will be assigned.

Relationship to professional component:
This course is 50 % Engineering Design

Prepared by: Raghu Echempati, Professor of Mechanical Engineering
MECH-521: Energy and Environmental Systems Design
Senior Capstone Design Elective

Catalog Data

Credit: 4 0 0 4
Prerequisites: MECH-300, MECH-312, MECH-420
Corequisites: MECH-422

The objective of this course is to provide a comprehensive capstone design experience in the engineering and design of energy systems. Students will work in design teams to complete the design of an energy efficient and environmentally friendly system for use in a residential or commercial building, a power plant, or any other system that requires energy. The course covers one or more of the following energy sources or energy conversion devices: fossil, solar, wind, tidal, hydro, wave, biomass, geothermal, alternative fuels, or fuel cells.

Textbook(s):
None

Coordinator:
Dr. Bassem Ramadan, Professor of Mechanical Engineering

Course Learning Objectives

Upon completion of this course the student will be able to perform one or more of the following:
1. Calculate heating loads in buildings [PO’s: a,c,e,h,k]
2. Calculate heat gains from solar radiation using ASHRAE’s method [PO’s: a,c,e,h,k]
3. Calculate cooling loads using heat gains from transmission heat, solar heat gains, lighting, equipment, people, and infiltration air [PO’s: a,c,e,h,k]
4. Perform solar radiation analysis to determine solar incident beam and diffuse radiation using solar angles [PO’s: a,c,e,h,k]
5. Analyze solar flat plate collectors to determine the amount of heat available to heat a fluid flowing in the collectors [PO’s: a,c,e,h,k]
6. Analyze wind turbines and build scaled models to determine wind power and energy available for power generation [PO’s: a,c,e,h,k]
7. Design renewable energy systems including geothermal and energy from ocean waves [PO’s: b,c,d,f,g,i,j,k,n]
8. Design energy efficient buildings using renewable energy sources [PO’s: b,c,d,f,g,i,j,k,n]
9. Design Energy recovery systems [PO’s: b,c,d,f,g,i,j,k,n,m,p]
10. Design energy conversion systems [PO’s: b,c,d,f,g,i,j,k,n,m]
11. Design energy efficient systems such as engines, compressors, turbines[PO’s: b,c,d,f,g,i,j,k,p]

Prerequisites by topic:
1. Thermodynamics, fluid mechanics, heat transfer
2. Statics, Dynamics
3. Design of Mechanical Systems

**Topics**

1. Psychrometrics
2. Heating/Cooling Load Calculation
3. Solar Radiation
5. Energy Recovery (Thermal to Mechanical, Thermal to Electrical, Mechanical to Electrical)
6. Alternative Fuels (Hydrogen, Ethanol, Methanol, Bio-fuels)

**Schedule:**
Two 2-hour sessions per week, 120 minutes each

**Computer usage:**
Basic computer skills, MSWord, MSExcel, MATLAB, or any specialized software needed such as EnergyPlus, ANSYS, IDEAS

**Laboratory projects:**
None

**Relationship to professional component:**
Four credits Engineering Design

**Prepared by:** Bassem Ramadan, 2/10/2009
MECH-522: Engineering Analysis
Elective
Catalog Data

Credit: 4 0 0 4
Prerequisites: MATH-204, MATH-305, MECH-330, MECH-420

The objectives of this course are to introduce the student to various analytical and numerical methods used in the analysis, design, and solution of engineering problems. Comparisons with analytical methods and why these methods cannot be used to solve all types of “real-life” engineering problems will be presented. The theory and application of various numerical methods will be introduced. Applications to real-world mechanical and fluid-thermal systems will be performed. Commercial computational codes such as: FLUENT, ANSYS, SDRC/I-DEAS, and MSC/NASTRAN may be utilized.

Textbook:

Coordinators:
Bassem Ramadan, Professor of Mechanical Engineering

Course Learning Objectives

Upon completion of this course, the students will be able to:
1. Solve ordinary homogeneous differential equations using analytical methods [PO’s: a,e,k]
2. Solve ordinary non-homogenous differential equations using analytical methods [PO’s: a,e,k]
3. Apply the solution of ordinary differential equations to engineering systems such as: spring-mass systems with and without damping [PO’s: a, c, e, i, j]
4. Perform matrix operations: addition, multiplication, and inversion, determinants (Cramer’s rule) and Gauss elimination methods to solve systems of linear algebraic equations [PO’s: a, k]
5. Use matrices to solve a system of ordinary differential equations to determine eigenvalues and eigenvectors [PO’s: a,c,e,i,j]
6. Solve partial differential differential equations using the method of separation of variables to solve engineering problems involving wave motion, or heat diffusion, or fluid flow [PO’s: a, e, i, j]
7. Perform numerical differentiation, integration, and interpolation [PO’s: a,e,k]
9. Determine the solution of partial differential equations using finite differences [PO’s: a,e,i,k].
10. Apply numerical methods to the solution of the diffusion equation, wave equation, and Laplace’s equation [PO’s: a, c, d, e, i, k]
**Schedule:**
Two sessions per week of 90 minutes or one 3-hour session.

**Computer usage:**
Unix and NT based commercial codes such as Fluent, SDRC/I-DEAS and MSC/NASTRAN.

**Relationship to professional component:**
Two credits of Engineering Science and two credits of Engineering Design

**Prepared by:** Bassem Ramadan

**Date:** 4/7/2003
MECH-523 Applied Computational Fluid Dynamics
Elective

Catalog Data

Credits: 4 0 0 4
Prerequisites: MECH-320, MECH-322, MATH-203 and MATH 204, or MATH 305, MECH 522 can replace all the MATH requirements, or permission of instructor

The course includes solution methods to the Navier-Stokes equations in a discrete domain. Grid generation, coordinate transformation, discretization, explicit, implicit, semi-implicit, a variety of algorithms, post-processing, and interpretation of results are discussed. Solution techniques for compressible and incompressible flows, their applicability, robustness, and limitations are covered. External and internal flows with and without chemical reactions are also introduced. The learning process involves hands-on experience on grid generation, setting up a CFD code, post-processing, and a thorough discussion on the results. The students will work on a final project that is a practical problem of significant magnitude and importance to industry. This work must be publishable in a student-level peer reviewed journal (AIAA Student Journal, ASEE, etc.) or presentable in a conference.

Textbook:

References:
Homayun K. Navaz Applied Computational Fluid Dynamics

Coordinator:
Homayun Navaz, Professor of Mechanical Engineering

Course Learning Objectives

Upon completion of this course, “Applied Computational Fluid Dynamics”, the student will be able to:
1. Generate computational grid for the problem in hand [PO’s: a, e, i, j]
2. Set up any CFD program to do a job [PO’s: a, c, e, i, j, k, l, m, o]
3. Set up correct boundary condition for any problem [PO’s a, e, m]
4. Run CFD Codes to convergence [PO’s: e, h, i, j, k, m]
5. Produce graphical representation of results (Post-processing) [PO’s: e, h, i, j, k, m]
6. Utilizing JANNAF (Joint Army NASA Navy Air Force) standard numerical tools to produce solution for practical problems with chemical reactions [PO’s: c, e, i, j, k, m, l, o]
7. Interpretation of simulation results [PO’s: i, j, k, o]
8. Understand the Necessity of experimental validation with available data in the literature
   [PO’s:  b, d, g, h, j, k, m, o]
9. To be able to successfully complete a project in team environments [PO’s:  d, g]

**Topics**

1. General Discussion, Concepts, Layout of the Course
2. Derivation of the Navier-Stokes Equations, Discussion of the Fully Conserved Form, Inviscid and viscous fluxes
3. From Boundary Layer Equations to Full Navier-Stokes and Corresponding Applications
4. Behavior of the Navier-Stokes Equations - Classification of PDE’s
5. Stability Analysis
6. Discretization Methods
7. Explicit and Implicit Schemes
8. Grid Generation and Coordinate Transformation
9. Characteristics and Boundary Conditions
10. Steady-State and Time-Dependent Algorithms
11. Discussion of Algorithms for Incompressible Flows
12. ADI Method
13. Upwind Algorithms
14. Advanced Topics in CFD and Multi-Species Flows
15. Navier-Stokes for Multi-Species Flows

**Schedule:**
Two days of two-hour classes. Three lecture hours and two hours of hands-on experience in the computer lab

**Computer Usage:**
Continuous usage of computer laboratories
Software: ©Fluent, ©ROYA, ©GRIDGEN, ©Tecplot

**Design Project**
Solving a problem of practical value that is publishable in a journal (Usually AIAA Student Journal)

**Relationship to Professional Component:**
This course is 80% engineering science and 20% engineering design.

**Prepared by:**
Homayun Navaz, Professor of Mechanical Engineering
MECH-526. Fuel Cell Science & Engineering
Elective

Catalog Data

Credit: 4 0 0 4
Prerequisites: CHEM-237, EE-210 or MECH-231, MECH-340 or Professor’s permission

This course is an introduction to fuel cell systems and their applications. It is intended for students in the mechanical and electrical engineering, and chemistry specialties. The course lecture will cover the five main types of fuel cells and their operational parameters and applications, efficiency and open circuit voltages. Other topics include: fuel cell systems, compressors, fans, blowers, pumps, DC voltage regulation and voltage conversion. An emphasis is placed on fuel production methods, storage and reformation techniques. Codes and standards for safe handling of fuels will be emphasized and also laws regulating the transportation of hazardous material contents of these devices. The laboratory exercises will include the effect of current density on stack voltage, the effect of stack temperature on the stack power output and the effect of hydrogen flow rate on the power output. Practical projects will include introduction of fuel cell stacks into various devices such as: a golf-cart, E-bicycles, laptops, toys, road signs, etc.

Textbook(s):

References:

SAE publications 1999-2006

Coordinator:
Dr. Etim U. Ubong, Associate Professor of Mechanical Engineering

Course Learning Objectives

1. Identify the electrolytes, temperature range and operation of PEMFC, DMFC, AFC, PAFC; MCFC, SOFC, and DMFC. [PO’s: a, e, h, j, i].
2. Analyze the efficiency and open circuit voltages of a fuel cell [PO’s: a, b, e, k].
3. Identify the fuel cell over-voltages: activation, ohmic, crossover and concentration losses and apply the Nernst/Butler Vollmer equation [PO’s: a, b, e, m].
4. Apply fuel cell equations to compute the mass flow rates of reactants, heat generated and water produced in a hydrogen fuel cell [PO’s: a, c, e, k, m].
5. Analyze physical compressor problems as applied to fuel cell systems [PO’s: a, b, e, h, k, n].
6. Demonstrate the systematic approach in reforming various types of fuels to obtain hydrogen and reformates, and also hydrogen storage techniques. [PO’s: a, h, k, l, m].
7. Develop an in-depth understanding of safety and regulatory issues regarding transportation, storage and onboard transportation of FC devices in passenger aircrafts and mass transportation systems. [PO’s: a, f, h, i, j, n]

**Topics**

1. Hydrogen fuel cells- introduction, types, basic principles
2. Efficiency and open current voltage
3. Operational fuel cell voltages, formulas
4. Proton exchange membrane fuel cells
5. Alkaline Electrolyte fuel cells
6. Medium and High temperature fuel cells, PAFC, MCFC, SOFC
7. Fueling fuel cells
8. Hydrogen production and storage
9. Compressors, turbines, fans, blowers, pumps
10. Laboratory exercises
11. Safety, codes and standards

**Schedule:**
Two 120-minute sessions per week

**Computer usage:**
Use of FC software to simulate fuel and oxidant flow rates and predict various processes occurring in the cell. Use of FEMLAM software to simulate heat and mass flow through the gas diffusion media and membrane electrode assembly.

**Laboratory projects:**
Five laboratory exercises using: Hydrogenics, Heliocentris Micro PEM fuel cell and DMFC single cell equipment, Heliocentris F-50 10-cell stack ~40W, and a multi-station-SERC test bench using a single cell, 200 W stack; and 1 kW stack.

**Relationship to professional component:**
Two credits of Engineering Science and two credits of Engineering Design.

**Prepared by:** Dr. Etim U. Ubong Date 09/09/05
MECH-527 Energy and the Environment
Elective

Catalog Data

Credits: 3 1 0 4
Prerequisites: None
Co-requisites: None

This course covers energy conversion and conservation, fossil fuels, renewable and biofuels, solar, geothermal and nuclear energy, alternative energy (wind, water, biomass), hydrogen as an energy carrier, historical context of the technology, the role of energy in society (economic, ethical, and environmental considerations), energy forecasts and the trend toward a hydrogen economy. Public policy, global warming and CO₂ footprints and offsetting are also discussed. A windmill laboratory experiment is a major component of this course.

Textbook:

Reference:
Fanchi, J. R., “Energy Technology and Directions for the Future”, 2004

Coordinator:
Ahmad Pourmovahed, Professor of Mechanical Engineering

Topics

1. A Brief History of Energy Consumption
2. Energy Conversion and Conservation
3. Fossil Energy, Nuclear Energy
4. Solar Energy, Geothermal, Wind and Water
5. Biomass and Synfuels, Midterm Exam
6. Hydrogen – An Energy Carrier
7. Electricity Generation and Distribution
8. Energy and the Environment
9. Laboratory Experiment
10. Energy Forecasts, Public Policy and Global Warming
11. Final Exam
Prepared by: Ahmad Pourmovahed, Professor of Mechanical Engineering
MECH-529 Design and Modeling of Fuel Cell Systems
Elective

Catalog Data

Credit: 4 0 0 4
Prerequisites: MECH-322, MECH-420
Co-requisites: MECH-422, MECH-526

A fuel cell is an electrochemical device that directly converts energy from fuels into electrical power. It has the potential for highly efficient and environmentally friendly power. Recently emphasis has been placed into the development of fuel cell systems for power sources including portable, APU, and stationary applications. The fundamental principles applied to fuel cells including the relevant electrochemistry, thermodynamics, and transport processes will be reviewed in this course. The primary focus will be on fundamental principles and processes in proton exchange membrane fuel cells and solid oxide fuel cells including modeling of both types of cells. An introduction to fuel cell stack design and system integration will be presented, in which the analysis and optimization of various components will be discussed. A survey of the cutting-edge issues including the future direction of fuel cell technology will also be conducted. Class projects will focus on the design of a fuel cell system for an application chosen by the students where teamwork will be emphasized. This course is designed to provide the student with the know-how to design a fuel cell system for a specific application of power generation.

Textbook:

References:
*ASME Journal Fuel Cell Science and Technology*
*Journal of Power Sources*
*Journal of The Electrochemical Society*

Coordinator:
Dr. Gianfranco DiGiuseppe, Assistant Professor of Mechanical Engineering
Course Learning Objectives

1. Identify the different fuel cells and their operating conditions [PO’s: a, e, h, j, i]
2. Understand the role that thermodynamics and efficiency plays in the operating voltage of fuel cells and stacks [PO’s: a, b, e, k]
3. Identify the fuel cell resistance losses such ohmic, kinetics, diffusion, fuel maldistribution, and concentration losses [PO’s: a, b, e, m]
4. Apply the fundamental laws to fuel cell systems such as mass, energy, and momentum balances [PO’s: a, c, e, k, m]
5. Analyze subcomponents that make up a fuel cell system such as fans, pumps, compressor, and turbines [PO’s: a, b, e, h, k, n]
6. Identify the different types of fuels that can be used in fuel cell system including reforming techniques. [PO’s: a, h, k, l, m]
7. Develop an understanding of the electrical output from a fuel cell system, including inverters, converters, and electric motors [PO’s: a, f, h, i, j, n]

Schedule:
Two 120-minute sessions per week. Terms Offered: Fall/Winter

Computer Usage:
Assignments requiring the use of software such as Unigraphics, MATLAB/Simulink, and/or COMSOL to design stacks, to simulate fluid flow, heat and mass transfer, and electrical flow in fuel cell systems.

Design Projects:
Design projects solving current technical problems involving fuel cell systems. Project must be of practicable value that may be published.

Relationship to professional component
This course is 40% engineering science and 60% engineering design

Prepared by: Dr. Gianfranco DiGiuseppe  Date 03/18/08
MECH-540 Introduction to Internal Combustion Engines
Elective
Catalog Data

Credit: 4 0 0 4
Prerequisites: MECH-320
Co requisite: None

The fundamentals of internal combustion engines (ICE) is an introduction to Engine design with topics that include: air capacity, engine vibration, kinematics and dynamics of the crank mechanism, air cycles, combustion, petroleum and alternative fuels, engine electronics and fuel cells. Automotive emissions, government standards, test procedures, instrumentation, and laboratory reports are emphasized.

Textbook(s):

References;
Willard W. Pulkrabek, Internal Combustion Engines, Prentice Hall, Inc.

Coordinator:
Etim Ubong, Associate Professor of Mechanical Engineering

Course Learning Objectives

On completion of the course, the student of internal combustion engines will be able to:
1. Demonstrate extensive mastery of the fundamental principles which govern the design and operation of internal combustion engines as well as a sound technical framework for understanding real world problems. [PO’s: a, b, c, e, h, k].
2. Analyze the physical engine operating parameters: brake torque, brake power, mechanical efficiency, mean effective pressure, volumetric efficiency, fuel conversion efficiency, compression ratio, emissions, etc. [PO’s: a, c, e, h, k].
3. Analyze and comprehend the influence of configuration, firing order, inertia forces, induction distribution on engine balance. Understand various methods of balancing single and multi-cylinder engines [PO’s: a, e, h, k]
4. Analyze the ideal models of an engine (Otto and Diesel cycles) and the thermodynamic relations for engine processes [PO’s: a, c, e, h, k]
5. Apply various methods of fluid motion within the cylinder: swirl, tumble and squish to improve engine performance [PO’s: a, c, e, k]
6. Comprehend combustion in spark ignition and diesel engines including how novel techniques: gasoline direct injection principle, homogeneous charge ignition engine are accomplished in internal combustion engines [PO’s: a, b, c, e, k].
7. Understand engine electronics (engine electronic management system). [PO’s: a, b, c, d, h, k]
8. Apply the fundamental principles of combustion characteristics of fossil fuels to understand the combustion characteristics of alternative fuels into engines and study fuel cells and its components. [PO’s: a, b, c, e, k]
9. Apply modern measurement techniques and test methods to analyze engine processes [PO’s: a, b, e, k, l].
10. Identify the environmental issues and extent of the problem of pollutant formation and control in internal combustion engines related to various methods of power production and the government legislation. [PO’s: a, b, c, e, k]
11. Communicate test outcomes effectively, orally and in writing [PO’s: b, c, g, k]

Schedule:
Two sessions per week of 120 minutes (2 hrs of lecture plus 2 hrs in the laboratory)

Computer usage:
Basic Computer Skills (ISOPLOT, MS Word, MicroSoft Project, Excel)

Laboratory projects:
One experiment and a laboratory report in every laboratory session.

Assignments for Laboratory:
1. Engine disassembly/assembly/ Instrumentation
2. Engine Energy Balance
3. Engine Power vs. Air Rate
4. Engine Balance & Vibration
5. Valves Flow
6. Engine Performance
7. No laboratory
8. Fuel Cell
9. Engine Electronics, emissions

Relationship to professional component:
This course is 100 % Engineering Science

Prepared by: Etim Ubong
MECH-541 Advanced Automotive Power Systems
Elective

Catalog Data

Credit: 4 0 0 4
Prerequisites: MECH-540
Corequisites: none

This course serves to expand student’s knowledge of automotive power systems. Topics covered include, detailed thermodynamic cycle analysis of various power cycles, emerging alternative fuels and power systems for automotive use(current topics include high-blend alcohol/gasoline fuels, gasoline direct injection(GDI) engines, hybrid electric Powertrains, and fuel-cells). Students are also expected to work on design projects which are determined by the instructor. Students are expected to work on projects leading to the development of power systems.

Textbook(s):
Departmental developed handout notes are used.

References:


Coordinator(s):
Gregory W. Davis, Professor, Mechanical Engineering

Course Learning Objectives

1. Students will demonstrate the ability to perform engine performance calculations. [PO’s: a, b, e, k, l, m]
2. Students will demonstrate the ability to work in groups to mathematically model various engines, including the effects of intake and exhaust conditions in order to design a new system. [PO’s: a, c, d, e, g, k, l, m]
3. Students will demonstrate the ability to work in groups designing and conducting laboratory experiments. [PO’s: a, b, c, d, e, g, k, l, m, n]
4. Students will demonstrate an understanding of the emissions formation and control processes including the effect of changing operating conditions. [PO’s: a, e, f, h, j, l]
5. Students will demonstrate an understanding of alternative fuels and power systems and their effects on the environment. [PO’s: a, e, f, h, j, k, l]
6. Students will be exposed to professional organizations through the use of field trips. [PO’s: f, h, i, j]
7. Students will demonstrate the ability to work on a topic which is relevant to industry. [PO’s: f, h, i, j]
Prerequisites by topic:

1. Thermodynamic laws and processes
2. Introductory Otto cycle analysis.
3. Introductory Diesel cycle analysis.
4. Introductory level laboratory experience.

Topics

1. Air Standard Engine Cycle review
2. Development of engine testing and performance equations.
3. Extension of Air Standard models to include exhaust and intakes.
4. Mathematical models used to predict effects of various operating parameters.
   Introduction to alternative power systems.
5. Emissions formation and control.
6. Introduction to alternative fuels.
7. Professional field trips.
8. Design and execution of engine experiments
9. Work on contemporary projects

Schedule:
Two 120 minute sessions per week.

Computer usage:
5-6 assignments requiring the use of spreadsheet, equation-solvers, etc.

Laboratory projects:
3 projects using automotive engine test equipment.

Relationship to professional component:
50% Engineering Science, 50% Engineering Design.

Prepared by: G. Davis
Date: 6/29/2009
MECH-542 Chassis System Design
Elective

Catalog Data

Credit: 4 0 0 4
Prerequisites: MECH-330

The objective of this course is to provide a comprehensive experience in the area of automotive chassis engineering. Students will work in teams to complete a chassis design project applicable to passenger cars or light trucks. The course covers tires and wheels, brakes, suspensions and steering. A vehicle system approach is used in learning and applications and the logic of vehicle dynamics and the science of improvement are integrated into the course content. Professional computer aided engineering tools are introduced and applied in areas of suspension design and overall vehicle dynamic performance.

Textbook:

References:

Coordinator:
Prof. Richard R. Lundstrom, Professor of Mechanical Engineering

Course Learning Objectives

Upon completion of the course, “Chassis System Design”, the student will be able to:
1. Given a vehicle, identify automotive chassis anatomy and architecture. [PO’s: c, i]
2. Given basic vehicle data, predict (calculate) weight distribution parameters. [PO’s: a, e, k]
3. Given braking performance metrics predict (calculate) vehicle brake system design parameters. [PO’s: a, c, e, k]
4. Given steering performance metrics, predict (calculate) vehicle steering system design parameters. [PO’s: a, c, e, k]
5. Given ride and handling performance metrics, predict (calculate) vehicle suspension system design parameters. [PO’s: a, c, e, k]
6. Given chassis system performance metrics and professional vehicle CAE software, perform a case study design analysis for an existing vehicle. [PO’s: a, c, e, k]

Prerequisites by Topic:
1. dynamic system analysis, including vibrations
2. Basic computer skills (MS Word and EXCEL)

**Topics**

1. Vehicle and Chassis System Architecture and Anatomy
2. Vehicle Weight Distribution and Tire Patch Forces Under Steady Acceleration, Braking & Cornering
3. Low Speed Steering
4. Brake System Performance and Design Analysis
5. Ride Performance and Suspension System Design Analysis
6. Handling Performance and Suspension System Design analysis
7. Case Study Design Analysis (Term Project)

**Schedule:**
Two Learning Blocks Per Week of 120 Minutes Each

**Prepared by:** Richard Lundstrom
MECH-544 Introduction to Automotive Powertrains
Elective
Catalog Data

Credit: 4 0 0 4
Prerequisites: MECH-212
Corequisites: MECH-312

An introduction to the performance of motor vehicles and the design of automotive power transmission systems. Topics covered include, loads on the vehicle, evaluation of various engine and vehicle drive ratios on acceleration performance and fuel economy, manual transmission design, and automatic transmission design.

Textbook(s):
Hoff, C. J., Davis, G. W., “Introduction to Automotive Powertrains.”

References:

Coordinator(s):
Gregory W. Davis, Professor, Mechanical Engineering
Craig J. Hoff, Professor, Mechanical Engineering

Course learning objectives:

1. Students will demonstrate the ability to calculate road loads on a motor vehicle. [PO’s: a,c,e,j]
2. Students will demonstrate the ability to select appropriate gear ratios for a given engine/chassis combination. [PO’s: a,c,e,j]
3. Students will demonstrate the ability to mathematically model the acceleration of an automobile. [PO’s: a,c,e,j]
4. Students will demonstrate the ability to mathematically model the fuel economy of an automobile. [PO’s: a,c,e,j]
5. Students will demonstrate an understanding of the operation of automotive clutches. [PO’s: a,c,e,j]
6. Students will demonstrate an understanding of the operation of manual transmissions. [PO’s: a,c,e,j]
7. Students will demonstrate an understanding of the operation of automatic transmissions. [PO’s: a,c,e,j]
8. Students will demonstrate the ability to use modern automotive test equipment. [PO’s: a,b,d,g]

Prerequisites by topic:
1. Torsional stress and angle of twist in circular bars.
2. Flexure formula.
3. Fatigue
4. Stress concentrations.
5. Rectilinear motion.
7. Dynamic equilibrium.

**Topics**

1. Vehicle required tractive effort and horsepower.
2. Torque and horsepower available characteristics of various power sources.
3. Selection of vehicle axle and transmission ratios.
4. Mathematical models used to predict vehicle acceleration.
5. Mathematical models used to predict vehicle fuel economy.
7. Design considerations for automatic transmissions
8. Examinations

**Schedule:**

Two 120 minute sessions per week.

**Computer usage:**

5-6 assignments requiring the use of spreadsheet, equation-solver, etc. Additionally, each student has a project where they utilize and write their own PC time-based automotive performance simulation program and use it to design an optimum vehicle drivetrain.

**Laboratory projects:**

6-8 projects using automotive test equipment; inertial dynamometer, chassis dynamometer, fifth-wheel, etc.

**Relationship to professional component:**

Two Credits (50%) of Engineering Science, Two Credits (50%) of Engineering Design.

**Prepared by:** G. W. Davis/C. J. Hoff  
**Date:** 03/27/2009
MECH-545 Hybrid Electric Vehicle Propulsion
Elective

Catalog Data

Credit: 4 0 0 4
Co requisites: MECH-430 or EE-432 or Instructor Permission

This course is an introduction to the principles of hybrid electrical vehicle propulsion systems for Mechanical and Electrical Engineering students. A major emphasis of the course will be to broaden the mechanical engineering student’s knowledge of electrical engineering so that he/she can understand the fundamentals of electrical motors, electrical motor controls, and electrical energy storage systems. The course is also intended to strengthen the knowledge of electrical engineering students relative to automotive powertrain design. With this background, the integration of these hybrid electric components into the hybrid electric vehicle powertrain system will be studied, including electric energy storage (Batteries, flywheels, ultra-capacitors) and electrical energy production-fuel cells. Relevant codes and standards will be emphasized.

Textbook(s):
In addition to an extensive set of course handouts, the following texts are used:

Recommended: MATLAB & Simulink Student Version Release 2008 (Direct: $99)

Coordinator:
Craig J. Hoff, Professor, Mechanical Engineering

Course Learning Objectives

1. Students will demonstrate the ability to calculate road loads on a motor vehicle. [PO’s: a, e, n]
2. Students will demonstrate an understanding of the advantages & disadvantages of hybrid electric vehicles. [PO’s: a, c, e, j, k, n]
3. Students will use computer software to predict the fuel economy of various powertrain configurations. [PO’s: a, c, e, j, k, n]
4. Students will demonstrate an ability to design a vehicle system using electrical motors. [PO’s: a, c, e, j, k, m]
5. Students will demonstrate an understanding of the operation of electrical motor controllers. [PO’s: a, e, j, k, n]
6. Students will demonstrate an understanding of electrical energy storage systems, including batteries, flywheels, and fuel cells. [PO’s: a, e, j, k, m]
7. Students will demonstrate an ability to design a hybrid electrical vehicle using the above technologies. [PO’s: a, c, e, j, k, n]
8. Students will demonstrate the ability to use modern automotive test equipment. [PO’s: a, e, k]

**Prerequisites by topic:**
1. Road load forces on an automobile
2. Dynamic equilibrium
3. Basic circuit theory
4. Gears
5. Rectilinear motion
6. Mass moment of inertia
7. Modeling with Matlab and Simulink

**Topics covered:**
1. Hybrid vehicle introduction – components, layout, operation (2 hours)
2. Road load calculations and vehicle required tractive effort and horsepower (2 hours)
3. Conventional vehicle characteristics and engine/powertrain mapping (6 hours)
4. Fuel economy considerations & modeling (2 hours)
5. Electrical engineering fundamentals (2 hours)
6. Electrical motors – design characteristics & powertrain mapping (8 hours)
7. Electrical energy storage (batteries, flywheels, ultra-capacitors) (6 hours)
8. Electrical energy production (fuel cells) (2 hours)
9. Electrical motor controllers - function, hardware & control strategy (4 hours)
10. Computer modeling of hybrid vehicles w/Simulink & ADVISOR (2 hours)
11. Laboratory Experiences/Exams (2 hours)

**Schedule:**
Two 120 minute sessions per week.

**Computer usage:**
10-12 assignments requiring the use of spreadsheet, equation-solver, or commercial vehicle modeling software

**Laboratory projects:**
1-2 projects using automotive test equipment

**Relationship to professional component:**
Three Credits (75%) of Engineering Science, One Credit (25%) of Engineering Design.

Prepared by: Craig J. Hoff  Date: 01/30/2009
MECH -546 Vehicle System Dynamics
Elective

Catalog Data

Credit: 4 0 0 4
Prerequisites: Senior standing and MECH-330
Corequisites: None

This course begins with an introduction of Ride and Handling concepts followed by the study of mechanics of pneumatic tires. Mathematical models for ride and handling are derived and presented. Vehicle ride and handling design criteria are demonstrated. Chassis design factors (CDF) and their effect on ride and handling are emphasized. Static, Dynamic and proving ground testing will be presented and demonstrated. Computer simulation design using software (e.g. MATLAB, Mathcad, ADAMS Working model, SSnap, Car-Sim and others) will be used as an integral part of the course and for the two projects assigned during semester. Overview on state-of-the art technology and the latest developments in the field of vehicle systems dynamics (e.g. SAE, ASME publications) will be part of this course.

Textbook(s):
Lecture notes by the instructor

References:
“Fundamentals of Vehicles Dynamics” By Thomas D. Gillispie SAE Book.” Race Car Vehicle Dynamics” By Miliken SAE – Book SAE “Handbook of Automotive Engineering” Edited by Haus-Herman Braess and Ulrich Seiffert SAE International–Transactions (To be listed during the course)

Coordinator(s):
Pinhas Barak, Professor of Mechanical Engineering

Course Learning Objectives:

1. a) Ability to obtain the mathematical models of vehicle of increasing complexity for ride and handling analysis, synthesis and design. [PO’s: a, b, c, e, k]
b) Apply scientific tools to the development and transformation of physical models to mathematical and computer simulation models [PO’s: a, b, c]
c) Ability to perform numerical analysis of vehicle models by means of computer simulation. [PO’s: a, b, c, e, k]
2. Ability to estimate and predict the effect of changing Chassis Design Factors (e.g. Weight, dimension, stiffness, damping and so forth) on ride and handling criteria. [PO’s: a, b, c, e, k]
3. Ability to analyze and evaluate the performance characteristics for ride quality control and handling behavior of ground motor vehicles. [PO’s: a, b, c, e, k, n]
4. Ability to comprehend the driver-vehicle ground system. [PO’s: a]
Prerequisite by:

1. Basic in kinematics and kinetics of particles and rigid body in 2-D and 3D.
2. Basic concepts in Mathematics such as Differentials equations, linear algebra and so forth.
3. Linear Time Invariant (LTI) equations \( \frac{dX}{dt} = AX + BU, \ Y = CX + DU. \)
4. Basic in Mechanical Vibrations.
5. Deterministic and random test inputs.
6. Use of “MATLAB” for solving LTI equations.
7. Transient and steady state response performance of a first and second order linear system.
8. Eigenvalues, eigenvectors and stability of LTI systems.

Topics

1. Introduction to ride and handling
   Review: Mathematics, Dynamics, Vibrations and System analysis
2. Mechanics of Pneumatic Tires
3. Ride Vehicle Models
4. Ride Characteristics and Criteria
5. Ride Computer Simulation
6. Handling Vehicle Models
7. Handling Characteristics and criteria
8. Handling Computer Simulation
9. Dynamic load transfer: Static, Dynamics and Proving Ground Testing for Ride and Handling
10. Chassis Design Factors (CDF) and their effect on Ride and Handling
11. Ride and Handling projects, concluding remarks, round table discussion and projects clarification

Schedule:
Two lecture sessions (120 minutes each every week) Lab or field trip will be used as necessary during the semester (2 hours lab per one lecture)

Computer Usage:
MATLAB, Working Model, SSnap, MathCAD, MCS – Word, Spread sheet, Car – Sim, CAD drawing of configuration and other software as available.

Relationship to Professional Component:
Two Credits of Engineering Science, Two Credits of Engineering Design

Prepared by: Pinhas Barak Date: April 21, 2008
MECH-548: Vehicle Design Project
Senior Capstone Design Elective

Catalog Data

Credit: 4 0 0 4
Prerequisites: MECH-320, Senior Standing

This course deals with a comprehensive vehicle design experience progressing from problem definition through ride, handling, chassis design, performance analysis to sketches, alternate design, general design, layout drawings, parts list of the chassis, body, suspension power-train and culminating with small-scale model of the vehicle and its subsystems.

Textbook(s):
Lecture notes

References:

Coordinator:
Dr. Mohamed El-Sayed, Professor of Mechanical Engineering

Course Learning Objectives

Objective 1: Creative thinking in automotive design [PO’s: c, d, e]
1.1 Students will be able to brainstorm and think creatively to achieve alternate design solutions.

Objective 2: Teamwork and communication skills [PO’s: d, g, p]
2.1 Students will be able to form teams and work effectively with others to achieve design goals.
2.2 Student will be able to present their ideas, plans and design alternatives in written and oral formats.

Objective 3: Project planning and management. [PO’s: c, d, e, f, g, h, i, j, k, p]
3.1 Student will be able to use project planning tools to plan tasks, timing and coordinate design activities.

Objective 4: Identify automotive systems attributes and design criteria. [PO’s: a, c, e, g, h, i, j, k, p]
4.2 Student will be able to use systematic design process thinking to analyze the conceptualized product attributes and transfer these attributes to design criteria and engineering targets.

Objective 5: Automotive systems simulation and synthesis. [PO’s: a, b, c, h, i, k, l, m, n, o, p]
5.1 Student will be able to apply their education and co-op experiences to simulate the conceptualized product in the intended environment and synthesize to achieve targets and attributes.

Prerequisites by topic:
1. Automotive components and performance
2. CAD Skills
3. Modeling and simulation Skills
4. Senior Standing
5. Basic computer skills

Topics
1. The Automotive Design and Development Process - Team formation and working in teams
2. Brainstorming and creativity in Automotive design - Project selection and Proposal writing
3. Project planning - Proposal in class presentations
4. Automotive Bill of Materials - Analytical and physical Simulations
5. Automotive systems analysis and Integration - Automotive systems synthesis and optimization
6. Writing progress reports - Engineering Ethics
7. Project management - Design progress in class presentations
8. Alternative Designs - Design to Cost
9. Automotive Design for Manufacturability - Automotive Bill of process
10. Automotive products’ assembly and variations - Quality issues in Automotive Engineering
11. Writing final reports - Final design in class presentations

Schedule:
Two sessions per week of 120 minutes

Computer usage:
Basic Computer Skills (CAD, FE Analysis, Automotive Performance Simulation, MathCAD/Working Model/Excel, MS-Word, MS-Project, MS-PowerPoint/or equivalent programs)

Laboratory projects:
One open-ended design project.

Relationship to professional component:
This course is 100 % Engineering Design.

Prepared by: Dr. Mohamed El-Sayed  Date: 03/24/2009
MECH-550: Automotive Bioengineering: Occupant Protection and Safety
Elective

Catalog Data

Credit: 4 0 0 4
Pre-requisites: MECH-310

This course deals with a discussion and application of the following fundamental concepts: (1) an overview of Federal Motor Vehicle Safety Standards; (2) basic anatomy and physiology of the overall human body; (3) introduction to injury biomechanics including rate, load, and acceleration dependent injury mechanisms; (4) overview of injury prevention strategies including a variety of air bags, multipoint restraint systems, and occupant sensing methodologies; (5) the basic structure and function of anthropomorphic test devices; (6) introduction to experimental crash simulation; (7) virtual occupant simulation using MADYMO or similar computational tools.

Textbook(s):

References:
Hybrid III: The first human-like crash test dummy, by Mertz and Backaitis, Society of Automotive Engineers, 1st Edition

Coordinator:
Patrick Atkinson, Associate Professor of Mechanical Engineering

Course Learning Objectives

1. Understand basic human anatomy and physiology terms and concepts [PO’s: a, i]
2. Understand the basis of tissue biomechanics and injury [PO’s: a, h, i, l]
3. Understand the basis for the design of injury prevention strategies in the automotive crash environment [PO’s: h, i, j, k]
4. Understand the basis for experimental crash simulation [PO’s: k, l, s]
5. Understand the basis for virtual occupant simulation during automotive crashes [PO’s: i, l, o]

Topics

1. Introduction, basic anatomy and physiology
2. Tissue mechanics, basic injury biomechanics
3. Basis for injury assessment reference values
4. History and basis for the Hybrid III and SID dummies
5. Design and basis of injury prevention strategies
6. Experimental crash simulation: sled design
7. Experimental crash simulation: instrumentation
8. Experimental crash simulation: sled laboratory
9. Virtual crash simulation: theoretical basis of various codes
10. Virtual crash simulations: frontal crash simulation

Schedule:
Two sessions per week of 120 minutes

Computer usage:
Advanced computer skills (MathCAD/Working Model/Excel/MADYMO)

Laboratory projects:
Several open-ended experimental and computational projects are planned.

Relationship to professional component:
This course is 75% Engineering Science and 25% Engineering Design.

Prepared by: Patrick Atkinson                  Date: March 22, 2006
MECH-551: Vehicular Crash Dynamics and Accident Reconstruction
Elective

Catalog Data

Credit: 4 0 0 4
Pre-requisites: MECH 310, Senior Standing

This course deals with a discussion and application of the following fundamental concepts: (1) 2D and 3D dynamics of vehicular crash, (2) application of linear and angular momentum principles to vehicular impact, (3) application of energy principle to vehicular impact, (4) estimation of crash energy from vehicular crush profile, (5) vehicular crash pulse analysis, (6) occupant kinematics, (7) dynamics of rollover and pole collision, (8) crash data recorder (CDR) analysis, (9) and special topics in accident investigation forensics.

Textbook(s):
Various SAE papers and class handouts/notes

References:
Vehicle Accident Analysis and Reconstruction Methods, Brach and Brach, SAE Int.

Coordinator:
Dr. Massoud S. Tavakoli, Professor of Mechanical Engineering

Course Learning Objectives

Objective 1: Apply basic particle and rigid-body dynamics [PO’s: a, e, k, m]
1.1 The students will be able to use particle and rigid-body dynamics to compute the pre-impact trajectory of a vehicle based on accident scene evidence.
1.2 The students will be able to use particle and rigid-body dynamics to compute the post-impact trajectory of a vehicle based on accident scene evidence.

Objective 2: Apply conservation of linear and angular momentum principles [PO’s: a, e, k, m]
2.1 The student will apply the principle of conservation of linear momentum to relate the pre- and post-impact velocities of a vehicle.
2.2 The student will apply the principle of conservation of angular momentum to relate the pre- and post-impact rotational velocities (pitch, yaw and roll) of a vehicle.

Objective 3: Understand crash and crush energy calculations [PO’s: a, b, e, k, m]
3.1 Apply the principle of conservation of energy to compute the crash energy.
3.2 Compute the crush energy from the deformation profile of a vehicle.

Objective 4: Understand the elements of vehicular crash pulse [PO’s: a, b, e, k, m]
4.1 Analyze a typical vehicle crash pulse to identify maximum acceleration levels and pulse duration.
4.2 Understand the effect design for crash worthiness on crash severity.
4.3 Apply several curve fitting estimations to a typical vehicle crash pulse.
Objective 5: Understand Occupant Kinematics [PO’s: a, e, k]
5.1 Determine occupants’ path with respect to the vehicle interior once a collision has occurred.
5.2 Understand the concept of “ride-down” and its benefits.

Objective 6: Become familiar with several aspects of sensors and data processing in crash testing [PO’s: j]
6.1 The student will learn about accelerometers used in crash testing.
6.2 The student will learn about data filtration and processing in crash testing.
6.3 The student will learn about sensors and signal collected from Anthropomorphic Test Devices.

Prerequisites by topic:
1. Particle and rigid body dynamics principles and concepts
2. Basic trigonometry, sine and cosine rules
3. Newton’s Laws of motion
4. Basics of free body diagrams
5. Basic computer skills

Topics
1. Introduction, basic particle impact dynamics
2. Two-dimensional rigid body impact dynamics – linear momentum principle
3. Two-dimensional rigid body impact dynamics – Angular momentum principle
4. Crash Energy – Conservation of energy principle
5. Crush energy estimation methodologies
6. Crash pulse analysis and estimation
7. Researching NHTSA and other government agency data bases
8. Occupant kinematics
9. Sensors and signal processing
10. Anthropomorphic Test Devices
11. Special topics: tire mark analysis, lamp filament analysis, litigation, etc.

Schedule:
Two sessions per week of 120 minutes

Computer usage:
Advanced computer skills (Working Model/Excel/PCCrash/Motion Analysis)

Laboratory projects:
A mini-sled impact project will be used in conjunction with motion analysis.

Relationship to professional component:
This course is 75% Engineering Science and 25% Engineering Design.

Prepared by: Dr. Massoud S. Tavakoli Date: 2/5/2009
MECH-554: Bioengineering Applications Project  
Senior Capstone Design Elective

Catalog Data

Credit: 4 0 0 4  
Pre-requisites: MECH 300, MECH 310, MECH 312, MECH 350, Senior Standing

This course deals with a comprehensive design experience focusing on a project with direct application to the bioengineering field. The course emphasizes the steps of a typical design process (problem identification, research, and concept generation) culminating in a documentation of the preferred embodiment of the design concept. The conceptual design will then be further developed through the application of sound engineering analysis and tools.

Textbook(s):
None

References:

Coordinator:
Dr. Massoud S. Tavakoli, Professor of Mechanical Engineering

Course Learning Objectives

1. Understand the steps involved in a typical design process [PO’s: c, k]  
1.3 See design as a process rather than an event.  
1.4 Differentiate the various steps of a typical design process.

2. Develop the discipline required for proper implementation of a typical design process [PO’s: c, g, j, k, p]  
2.3 Execute the various steps of the design process in a disciplined fashion without short changing and/or circumventing any of the steps.

3. Apply scientific tools to the development of each design step [PO’s: c, e, k, p]  
3.3 Use design tools such as objective tree to properly define design goals, constraints and scope.  
3.4 Use design tools such as brainstorming, concept tree, abstraction, etc. to generate design concepts.  
3.5 Use design tools such as Pugh’s decision matrix to select from a pool of design concepts.  
3.6 Use design tools such as failure mode effect analysis (FMEA) to generate refine concepts.  
3.7 Use computational tools such as finite elements analysis (FEA) and dynamic simulation software (e.g. Working Model) to develop detailed designs.  
3.8 Use manufacturing tools such as laser scanning, rapid prototyping and CNC machining to fabricate design prototypes.
4. Work in teams and manage an open-ended project with strict deadlines [PO’s: c, f, g]
4.4 Function as members of a design team.
4.5 Manage an open-ended design project.
5. Use written, oral and graphical communication skills effectively [PO’s: g]
5.1 Present design concepts graphically and orally, while documenting their work according to an established set of professional publication guidelines (e.g. SAE, ASME).

Prerequisites by topic:
1. Basic anatomy and physiology terms and concepts
2. Normal and shear stress analysis
3. Basic mechanical properties of metallic and polymeric materials
4. Basic familiarity with microelectronics and instrumentation
5. CAD modeling and finite element analysis

Topics
1. Problem identification
2. Background research using patents, journal articles and commercial literature
3. Concept generation
4. Concept selection and feasibility assessment
5. Detailed Design Proposal
6. Detailed Design Analysis
7. Design Review
8. Finalization of Design
9. Project Presentation

Schedule:
Two sessions per week of 120 minutes each.

Computer usage:
CAD (e.g. Ideas, UG, ProE), dynamic simulation tools (e.g. Working Model), finite element analysis

Laboratory projects:
The entire course consists of an open-ended design project.

Relationship to professional component:
This course is 100% Engineering Design.

Prepared by: Dr. Massoud S. Tavakoli       Date: 2/5/09
MECH-562 Compressible Flow/Gas Dynamics
Elective

Catalog Data

Credits: 3 0 2 4

Prerequisites: MECH-320 (or equivalent), MECH-322, or Permission of Instructor

The course includes the derivation and physical interpretation of the Navier-Stokes
equations for compressible flows. Analysis of one-dimensional flows with discussions on
normal, oblique, and bow shocks. Sound waves and unsteady wave motion are also
covered. The method of characteristics (MOC) is taught and standard JANNAF CFD
codes is utilized to understand the compressible flows and shock formation and behavior.
The study is then further carried out to nozzle flows and jet/shock layer interaction. The
students are required to not only understand the conventional methods used to obtain
solution for compressible flow problems, but also to be able to utilized CFD and
experimental methods to obtain solution for complex problems.

Textbook:
Anderson, A. A., Modern Compressible Flow with Historical Perspective, 2nd edition,

References:
Zucker, R. D., Fundamentals of Gas Dynamics, Matrix Publishing Company

Coordinator:
Homayun Navaz, Professor of Mechanical Engineering

Course Learning Objectives

Upon completion of this course the student will be able to:
1. Understanding of basic concepts in compressible flow and gas dynamics [PO’s: a, b, e, j]
2. Understanding the nature of sound and shock waves [PO’s: a, e, m]
3. Understanding the normal, oblique, and bow shocks [PO’s: a, b, e, m]
4. Understanding the method of characteristics, its application, and practical value [PO’s:c, e, i, j, k, l]
5. Understanding of subsonic, choked flow, supersonic, and hypersonic flows [PO’s: c, e, i, j, k, m, and l]
6. Utilizing JANNAF (Joint Army NASA Navy Air Force) standard numerical tools to
produce solution for practical problems [PO’s: c, e, i, j, k, m, l, o]
7. Interpretation of simulation results [PO’s: i, j, k, o]
8. Validation of numerical solutions with experimental data [PO’s: b, e, h, i, j, k, m, l, o]
9. To be able to successfully complete a project in team environments [PO’s: d,g]
**Topics**

1. Review of essential topics in thermodynamics
2. Navier-Stokes equations - Full conservation form
3. One-dimensional flows
   a. Isentropic relations
   b. Normal shock relations
   c. Sound waves
4. Oblique shocks and expansion waves - Quasi one-dimensional flows
5. Choked flow/Choked jets - Unsteady wave motion
6. Traveling shock waves - Linearized supersonic flows
7. Linearized supersonic flows - Method of Characteristics (MOC)
8. MOC – TDK Code
9. MOC
10. Introduction to transonic and hypersonic flows
11. Review and final exam

**Schedule:**

Two days of two-hour classes. Three lecture hours and two hours of hands-on experience in the computer lab

**Computer Usage:**

JANAAP Standard Codes: TDK, VIPER, ROYA, LTCP

**Laboratory Projects:**

2. Computer Lab on oblique shocks
3. Computer Lab on nozzle flow with shocks
4. Computer Lab on the MOC
5. Computer lab on moving shock waves
6. Computer lab on fuel detonation
7. Computer Lab on transonic/hypersonic flow
8. Design Project

**Relationship to Professional Component:**

This course is 80% engineering science and 20% engineering design.

**Prepared by:**

Homayun Navaz, Professor of Mechanical Engineering
MECH-564 Aerodynamics and Wing Theory
Elective

Catalog Data

Credits: 4 0 0 4
Prerequisites: MECH-320 (or equivalent), MECH-322, MATH-305/MECH-522, or Permission of Instructor

The course includes discussions on fundamentals of inviscid and viscous incompressible flows. Important topics in fluid mechanics such as potential flow, vortices, point sources, and coupling of inviscid and boundary layer flows are covered. Two and three dimensional wings (or airfoils) and some exact solutions to such flow problems are discussed. Semi-analytical methods for disturbance distribution on wings are introduced by perturbation method. The computational Panel method for two and three dimensional aerodynamics problems is discussed. Commercial computer programs are used to solve realistic problems in a three dimensional space.

Textbook:

References:
Aerodynamics of Wings and Bodies by H. Ashley and M. Landahl, Dover Publishing Company, 2002

Coordinator:
Homayun Navaz, Professor of Mechanical Engineering

Course Learning Objectives

Upon completion of this course the student will be able to:
1. Develop understanding of fluid mechanic concepts involved in low speed aerodynamics [PO’s: a, e, k, m]
2. Find basic solutions for simple aerodynamic problems in 1-D and 2-D space [PO’s: a, e, k]
3. Analyze small disturbance propagations in a flow and calculate lift and drag forces [PO’s: a, c, e, k, j, l, m]
4. Find exact and use perturbation method to find semi-exact solutions for an aerodynamic problem involving wings and airfoils [PO’s: a, c, e, k, j, m]
5. Analyzing three dimensional bodies and wings with aerodynamic loads [PO’s: a, c, e, k, j, l, m]
6. Use numerical Panel method to solve complex aerodynamic problems [PO’s: a, e, k, l, n]

Prerequisites by Topic:
1. Any thermodynamics
2. Fluid Mechanics
3. Numerical Methods or Engineering Analysis

Topics

1. Review of essential topics in fluid mechanics (pathline, streamline, streakline, vortices)
2. Navier-Stokes equations - Full conservation form – Inviscid and viscous flows
3. Solution to potential flows
4. Propagation of small disturbances over airfoils
5. Perturbation method and its application in aerodynamics
6. Three-dimensional problems with small disturbances
7. Numerical Panel method
8. Numerical solutions for two dimensional flows
9. Numerical solutions for three dimensional flows
10. Unsteady incompressible potential flows
11. Review and final exam

Schedule:
Two days of two-hour classes, or one day of three-hour class and one day of one-hour computer lab

Computer Usage:
Maple, MATLAB

Laboratory Projects:
Numerous problems to be solved by using computer programs

Relationship to Professional Component:
This course is 90% engineering science and 10% engineering design.

Prepared by: Homayun Navaz, Professor of Mechanical Engineering (2/20/2009)
MECH-570: Computer Simulation of Metal Forming Processes (4-0-4)
Elective

Catalog Data:

Credit: 4 0 0 4
Prerequisites: IME-301, MECH-212, MECH-310, MECH-300

The main aim of this course is to introduce some of the latest techniques for modeling bulk and surface deformation processes through computer simulation. This requires an integration of the knowledge attained in other related courses such as engineering materials, solid mechanics, dynamics and computer-aided engineering. The computer simulations include sheet metal forming operations, rolling, swaging and the other bulk deformation processes. Modern high-speed computer aided design methodology is introduced to study the behavior of the material during metal forming process, including the study of the strain pattern. Standard one-step and incremental software codes such as Quickstamp® and LS-DYNA® will be used for the course. These solution procedures along with limitations of the software will be discussed with emphasis on techniques in an applied manner.

Textbook:
Class notes will be provided, and software online tutorials will be used.

References:
3. DYNAFORM/LS-DYNA Lab manuals.

Coordinator(s):
Raghu Echempati, Professor of Mechanical Engineering

Course Learning Objectives

Upon completion of this course, the students will be able to
1. Understand the benefits of virtual forming and its consequences on the early stages of a product design [PO’s: h, i]
2. Integrate the concepts learned in engineering materials, solid mechanics, dynamics and computer-aided engineering to understand the large deformation processes such as sheet metal forming and bulk metal forming [PO’s: a, k]
3. Understand the difference between the implicit and the explicit integration schemes used in the solution processes [PO’s: a, e, k]
4. Enhance their understanding and correct interpretation of the results of modeling and simulation, and to develop strategies to improve the product and process design based on the results obtained [PO’s: a, e, d, c, h]

Prerequisites by Topics:
7. Basic manufacturing processes
8. Engineering materials (true stress, true strain, plastic behavior of engineering materials)
9. Solid mechanics and introductory finite element analysis (linear analysis)
10. Computer-aided engineering (solid modeling and design communication)

Topics

1. Review and introduction to various metal forming processes
2. Plastic behavior of engineering materials, power law of plasticity
3. Introductory finite element analysis (linear and nonlinear)
4. Basics of sheet metal forming with practical modeling considerations
5. Benefits of virtual forming of bulk deformation processes
6. Discussion of one-step and incremental solvers
7. Discussion of the numerical methods used for modeling large deformation processes (implicit versus explicit integration schemes) and computer codes
8. Pre- and Postprocessing, and solving by use of commercial software
9. Interpretation of results and course review

Schedule:
Two sessions per week of 120 minutes

Computer usage:
PC based software installed in GM PACE Lab, or unix based software installed on blade and/or galaxy servers will be used (UG, DYNAFORM/LS-DYNA, HyperMesh/HyperForm, I-DEAS)

Laboratory projects:
Several laboratory exercises that are open-ended involving computer simulation and parametric studies on the modeling and analysis of nonlinear, large deformation processes will be assigned.

Relationship to professional component:
This course is 100 % Engineering Design

Prepared by: Raghu Echempati Date: March 25, 2009
MECH-584 Plastics Product Design  
Senior Capstone Design Project  

Catalog Data

Credit: 2 0 4 4  
Prerequisites: MECH-300, MECH-310, MECH-312, MECH-580, IME-507  
Corequisites: None

Capstone design class for Plastics Product Design Specialty students. A comprehensive 
plastic product design experience beginning with problem definition which leads to 
material selection and progresses into physical design. Students will perform structural 
FEA and mold filling simulations on solid models. Computing piece price and tooling 
costs will complete the design process.

Textbooks:  
N/A

References:  
1. Material Selection – Thermoplastics and Polyurethanes, Bayer, 1995  
2. Snap-fit Joints for Plastics a design guide, Bayer, 1996  
3. Part and Mold Design – Thermoplastics, Bayer, 2000  
4. Moldflow Plastic Advisers software (ver. 8.1, 2007) online tutorials  
5. Unigraphics NX3 Mold Wizard, EDS course materials

Coordinator:  
Dr. Maciej Zgorzelski, Professor of Mechanical Engineering

Course Learning Objectives

Upon completion of the course the student will be able to:  
1. Design plastic products using CAD/CAE tools. [PO’s: a, c, e]  
2. Select plastic materials. [PO’s:: a, c, n]  
3. Perform structural and mold-filling simulations. [PO’s: a, c, e, k, o, p]  
4. Design mold tooling for injection molding [PO’s: c, e, k, o]  
5. Communicate design results visually; orally and in writing.[ PO’s: g, n, o, p]

Prerequisites by topic:  
1. CAD/CAE skills – solid modeling, finite element analysis  
2. PC skills (word processing, spreadsheets and web).  
3. Plastics’ materials properties  
4. Injection molding equipment and processes.

Topics covered:  
1. Principles of designing from plastics [1 Week]  
2. Creating plastic part solid geometry with UG Nx. [1 Week]
3. Snap-fit joint design and FEA [2 Weeks]
4. Filling simulations and material selection with Moldflow. [1 Week]
5. Mold design in UG NX Mold Wizard [1 Week]
7. Team project [5 Weeks]

Schedule:
Three 120-minute lecture/lab sessions per week.

Computer usage:

Laboratory projects:
Week 1: Course introduction, refresher of UG NX3 solid and surface modeling skills
Week 2: Designing parts from plastics, FEA structural analysis refresher
Week 3: Introduction to injection molding process and equipment simulation using Moldflow Plastic Adviser
Week 4: Introduction to basic functionality of UG NX3 Mold Wizard for tooling design
Week 5: Term project introduction, team formation, discussions
Week 6: Advanced functionality of UG NX3 Mold Wizard, project work
Week 7: Project progress review presentations
Week 8 - 9: Project work
Week 10: Final presentations of project results by team members, discussions
Week 11: Project final report due

Relationship to professional component:
12.5% credits of Engineering Science and 87.5% credits of Engineering Design.

Prepared by: Maciej Zgorzelski, Professor of Mechanical Engineering, 10/6/2008