ME/CEE 1770 Introduction to Engineering Graphics and Visualization (Required)

Catalog Description: ME/CEE 1770 Introduction to Engineering Graphics and Visualization (2-3-3)
Prerequisites or Corequisites: None
Introduction to engineering graphics and visualization including sketching, line drawing, and solid modeling. Development and interpretation of drawings and specifications for product realization.

Textbook: Timothy Sexton, *A Concise Introduction of Engineering Graphics: Theory & Problems*, SDC Publishing. (Text Only)

Topics Covered:

1. Introduction: need for spatial representation and visualization.
2. Drawing projections: (multiview orthographic, isometric, oblique, perspective etc.)
3. Three dimensional representations and model construction processes.
4. Graphic and written requirements for product realization.

Course Outcomes:

Outcome 1: To familiarize students with the elements of 3D visualization and good sketching technique.

1.1Students are able to prepare elementary sketches of 3D objects with correct interpretation of 3D geometry and topology.
1.2 Students are able to interpret and comprehend a sketch.

Outcome 2: To familiarize students with the basic structure and content of engineering drawings.

2.1 Students are able to draw multiview orthographic and other projections including isometric, sectional, true, and perspective.
2.2 Students are able to use 2-D computer-aided design software for basic drafting applications.
2.3 Students are able to properly dimension and tolerance a drawing.
2.4 Students are familiar with common drawing notation.

Outcome 3: To familiarize students with elementary solid modeling and visualization

3.1 Students are able to generate parametric, feature-based solid models from two-dimensional representations.
3.2 Students are able to generate two dimensional views from three dimensional solids.
3.3 Students understand techniques used to generate solid models such as Boolean operations, surface smoothing, and shading. Examples include curve design in two and three dimensions.

Outcome 4: To introduce students to the visual and written requirements associated with product realization.

4.1 Students understand requirements for complete product specifications (e.g., drawings and technical specifications).
4.2 Students will read, understand and interpret drawings (e.g., assembly, articulation, quantity take-offs).
4.3 Students will be able to extract information from drawings and geometric models for use in analysis and simulation studies.

Correlation between Course Outcomes and Program Educational Outcomes:

ME 1770												
	Mechanical Engineering Program Educational Outcomes											
Course Outcomes	a	b	c	d	e	f	g	h	i	j	k	l
Course Outcome 1.1	X	X			X		X				X	X
Course Outcome 1.2		X			X		X				X	X
Course Outcome 2.1	X	X			X		X				X	X
Course Outcome 2.2	X	X		X	X		X			X	X	X
Course Outcome 2.3	X	X			X		X				X	X
Course Outcome 2.4	X	X			X		X				X	X
Course Outcome 3.1	X	X		X	X		X			X	X	X
Course Outcome 3.2	X	X			X		X				X	X
Course Outcome 3.3	X	X			X		X				X	X
Course Outcome 4.1	X	X		X	X		X		X	X	X	X
Course Outcome 4.2	X	X			X		X				X	X
Course Outcome 4.3	X	X			X		X				X	X

Prepared by: Michael Stewart

ME 2016 Computing Techniques (Required)

Catalog Description: ME 2016 Computing Techniques (3-0-3)
Prerequisites: CS 1371 Introduction to Computing and MATH 1502 Calculus II
Corequisite: MATH 2403 Differential Equations
An introduction to the use of computers and MATLAB programming for the solution of mechanical engineering problems. Topics include: sources of errors in computing, model-based problem solving, basic numerical methods, and signal processing.

Textbook: Steven C. Chapra, and Raymond P. Canale, *Numerical Methods for Engineers*, 5th Edition, McGraw-Hill, 2006.

Topics Covered:

1. Introduction to mathematical modeling and numerical solution of engineering problems.
2. Numerical errors – Computer representation of real numbers. Accuracy, precision, and round-off errors. Taylor series and truncation error.
3. Root finding – Bisection and Newton-Raphson method.
4. Systems of linear equations - Gauss elimination. LU-decomposition. Algorithm complexity.
5. Curve fitting – Least-squares regression methods.
6. Interpolation – Piecewise linear- and cubic-spline interpolation.
7. Numerical integration – The trapezoidal rule and Simpson's rules. Order of convergence.
8. Ordinary differential equations – Euler's methods, Runge-Kutta methods. Truncation error, order of convergence, and stability.
9. Optimization – Golden section search.
10. Signal processing – Sampling and aliasing, spectrum analysis, and digital filters.

Course Outcomes:

Outcome 1: To further develop a student's ability to use computers and computer networks.

1.1 The student will demonstrate an ability to use the Georgia Tech computer network to obtain course information and help using a course web site.
1.2 The student will demonstrate an ability to submit homework electronically.
1.3 The student will demonstrate an ability to use a computer to do the homework assignments.

Outcome 2: To develop a student's ability to use structured software design concepts in the development of efficient computer software for the solution and data visualization of engineering problems.

2.1 The student will demonstrate an ability to write efficient computer programs using the MATLAB programming language.
2.2 The student will demonstrate an ability to write well-structured, well-documented programs.
2.3 The student will demonstrate an ability to use these computer programs to solve simple engineering problems.
2.4 The student will demonstrate an ability to display the results of their computations using the graphics capabilities of MATLAB.

Outcome 3: To give the student a working knowledge of a variety of numerical methods used in mechanical engineering and some practical experience with their use.

3.1 The student will demonstrate a basic understanding of several numerical methods.

3.2 The student will demonstrate the ability to translate a numerical algorithm into a working MATLAB program.
3.3 The student will demonstrate the ability to formulate simple mathematical models of engineering problems.
3.4 The student will use numerical methods and computer models to solve several engineering problems using a computer.

Outcome 4: To give the student a working knowledge of some of the methods used for signal processing and analysis and some practical experience with their use on real-world and laboratory data.

4.1 The student will demonstrate a basic understanding of simple signal processing and analysis.
4.2 The student will demonstrate an ability to process, analyze, and display data from a real-world or laboratory experiment or process.

Outcome 5: To develop a student's ability to formulate a problem, analyze it, and then communicate the results of their work in written and graphical form.

5.1 The student will demonstrate an ability to formulate an open-ended engineering problem into a form suitable for computer analysis.
5.2 The student will demonstrate an ability to solve such problems using the numerical methods from this course.
5.3 The student will demonstrate an ability to communicate the results of their work in a written report format.

Correlation between Course Outcomes and Program Educational Outcomes:

ME 2016												
	Mechanical Engineering Program Educational Outcomes											
Course Outcomes	a	b	c	d	e	f	g	h	i	j	k	l
Course Outcome 1.1											X	
Course Outcome 1.2											X	
Course Outcome 1.3											X	
Course Outcome 2.1	X										X	X
Course Outcome 2.2	X										X	X
Course Outcome 2.3	X				X						X	X
Course Outcome 2.4							X				X	
Course Outcome 3.1	X											X
Course Outcome 3.2	X										X	X
Course Outcome 3.3	X				X						X	X
Course Outcome 3.4	X				X						X	X
Course Outcome 4.1	X											X
Course Outcome 4.2	X	X			X						X	X
Course Outcome 5.1	X				X							X
Course Outcome 5.2	X				X						X	X
Course Outcome 5.3	X						X					X

Prepared by: Chris Paredis

ME 2110 Creative Decisions and Design (Required)

Catalog Description: ME 2110 Creative Decisions and Design (2-3-3)
Prerequisites: AE/ME/CEE 1770 Introduction to Engineering Graphics and Visualization.
Prerequisites or Corequisites: COE 2001 Statics; ME 2016 Computing Techniques
To learn fundamental techniques for creating, analyzing, synthesizing, and implementing design solutions to open ended problems with flexibility, adaptability, and creativity through team and individual efforts.

Textbook: David G. Ullman, *The Mechanical Design Process*, 3rd Edition, McGraw-Hill, 2002.

Topics Covered:

1. Phases of design
2. Customer needs and market analysis – Quality Function Deployment (QFD).
3. Design assessment and evaluation.
4. Basic system fabrication techniques.
5. Basic electronics and pneumatics.
6. Design documentation and project reporting.
7. Management and planning tools.
8. Problem definition and specification, functional requirements.
9. Conceptual design.
10. Design for manufacturing, assembly, maintenance, and the environment.
11. Design case studies.
12. Intellectual property issues.

Course Outcomes:

Outcome 1: To enable students to learn how to formulate and address open ended design problems, including problem definitions and specifications and the identification of functional requirements.

> 1.1 Students will demonstrate their ability to formulate functional requirements for open ended design problems.
> 1.2 Students will learn to formulate specifications for a design problem based on functional requirements, customer needs and physical reality.

Outcome 2: To provide students with a systematic approach to design, based on a variety of design methods, that permit the consideration and incorporation of a broad spectrum of design options.

> 2.1 Students will demonstrate their ability to consider multiple design alternatives and identify the best possible choice based on the design specifications.
> 2.2 Students will learn to use a broad spectrum of design tools to implement a number of methodologies used in conceptual design evaluation.

Outcome 3: To enable students to learn to consider a variety of issues such as manufacturing, maintenance, quality, environmental issues and related aspects while designing.

> 3.1 Students will learn to consider a variety of issues that are critical to the successful implementation of a design.

Outcome 4: To enhance a student's ability to communicate at personal and technical levels, in both oral and written fashions.

> 4.1 Students will give oral presentations relating to work accomplished in their design studio sections pertaining to both the mini-projects and the major project.
> 4.2 Students will provide written reports (including final and interim reports) detailing their design developments in their studio sections.

Outcome 5: To provide students with a hands-on experience permitting them to realize basic design concepts in a studio environment.

> 5.1 Students will demonstrate the ability to fabricate various mechanical systems in their studio sections. The systems they fabricate will be of their own design to meet specific functional requirements.
> 5.2 Students will learn that specifications may be difficult to achieve with an actual system despite the fact that the specifications are theoretically possible.

Outcome 6: To enable students to work in self managed teams.

> 6.1 Students will demonstrate the ability to work in teams by developing and implementing designs as well as documenting the designs in written and oral reports.

Outcome 7: To provide students with the opportunity to demonstrate basic concepts in mechanical systems via the implementation of their designs.

> 7.1 Students will demonstrate a variety of mechanical system concepts and theories by designing small scale mechanical systems based on fundamental principles, and subsequently fabricating these systems in their studio.

Correlation between Course Outcomes and Program Educational Outcomes:

ME 2110												
	Mechanical Engineering Program Educational Outcomes											
Course Outcomes	a	b	c	d	e	f	g	h	i	j	k	l
Course Outcome 1.1	X		X		X	X		X		X	X	X
Course Outcome 1.2	X		X		X	X		X		X	X	X
Course Outcome 2.1	X		X		X	X		X		X	X	X
Course Outcome 2.2	X		X		X			X			X	X
Course Outcome 3.1			X		X	X		X		X		X
Course Outcome 4.1							X	X			X	
Course Outcome 4.2							X	X			X	
Course Outcome 5.1			X		X			X	X		X	X
Course Outcome 5.2		X	X		X			X	X		X	X
Course Outcome 6.1	X	X	X	X	X	X	X	X	X		X	
Course Outcome 7.1	X	X	X	X	X	X		X			X	X

Prepared by: Jonathan Colton

ME 2202 Dynamics of Rigid Bodies (Required)

Catalog Description: ME 2202 Dynamics of Rigid Bodies (3-0-3)
Prerequisites: COE 2001 Statics
Kinematics and dynamics of particles and rigid bodies in one, two, and three dimensions. Work-energy and impulse-momentum concepts.

Textbook: David J. McGill and Wilton W. King, *Engineering Mechanics*, *An Introduction to Dynamics,* 4th Edition, Tichenor Publishing, 2003. (Custom published for Georgia Tech. This book can only be obtained from the bookstore.)

Topics Covered:

1. Particle motion
2. Planar kinematics of rigid bodies
3. Newton-Euler analysis of planar rigid body systems
4. Angular velocity in three dimensions
5. Angular acceleration in three dimensions
6. Euler angles
7. Rotation matrices
8. Angular momentum
9. Inertia properties
10. Principal moments and axes of inertia
11. Euler equations
12. Impact; Impulse-momentum relations for rigid bodies
13. Work-Energy analysis of conservative and nonconservative rigid body systems

Course Outcomes:

Outcome 1: To teach students the basic principles underlying the dynamics of rigid bodies in planar and 3D motion

> 1.1 Students will demonstrate an understanding of Newtonian-Eulerian physics and basic equations underlying kinematics and kinetics of rigid bodies in 2D and 3D motion.

Outcome 2: To educate students to identify, formulate and solve engineering problems in rigid body dynamics.

> 2.1 Students will demonstrate the ability to isolate rigid bodies and to draw clear and appropriate free body diagrams.
> 2.2 Students will demonstrate an ability to identify kinematic and kinetic knowns and unknowns.
> 2.3 Students will demonstrate an ability to identify and effectively account for kinematic constraints such as rolling and/or sliding, and their kinetic consequences.
> 2.4 Students will demonstrate that they can apply the appropriate principles referred to in Objective 1 to the solution of problems.
> 2.5 Students will demonstrate that they can combine the appropriate principles referred to in Objective 1 in the solution of problems.
> 2.6 Students will demonstrate that they can determine the mass moments and products of inertia for arbitrary rigid bodies.
> 2.7 Students will demonstrate that they can calculate the principal coordinates and the principal moments of inertia for arbitrary rigid bodies.

Outcome 3: To introduce students to the concepts of work-energy and impulse-momentum for rigid body systems.

3.1 Students will demonstrate an understanding of work-energy principles as applied to rigid bodies in 2D and 3D motion.
3.2 Students will be able to evaluate the kinetic energy of rigid bodies as well as the potential energy associated with gravity and spring forces.
3.3 Students will demonstrate an understanding of conservation laws for momentum and energy.
3.4 Students will demonstrate an ability to apply impulse-momentum relations where appropriate.
3.5 Students will demonstrate that they can utilize coefficient of restitution data in the solution of impact problems in rigid-body dynamics.

Correlation between Course Outcomes and Program Educational Outcomes:

ME 2202												
	Mechanical Engineering Program Educational Outcomes											
Course Outcomes	a	b	c	d	e	f	g	h	i	j	k	l
Course Outcome 1.1	X				X						X	
Course Outcome 2.1	X				X						X	
Course Outcome 2.2	X				X						X	
Course Outcome 2.3	X				X						X	
Course Outcome 2.4	X				X						X	X
Course Outcome 2.5	X				X						X	X
Course Outcome 2.6	X				X						X	
Course Outcome 2.7	X				X						X	
Course Outcome 3.1	X				X						X	
Course Outcome 3.2	X				X						X	
Course Outcome 3.3	X				X						X	
Course Outcome 3.4	X				X						X	
Course Outcome 3.5	X				X						X	

Prepared by: Wayne Whiteman

ME 3015 System Dynamics and Control (Required)

Catalog Description: ME 3015 System Dynamics and Control (4-0-4)
Prerequisites: MATH 2403 Differential Equations, ME 2016 Computing Techniques, ME 2202 Dynamics of Rigid Bodies, and ECE 3710 Circuits and Electronics
Dynamic modeling and response of systems with mechanical, hydraulic, thermal and/or electrical elements. Linear feedback control systems design and analysis in time and frequency domains.

Textbook: Ogata, K., System Dynamics, 4th Edition, Prentice-Hall, 2004.

Topics:

1. Mathematical Background
2. Modeling of Mechanical Systems
3. Model Representation and Response
4. Vibration Analysis of Mechanical Systems
5. Modeling of Electrical, Hydraulic & Thermal Systems
6. Modeling of Mixed Systems
7. Basic Feedback Control Systems
8. Time Response Analysis of Linear Dynamic Systems
9. Root-Locus Technique
10. Frequency Response Analysis and Design of Feedback Systems.

Course Outcomes:

Outcome 1: To teach students basic mathematical and computational tools for modeling and analysis of dynamic systems.

1.1 Students will demonstrate understanding of various mathematical models, such as transfer function and state-space, for dynamic systems.
1.2 Students will demonstrate the ability to simulate the transient and steady-state response of dynamic systems.

Outcome 2: To train students to identify, model, analyze, design, and simulate dynamic systems in various engineering disciplines using a unified approach.

2.1 Students will demonstrate that they can analyze transient, steady-state, and frequency response of linear dynamic systems.
2.2 Students will demonstrate an ability to mathematically model systems in various engineering disciplines including mixed systems.
2.3 Students will be able to design basic control compensation using time and frequency domain techniques.

Correlation between Course Outcomes and Program Educational Outcomes:

ME 3015												
	Mechanical Engineering Program Educational Outcomes											
Course Outcomes	a	b	c	d	e	f	g	h	i	j	k	l
Course Outcome 1.1	X											
Course Outcome 1.2											X	
Course Outcome 2.1												X
Course Outcome 2.2					X							X
Course Outcome 2.3					X							X

Prepared by: Kok-Meng Lee

ME 3057 Experimental Methods Laboratory (Required)

Catalog Description: ME 3057 Experimental Methods Laboratory (2-3-3)
Prerequisites: COE 3001 Deformable Bodies, ME 3015 System Dynamics and Control, ME 3340 Fluid Mechanics
Corequisites: MATH/ISYE 3770 Statistics and Applications and ME 3345 Heat Transfer
Introduction to basic instrumentation and experimental methodology used in mechanical engineering, including calibration, use, precision, and accuracy. Consideration of errors, precision, and accuracy in experimental measurements. Preparation of technical reports.

Textbooks: Laboratory Manual for *ME 3057, Experimental Methodology.* The George W. Woodruff School of Mechanical Engineering.
Jeff Donnell and Sheldon Jeter, *Uniform Writing and Style Manual*, College Publishing, 2004.

Topics Covered:

1. Teaming, planning, and collaboration
2. Technical report writing
3. Data acquisition, instrument response, precision, and accuracy (consideration of 1st and 2nd order systems; practice with MATLAB modeling)
4. Characterization of second order systems
5. Introduction to microprocessors (consideration of ADC, aliasing, and data I/O; practice with a piezoelectric film strain sensor on a vibrating beam)
6. Open loop control (consideration of calibration, resolution, and sensitivity; programming practice; using optical encoder and tachometer)
7. Closed loop control (consideration of feedback in control; further programming practice)
8. Thermal measurements (practice in the use of thermocouples, RTDs, and heat flux sensors) for transient and steady-state heat transfer problems
9. Stress, strain, and force measurements (consideration of resonance and damping; practice with load cells, strain gauges and rosettes, and LVDTs)
10. Viscosity measurements (use of various viscometers)
11. Machine diagnostics (time domain and frequency domain representation of data, FFT analysis and aliasing)
12. Acoustics(consideration of sound pressure levels and use of the anechoic chamber)
13. Optics (laser interferometric & diffractive sensors)

Course Outcomes:

Outcome 1: To apply in practice the logical steps in experimentation: conceptualization, planning, execution, data acquisition, analysis, interpretation, conclusion, and reporting.

> 1.1 Students will demonstrate proficiency in planning and performing experiments, data acquisition, and in writing laboratory reports. Knowledge and understanding of data acquisition from sensors used in the many fields of mechanical engineering is tested. Proficiency with varieties of signal conditioning and filtering and spread sheet based data analysis will be demonstrated.

Outcome 2: To develop the ability to work in teams.

> 2.1 Students will successfully perform experiments and prepare reports individually and in teams. A standard format is used for reports, graphs, charts, and sample calculations.

Outcome 3: To practice the principles of operation, calibration, and use of basic instrumentation.

3.1 Students will demonstrate an understanding of the operating principles, calibration, and use of basic instrumentation.

Outcome 4: To apply concepts of sensitivity, resolution, random and systemic errors, precision, accuracy, and uncertainty in experimental measurements.

4.1 Students will demonstrate an understanding of sensitivity and resolution, random and bias error, and precision and accuracy in evaluating data. Estimation of uncertainty error will be performed using statistical analysis.

Correlation between Course Outcomes and Program Educational Outcomes:

ME 3057												
	Mechanical Engineering Program Educational Outcomes											
Course Outcomes	a	b	c	d	e	f	g	h	i	j	k	l
Course Outcome 1.1	X	X		X			X				X	X
Course Outcome 2.1	X			X	X		X				X	X
Course Outcome 3.1	X	X			X						X	
Course Outcome 4.1	X				X						X	

Prepared by: Nader Sadegh

ME 3180 Mechanical Design and Analysis (Either ME 3180 or ME 4315 is required)

Catalog Description: ME 3180 Machine Design (3-0-3)
Prerequisites: ME/CE 1770 Introduction to Engineering Graphics and Visualization, ME 2110 Creative Decisions and Design, and COE 3001 Deformable Bodies
The analysis, selection and synthesis of machine components, as applied to springs, bearings, shafts, gears, fasteners, and other elements in a mechanical system.

Textbook: Charles Mischke, and Richard Budynas, *Shigley's Mechanical Engineering Design*, 8th Edition, McGraw-Hill, 2007.

Topics Covered:

Specific mechanical components to be covered are:

1. Review of Static Failure Mechanisms in the Context of Machine Design
2. Fatigue Failure Mechanisms
3. Spring Design
4. Joining and Fastening Methods
5. Shafts, Keys, and Couplings
6. Bearings and Lubrication
7. Gear Trains
8. Spur Gears
9. Helical, Bevel, and Worm Gears
10. Optional Topics including System Design and Optimization, Design with Microcomputers, and Projects.

Course Outcomes:

Outcome 1: To illustrate to students the variety of mechanical components available and emphasize the need to keep learning.

> 1.1 Students will demonstrate the ability to seek and learn new material outside the class topics through the completion of an open-ended homework, report, term paper, computer assignment and/or project. The amount as well as depth of new material identified and used by the students are measurable indicators of the student's performance.

Outcome 2: To enable students to learn how to identify and quantify the specifications and trade-offs for the selection and application of components which are commonly used in the design of complete mechanical systems.

> 2.1 Students will demonstrate the ability to take technical, economical, safety, quality, legislative and other issues (such as environmental) into account when selecting and/or designing mechanical components. The breadth and depth of the issues taken into account by students are measurable indicators of their performance.

Outcome 3: To teach students how to apply the fundamentals of engineering science to analyze and design commonly used mechanical components to meet specifications.

> 3.1 Students will demonstrate the ability to apply fundamentals of engineering science to make proper assumptions, perform correct analyses, and draw upon different mechanical engineering

subject areas in the analysis of bolted joints, shafts, bearings, springs, gears, and other components covered.
3.2 Students will demonstrate the ability to design mechanical components using the analyses mentioned above.

Outcome 4: To develop in students an ability to select, configure, and synthesize mechanical components into complete systems.

4.1 Students will demonstrate the ability to select, configure, and synthesize mechanical components into assemblies using engineering science fundamentals to meet specifications as described in 2.1 above.

Outcome 5: To let students apply modern computer-based techniques in the selection, analysis, and synthesis of components and their integration into complete mechanical systems.

5.1 Students will demonstrate their ability to use existing computer-based techniques and algorithms for the analysis and synthesis of mechanical components and systems, in particular with respect to those components and systems defined in the topical areas. The maturity, completeness and efficiency of their approach are indicators for their performance.

Correlation between Course Outcomes and Program Educational Outcomes:

ME 3180												
	Mechanical Engineering Program Educational Outcomes											
Course Outcomes	a	b	c	d	e	f	g	h	i	j	k	l
Course Outcome 1.1	X			X	X	X	X		X	X	X	X
Course Outcome 2.1	X		X	X	X	X		X	X	X	X	X
Course Outcome 3.1	X		X	X	X	X				X	X	X
Course Outcome 3.2	X		X	X	X	X				X	X	X
Course Outcome 4.1	X		X	X	X	X		X	X	X	X	X
Course Outcome 5.1	X		X	X	X	X	X			X	X	X

Prepared by: Steven Liang

ME 3322 Thermodynamics (Required)

Catalog Description: ME 3322 Thermodynamics (3-0-3)
Prerequisites**:** PHYS 2211 General Physics I and MATH 2403
Introduction to thermodynamics. Thermodynamic properties, energy and mass conservation, entropy and the Second Law. Second Law analysis of thermodynamic systems, gas cycles, vapor cycles.

Textbook: Michael J. Moran and Howard N. Shapiro, *Fundamentals of Engineering Thermodynamics*, 6th Edition, John Wiley & Sons, 2008.

Topics Covered:

1. Definitions: property, state, closed and open systems, temperature, pressure, work interactions, heat transfer. State postulate.
2. Forms of energy: kinetic, potential, internal.
3. Properties of pure substances, equilibrium diagrams, quality. Ideal gas and incompressible substances.
4. Conservation of mass; steady and transient processes.
5. Conservation of energy; closed and open systems; steady and transient processes.
6. Introduction to Second Law; Kelvin-Planck and Clausius statements. Clausius inequality, entropy, Tds equations.
7. Second Law analysis of thermodynamic systems. Irreversibility, exergy (availability).
8. Gas power: air standard cycles, Otto, diesel, Brayton, regeneration, intercooling and reheat, component efficiencies.
9. Vapor power cycles: Rankine cycle, ideal cycle, reheat, regeneration, component efficiencies.

Course Outcomes:

Outcome 1: To teach students the basic principles of classical thermodynamics.

1.1 Students will demonstrate an understanding of the concepts of conservation of mass, conservation of energy, and the second law of thermodynamics.
1.2 Students will demonstrate an understanding of the concepts of work interaction and heat transfer.
1.3 Students will demonstrate an understanding of methods for determining thermodynamic properties of simple compressible substances.

Outcome 2: To train students to identify, formulate and solve engineering problems in classical thermodynamics involving closed and open systems for both steady state and transient processes.

2.1 Students will demonstrate the ability to identify closed and open systems.
2.2 Students will demonstrate the ability to identify work interactions and heat transfer.
2.3 Students will demonstrate the ability to determine accurately the thermodynamic properties of simple compressible substances including incompressible substances and ideal gases.
2.4 Students will demonstrate that they can apply the principles of conservation of mass and conservation of energy to the solution of problems.

Outcome 3: To teach students the application of Second Law analysis methods for thermodynamic systems.

3.1 Students will demonstrate an understanding of the concepts of Second Law analysis and an ability to apply them to closed and open systems for both steady and transient processes.

3.2 Students will demonstrate an understanding of the concepts of irreversibility, exergy (availability), adiabatic efficiency, and effectiveness.
3.3 Students will demonstrate that they can apply Second Law analysis methods to the solution of problems.

Outcome 4: To train students to analyze the performance of power and refrigeration cycles.

4.1 Students will demonstrate that they can apply the principles of conservation of mass, conservation of energy, and the Second Law of Thermodynamics to thermodynamic cycles.
4.2 Students will demonstrate the ability to analyze the performance of vapor power cycles and to identify methods for improving thermodynamic performance.
4.3 Students will demonstrate the ability to analyze the performance of gas power cycles and to identify methods for improving thermodynamic performance.

Correlation between Course Outcomes and Program Educational Outcomes:

ME 3322												
	Mechanical Engineering Program Educational Outcomes											
Course Outcomes	a	b	c	d	e	f	g	h	i	j	k	l
Course Outcome 1.1	X										X	X
Course Outcome 1.2	X										X	X
Course Outcome 1.3	X										X	X
Course Outcome 2.1	X				X						X	X
Course Outcome 2.2	X				X						X	X
Course Outcome 2.3	X				X						X	X
Course Outcome 2.4	X				X						X	X
Course Outcome 3.1	X				X						X	X
Course Outcome 3.2	X				X						X	X
Course Outcome 3.3	X				X						X	X
Course Outcome 4.1	X				X						X	X
Course Outcome 4.2	X				X						X	X
Course Outcome 4.3	X				X						X	X

Prepared by: Richard Salant

ME 3340 Fluid Mechanics (Required)

Catalog Description: ME 3340 Fluid Mechanics (3-0-3)
Prerequisites: ME 2202 Dynamics of Rigid Bodies, MATH 2403 Differential Equations
Prerequisites or Corequisites: ME 3322 Thermodynamics
The fundamentals of fluid mechanics. Topics include fluid statics, control-volume analysis, the Navier-Stokes equations, similitude, viscous, inviscid and turbulent flows, boundary layers.

Textbook: Bruce R. Munson, Donald F. Young, and Theodore H. Okiishi, *Fundamentals of Fluid Mechanics*, 5th Edition, John Wiley and Sons, 2006.

Topics Covered:

1. Fluid statics - Pressure distribution in a fluid. Manometry. Force on plane and curved submerged surfaces. Buoyancy.
2. Fluid velocity and acceleration fields - Eulerian vs. Lagrangian descriptions. Velocity field. Flow lines. Acceleration in a fluid.
3. Control-volume analysis - Reynolds transport theorem. Conservation of mass. Momentum balance. Angular momentum balance. Conservation of energy. Bernoulli's equation.
4. Local analysis – Derivation of continuity and Navier-Stokes equations. Kinematics. Stream function and velocity potential. Simple viscous-flow solutions in Cartesian and polar coordinates. Reduction to Euler equations.
5. Similitude - Dimensional analysis. Buckingham Pi theorem. Dimensionless groups. Modeling. Scaling equations of motion.
6. Boundary layers - Laminar and turbulent boundary layers. Transition.
7. Pipe flow - Entry region. Fully developed flow - laminar and turbulent. Colebrook formula. Pipe systems. Pumps.
8. Drag - Pressure drag. Friction drag. Separation.
9. Turbulent flow – Introduction to basic concepts.

Course Outcomes:

Outcome 1: To develop a student's understanding of the basic principles of fluid mechanics.

1.1 The student will demonstrate an ability to recognize the type of fluid flow that is occurring in a particular physical system.
1.2 The student will demonstrate an ability to choose the appropriate fluid mechanical principles needed to analyze fluid-flow situations.

Outcome 2: To develop a student's skills in analyzing fluid flows through the proper use of modeling and the application of the basic fluid-flow principles.

2.1 The student will demonstrate an ability to apply appropriate simplifying assumptions and basic fluid-flow principles to produce a mathematical model of a physical fluid-flow system.
2.2 The student will demonstrate an ability to solve and analyze the mathematical model associated with a physical fluid-flow system.

Outcome 3: To provide the student with some specific knowledge regarding fluid-flow phenomena observed in mechanical engineering systems, such as flow in a pipe, boundary-layer flows, drag, etc.

3.1 The student will be able to recognize the particular flow regime that is present in a typical engineering system.
3.2 The student will demonstrate knowledge of important practical results in common fluid flows and their physical implications.

Correlation between Course Outcomes and Program Educational Outcomes:

ME 3340												
	Mechanical Engineering Program Educational Outcomes											
Course Outcomes	a	b	c	d	e	f	g	h	i	j	k	l
Course Outcome 1.1	X	X			X				X		X	X
Course Outcome 1.2	X	X			X				X		X	X
Course Outcome 2.1	X	X			X				X		X	X
Course Outcome 2.2	X	X			X				X		X	X
Course Outcome 3.1	X	X			X				X	X	X	X
Course Outcome 3.2	X	X			X				X	X	X	X

Prepared by: Paul Neitzel

ME 3345 Heat Transfer (Required)

Catalog Description: ME 3345 Heat Transfer (3-0-3)
Prerequisites: MATH 2403, ME 3322 Thermodynamics and ME 3340 Fluid Mechanics
Introduction to the study of heat transfer, transport coefficients, steady state conduction, transient conduction, radiative heat transfer, and forced and natural convection.

Textbook: Frank P. Incropera, David P. DeWitt, Theodore L. Bergman, and Adrienne S. Lavine, *Fundamentals of Heat and Mass Transfer*, 6th Edition, John Wiley, 2007.

Topics Covered:

1. Basic concepts. Fourier's law, Newton's law of cooling, Stefan-Boltzmann law. Conservation of energy, heat flux, boundary and initial conditions.
2. One-dimensional steady-state conduction with and without heat generation; heat transfer from extended surfaces.
3. Two and three dimensional steady-state conduction; numerical solutions.
4. Transient conduction: lumped capacitance method; semi-infinite media.
5. Fundamentals of thermal radiation: black and gray surfaces, surface properties.
6. View factor, radiative exchange among black surfaces and among diffuse gray surfaces, electric analogs, radiation shields.
7. Fundamentals of convection. Conservation of energy; Thermal boundary layers; similarity and dimensionless parameters; momentum/heat/mass transfer analogies.
8. Forced convection external flows: similarity parameters; laminar and turbulent boundary layers on flat surfaces; heat transfer to cylinders, spheres, tube banks and packed beds; impinging jets.
9. Forced convection internal flows: laminar and turbulent flow through circular and noncircular ducts, fully developed flow, hydrodynamically and thermally developing flows,, empirical correlations.
10. Free convection boundary layer equations: laminar boundary layers on flat surfaces; turbulence; empirical correlations.
11. Heat exchangers: overall heat transfer coefficient; cocurrent and countercurrent flow; cross flow; effectiveness-NTU method; condensers, evaporators and compact heat exchangers.

Course Outcomes:

Outcome 1: To teach students the basic principles of conduction, radiation, and convection heat transfer.

1.1 Students will demonstrate an understanding of the basic concepts of conduction, radiation, and convection heat transfer.

Outcome 2: To extend the basic principle of conservation of energy to systems which involve conduction, radiation, and heat transfer.

2.1 Students will demonstrate an understanding of the concept of conservation of energy and its application to problems involving conduction, radiation, and/or convection heat transfer. This principle will be used to formulate appropriate mathematical models and associated thermal boundary conditions.

Outcome 3: To train students to identify, formulate and solve engineering problems involving conduction heat transfer.

3.1 Students will demonstrate the ability to formulate practical conduction heat transfer problems by transforming the physical system into a mathematical model, selecting an appropriate solution technique and evaluating the significance of results.

Outcome 4: To train students to identify, formulate and solve engineering problems involving radiation heat transfer among black surfaces and among diffuse gray surfaces.

4.1 Students will demonstrate the ability to formulate practical radiation heat transfer problems by transforming the physical system into a mathematical model, selecting an appropriate solution technique and evaluating the significance of results.

Outcome 5: To train students to identify, formulate and solve engineering problems involving forced convection heat transfer, natural convection heat transfer, and heat exchangers.

5.1 Students will demonstrate the ability to formulate practical forced and natural conduction heat transfer problems by transforming the physical system into a mathematical model, selecting an appropriate solution technique and evaluating the significance of results. Students will also demonstrate an ability to analyze the performance.

Correlation between Course Outcomes and Program Educational Outcomes:

ME 3345												
	Mechanical Engineering Program Educational Outcomes											
Course Outcomes	a	B	c	d	e	f	g	h	i	j	k	l
Course Outcome 1.1	X				X						X	X
Course Outcome 2.1	X				X						X	X
Course Outcome 3.1	X				X						X	X
Course Outcome 4.1	X				X						X	X
Course Outcome 5.1	X		X		X						X	X

Prepared by: Srinivas Garimella

ME 4053 Mechanical Engineering Systems Laboratory (Required)

Catalog Description: ME 4053 Mechanical Engineering Systems Laboratory (1-3-2)
Prerequisites: ME 3057 Experimental Methodology Laboratory, ME 3345 Heat Transfer, and MATH/ISYE 3770 Statistics and Applications
Measurement and analysis of mechanical, acoustic, manufacturing, thermodynamic, fluid, and heat transfer phenomena. Emphasis on data acquisition, reduction, analysis, and report preparation.

Textbooks: Lab Manual and Lecture Notes for *ME 4053a, Thermal Energy and Fluids Laboratory*, The George W. Woodruff School of Mechanical Engineering.
Lab Manual for *ME 4053b, Mechanical Systems Lab*, The George W. Woodruff School of Mechanical Engineering.
J. A. Donnell and S. M. Jeter, *Writing Style and Standards in Undergraduate Reports,* College Publishing, 2004.

Topics Covered:

1. Principles and standard practice of written and graphical reporting
2. Oral and visual presentation techniques
3. Experimental statistics including regression and significance tests
4. Teaming, planning, and collaboration
5. Investigation of mechanical behavior such as structural vibration
6. Investigation of acoustic phenomena such as propagation and attenuation
7. Investigation of tribological systems such as elasto- hydrodynamic lubrication
8. Investigation of simple open and closed loop control systems
9. Investigation of thermodynamic properties such as vapor pressure and thermal systems such as refrigerators and heat pumps
10. Investigation of internal and/or external fluid flow with pressure, thermal, and laser-Doppler sensors
11. Investigation of heat transfer and heat exchangers
12. Investigation of fluid machines such as the centrifugal pump
13. Estimation of bias by error propagation

Course Outcomes:

Outcome 1: Instruction and practice in empirical investigation and quantitative assessment of important and representative mechanical, acoustic, control, manufacturing, thermal and fluid processes and systems.

> 1.1 Students will demonstrate facility in empirical investigation and quantitative assessment of important and representative thermal and mechanical processes and systems by laboratory participation, written and oral reports. Students will apply knowledge of engineering principles to perform experiments and analyze the results.

Outcome 2: Instruct and practice concepts of experimental engineering including experimental planning and practical applications of experimental statistics.

> 2.1 Students will demonstrate in practice concepts of experimental engineering including experimental planning and statistical methods. Students will use the state-of-the-art measurement techniques and data processing methods.

Outcome 3: Further develop the ability to organize and work in teams.

3.1 Students will successfully plan and perform experiments and plan and accomplish report preparation in teams.

Outcome 4: Instruct and practice written and graphical communication of research data and findings.

4.1 Students will prepare written reports of research data and findings with substantial graphical content.

Outcome 5: Instruct and practice oral and visual presentation of research data and findings.

5.1 Students will conduct oral presentations with visual aids, including text and graphics, of research data and findings.

Correlation between Course Outcomes and Program Educational Outcomes:

ME 4053												
	Mechanical Engineering Program Educational Outcomes											
Course Outcomes	a	b	c	d	e	f	g	h	i	j	k	l
Course Outcome 1.1	X	X				X	X				X	X
Course Outcome 2.1	X	X									X	X
Course Outcome 3.1				X								
Course Outcome 4.1							X					
Course Outcome 5.1							X					

Prepared by: Zhuomin Zhang

ME 4182 Capstone Design (Required)

Catalog Description: ME 4182 Capstone Design Project (1-6-3)
Prerequisites: ME 2110 Creative Decisions and Design and ME 3180 Machine Design or ME 4315 Energy Systems Design
Co-requisite: ME 4210 Manufacturing Processes and Engineering
Teams apply a systematic design process to real multidisciplinary problems. Problems selected from a broad spectrum of interest areas, including biomedical, ecological, environmental, mechanical, and thermal.

Textbook: No text. Suggested reference is *Mark's Standard Handbook*.

Topics Covered:

1. Project selection.
2. Specification formulation within given constraints
3. Project planning.
4. Product and patent research.
5. Manufacturing considerations.
6. Engineering standards.
7. Environmental, sustainability, health, and safety considerations.
8. Proof-of-Concept methods.

Course Outcomes:

Outcome 1: To enable students to synthesize the knowledge and skills acquired in their undergraduate curriculum, in the context of a realistic design project.

> 1.1 Students will be able to identify relevant topics from earlier courses, then apply them to their design project.
> 1.2 Students will be able to critically evaluate designs using engineering criteria and predictive usage.

Outcome 2: To develop in students the ability to address a broad range of requirements, including most of the following: performance, economic, marketing, environmental, sustainable, manufacturing, ethical, safety, and social and political.

> 2.1 Students will demonstrate an ability to identify and specify design requirements, from general problem descriptions within the applicable realistic constraints.
> 2.2 Students will be able to systematically develop a design from the problem statement to a detailed, proof-of-concept design meeting all of the specifications.

Outcome 3: To prepare for the professional design environment by learning how to learn, through teamwork and by enhancing student's communication abilities.

> 3.1 Students will be able to clearly communicate design ideas and information.
> 3.2 Students will be able to work collaboratively and responsibly as a team.
> 3.3 Students will demonstrate the ability to facilitate their learning by identifying design issues and questions that require additional investigation, then formulating appropriate courses of action.

Correlation between Course Outcomes and Program Educational Outcomes:

ME 4182												
	Mechanical Engineering Program Educational Outcomes											
Course Outcomes	a	b	c	d	e	f	g	h	i	j	k	l
Course Outcome 1.1	X		X	X	X	X	X	X	X	X	X	X
Course Outcome 1.2	X		X	X	X	X	X	X	X	X	X	X
Course Outcome 2.1			X	X	X	X	X			X	X	X
Course Outcome 2.2	X		X	X	X	X	X		X	X	X	X
Course Outcome 3.1							X					X
Course Outcome 3.2				X			X					X
Course Outcome 3.3								X	X			

Prepared by: David Sanborn

ME 4210 Manufacturing Processes and Engineering (Required)

Catalog Description: ME 4210 Manufacturing Processes and Engineering (3-0-3)
Prerequisites: (MATH 3770 or ISyE 3770 Statistics and Applications), COE 3001 Mechanics of Deformable Bodies, and ME 3345 Heat Transfer
Major manufacturing processes, their capabilities, analysis, and economics. Manufacturing process selection.

Textbook: Serope Kalpakjian, Steven R. Schmid, *Manufacturing Processes for Engineering Materials, 5*th Edition, Prentice Hall, 2007.

Topics Covered:

1. Basics:
    - 1.1 Review of materials and mechanical properties
    - 1.2 Metrology and surface finish
    - 1.3 Taxonomy of manufacturing processes
2. Manufacturing Processes:
    - 2.1 Casting
    - 2.2 Bulk deformation (forging, rolling, drawing, extrusion)
    - 2.3 Sheet metal forming
    - 2.4 Mechanical material removal (cutting, grinding)
    - 2.5 Non-Mechanical material removal (ECM, EDM, laser, electron beam, water jet)
    - 2.6 Polymer and polymer composites processing
    - 2.7 Joining (welding, adhesives, rivets)
    - 2.8 Micro manufacturing methods (MEMS, Micromachining)
3. Manufacturing Engineering:
    - 3.1 Economic modeling and cost analysis
    - 3.2 Process selection

Course Outcomes:

Outcome 1: To teach students to perform mathematical analyses of conventional and non-traditional manufacturing processes

1.1 Students will demonstrate the ability to break down manufacturing processes for analysis.
1.2 Students will demonstrate the ability to identify known and unknown parameters including initial and boundary conditions for major manufacturing processes.
1.3 Students will demonstrate the ability to draw clear and appropriate free body diagrams and control volumes of select manufacturing processes.
1.4 Students will demonstrate the ability to apply the fundamental principles from prerequisite courses in mechanics, materials and thermo-fluids to analyze manufacturing processes.

Outcome 2: To teach students to integrate core mechanical engineering principles to design manufacturing processes and systems

2.1 Students will demonstrate the ability to integrate the relevant core principles in mechanical engineering (mechanics, materials and thermo-fluids) to solve problems in manufacturing.
2.2 Students will demonstrate the ability to carry out manufacturing process design based on first principles.

Outcome 3: To train students to interpret product requirements, manufacturing process capability data and apply them to select and/or synthesize suitable manufacturing process(es)

3.1 Students will demonstrate knowledge of process capabilities of major manufacturing processes.
3.2 Students will demonstrate the ability to make use of process capability information to select and/or synthesize manufacturing processes and systems.

Outcome 4: To teach students basic process optimization techniques

4.1 Students will demonstrate an understanding of the role of economic considerations in manufacturing process selection and optimization.
4.2 Students will demonstrate the ability to perform simple cost and time based process optimization for select manufacturing processes.

Correlation between Course Outcomes and Program Educational Outcomes:

ME 4210												
	Mechanical Engineering Program Educational Outcomes											
Course Outcomes	a	b	c	d	e	f	g	h	i	j	k	l
Course Outcome 1.1							X		X		X	X
Course Outcome 1.2	X				X		X		X		X	X
Course Outcome 1.3	X				X		X				X	X
Course Outcome 1.4	X				X		X				X	X
Course Outcome 2.1	X				X		X				X	X
Course Outcome 2.2	X		X		X		X		X		X	X
Course Outcome 3.1			X				X			X	X	
Course Outcome 3.2			X				X	X	X	X	X	X
Course Outcome 4.1			X			X	X	X	X		X	
Course Outcome 4.2			X			X	X	X			X	

Prepared by: Shreyes Melkote

MATH 1501
MATH 1502
MATH 2401
MATH 2403

CHEM 1310
PHYS 2211
PHYS 2212

COE 2001