Course Title: MEEN 4301: Mechanical Engineering Lab I

Semester Credit Hours: 5 (1,4)

I. Course Overview

This laboratory course introduces students to the concepts of engineering measurement and experimentation in the thermal sciences. It develops physical understanding through experimentation as students analyze raw data and organize the results into a comprehensive lab report.

II. PMU Competencies and Learning Outcomes

Critical thinking and problem solving are the cornerstones of this course, as students are introduced to the concepts of engineering experimentation. This course builds professional competencies as it extends prior knowledge from the thermal sciences. Written laboratory reports for each experiment enhance communications abilities and data analyses build technology competencies. No formal oral presentations or group assignments are included in the course.

III. Detailed Course Description

This course is an introduction to experimental methods in the thermal sciences. Students learn to analyze raw data and organize the results into a comprehensive lab report. They also are exposed to experiments and techniques in the various areas of thermal science. Students are expected to have a thorough understanding of fluid mechanics and thermodynamics, with heat transfer to be successful in this course.

IV. Requirements Fulfilled

This course is required for majors in mechanical engineering.

V. Required Prerequisites

- GEEN 3311: Introduction to Fluid Mechanics
- MEEN 3322: Thermodynamics II
- MEEN 4321: Heat Transfer (co-requisite)

VI. Learning Outcomes

- To teach the students the concepts of engineering measurements
- To teach the students to understand experimental techniques in the thermal sciences.
- To teach the students how to organize and conduct an experimental investigation.
- To teach the students how to analyze and present experimental results.

VII. Assessment Strategy

- This is a laboratory course in which the students are divided into groups of three to conduct experiments. There are regular laboratory report submissions, and students receive feedback from the instructor regarding their performance on the lab reports. The major part of the course grade is based on the performance of the student from the lab reports.
- Laboratory reports – reports are submitted from each experiment performed.
- Examinations – in-class exams are given to test the student's ability to solve related problems in the thermal sciences.

VIII. Course Format

This laboratory course meets one hour per week in a lecture setting which is followed by one laboratory session up to four hours in length. Students are required to work on their data analysis and report writing in an out-of-class setting.

Classroom Hours (5 hours per week)	**Class:** 1 **Lab:** 4

IX. Topics to Be Covered

A. Basic experimental procedures and principles of measurement in Mechanical Engineering
B. Electrical and electronic circuit analysis
C. Data presentation and report writing
D. Measurement of pressure, temperature, and velocity
E. Determination of pressure drop and flow rate in a pipe
F. Determination of force on objects in internal and external flow
G. Heat transfer by conduction
H. Heat transfer by convection
I. Heat transfer by radiation
J. Energy balances for a control volume
K. Analysis of a simple thermodynamic cycle

X. Laboratory Exercises

The laboratory experiments are listed in Section IX as items A – K. Students are required to do five of the eight experiments.

XI. Technology Component

Students are required to use their laptop computers in doing and submitting their laboratory reports. Examinations are taken in the classroom using no electronic assistance. Graphical presentations using MATLAB are required in the laboratory reports in this course.

XII. Special Projects/Activities

There are no special projects associated with this course.

XIII. Textbooks and Teaching Aids

A. Required Textbook

1. Wheeler, A.J., and A.R. Ganji. *Introduction to Engineering Experimentation.* ___: Prentice Hall, 2004.
   ISBN:
2. Text books from the prerequisite courses are also required.

B. Alternative Textbooks

None.

C. Supplemental Print Materials

None.

D. Supplemental Online Materials

None.

Course Title: MEEN 4302: Mechanical Engineering Lab II

Semester Credit Hours: 5 (1, 4)

I. Course Overview

This laboratory course introduces students to the concepts of engineering measurement and experimentation in mechanics, mechanisms, and controls. Students are exposed to experiments and techniques in the various areas of mechanics, mechanisms, and controls as they develop physical understanding through experimentation.

II. PMU Competencies and Learning Outcomes

Critical thinking and problem solving are the cornerstones of this course, as students are introduced to the concepts of engineering experimentation. This course builds professional competencies by extending prior knowledge from mechanics, mechanisms, and controls. Written laboratory reports each experiment enhance communications abilities. Computer based data analysis builds technology competence. No formal oral presentations or group assignments are included in the course.

III. Detailed Course Description

This course is an introduction to experimental methods in mechanics, mechanisms, and controls. The students learn to analyze raw data and organize the results into a comprehensive lab report. Students are expected to have a thorough understanding of mechanics, mechanisms, and controls to be successful in this course.

IV. Requirements Fulfilled

This course is required for majors in mechanical engineering.

V. Required Prerequisites

- MEEN 2313: Mechanics of Solids
- MEEN 3393: Engineering Design III

VI. Learning Outcomes

- To learn the concepts of engineering measurements.
- To understand experimental techniques in mechanics, mechanisms, and controls.
- To know how to organize and conduct an experimental investigation.
- To be able to analyze and present experimental results.

VII. Assessment Strategy

In this laboratory course, students are divided into groups of three for the purpose of conducting experiments. There are regular laboratory report submissions, and students receive feedback from the instructor regarding their performance on the lab reports. The major part of the course grade is based on the performance of the student from the lab reports.

- Laboratory reports – reports are submitted from each experiment performed.
- Examinations – in-class exams are given to test the student's ability to solve related problems in the thermal sciences.

VIII. Course Format

This course meets in a lecture setting one hour per week in a lecture room setting. This lecture session is followed by a lab session of up to four hours. Students are required to work on analyzing their data and writing lab reports in an out-of-class setting.

Classroom Hours (5 hours per week) **Class:** 4
Lab: 1

IX. Topics to Be Covered

A. Basic experimental procedures and principles of measurement in mechanics, mechanisms, and controls
B. Electrical and electronic circuit analysis and sensing devices
C. Data presentation and report writing
D. Stress, strain, and deflection on a cantilevered beam and/or a rotated shaft
E. Natural frequency of a vibrating beam with various end masses
F. Analysis and control of base-excited resonant-type vibrations
G. Analysis of rotating imbalance

X. Laboratory Exercises

The laboratory experiments for this course are listed in Section IX, items A – G.

XI. Technology Component

Students are required to use their laptop computers in completing and submitting their laboratory reports. Examinations are taken in the classroom using no electronic assistance. Graphical presentations using MATLAB are required in the laboratory reports in this course.

XII. Special Projects/Activities

There are no special projects associated with this course.

XIII. Textbooks and Teaching Aids

A. Required Textbook

1. Wheeler, A.J., and A.R. Ganji. *Introduction to Engineering Experimentation*. ___: Prentice Hall, 2004.
   ISBN:

2. Text books from the prerequisite courses are also required.

B. Alternative Textbooks

None.

C. Supplemental Print Materials

None.

D. Supplemental Online Materials

None.

Course Title: MEEN 4311: Principles of Heating, Ventilating, and Air Conditioning (HVAC)

Semester Credit Hours: 3 (3,0)

I. Course Overview

The course is an application of thermodynamics, fluid mechanics, and heat transfer to the design and selection of HVAC equipment. It covers psychometrics, thermodynamic cycles, HVAC components, and piping and duct layouts, pumps, and fans in a lecture format.

II. PMU Competencies and Learning Outcomes

In addition to technological concerns, this course discusses the impact of HVAC on society, global energy awareness, and energy efficient design. These discussions emphasize analysis and problem solving skills in addition to the critical thinking abilities required in the design and selection of HVAC equipment. Two team projects build teamwork skills. A written paper and an oral presentation build communications skills.

III. Detailed Course Description

The subject matter of this course includes an overview of various HVAC systems with an emphasis on cooling applications. Comfort conditions, psychometrics, HVAC components, equipment sizing and selection, cycle efficiencies, and duct and piping layouts are analyzed and designed.

IV. Requirements Fulfilled

This course is required for majors in mechanical engineering.

V. Required Prerequisites

- GEEN 3311: Introduction to Fluid Mechanics
- MEEN 3322: Thermodynamics II
- MEEN 4321: Heat Transfer

VI. Learning Outcomes

- To learn the basics of HVAC, including comfort, indoor air quality, and equipment.
- To develop the skills necessary to be able to design an HVAC system.

VII. Assessment Strategy

Students are assessed in a variety of ways, including examinations, projects, and homework. They work in teams to develop teamwork and learn leadership skills.

- Examinations – in class exams measure the progress of the students in being able to apply thermo, fluid mechanics, and heat transfer theory to HVAC designs
- Projects – two projects are assigned.

  The first assesses the student's skills in doing library and Internet research on a topic of global importance. Students prepare a written report and a power point oral presentation. Two person groups are used for each project.

  The second project involves four-person teams, and is a technical design project. Both a written report and an oral presentation are required.
- Homework – numerous homework problems are assigned to provide practice on problem solving and critical thinking. The problems draw heavily on prior skills learned in thermo, fluid mechanics, and heat transfer.

VIII. Course Format

The format of the course is all lecture.

Classroom Hours (3 hours per week) **Class:** 3
Lab: 0

IX. Topics to Be Covered

A. Introduction to HVAC systems
B. Energy efficiency and importance to world energy issues
C. Psychometrics
D. Indoor air quality/comfort issues
E. HVAC thermodynamic cycles
F. Refrigerants
G. HVAC system components
H. Heat pumps
I. Absorption systems
J. Pumps and piping design
K. Fans and duct system design

X. Laboratory Exercises

This course does not require a separate lab.

XI. Technology Component

A. Students are required to use the Internet extensively for the initial project. In addition the textbook provides a CD containing various software programs which can be used for psychometric properties, piping selection, and design, and coil design. After learning the basics which are used in the programs, the students use the software for design and analysis.

B. The software provided with the text requires the use of the student's personal laptop computer. Projects also require use of the laptop.

XII. Special Projects/Activities

The two projects are very different in nature, but both are team efforts.

A. <u>Project One</u>

The first project is on a topic of global interest to the students and the course. It involves two-person teams, extensive Internet and library research, a written report, and an oral, power point presentation. Topics might include:

- Energy efficiency in HVAC design
- The importance of sustainable development to Islamic countries
- Energy growth in third world countries
- Energy supply and demand – future growth
- The impact of LNG to foreign markets
- Historical energy consumption in the Western countries and projected growth
- Importance of China and India on projections of future energy needs

B. <u>Project Two</u>

The second project is a technical project assigned to four-person teams. These teams are given a project to design and size an HVAC system, including piping layout, pump selection, duct layout and fan selection. The student teams prepare a written report and make an oral presentation.

XIII. Textbooks and Teaching Aids

A. Required Textbook

McQuiston, Parker, and Spitler. *Heating, Ventilating and Air Conditioning*, Revised 5th Edition. ___: John Wiley, 2000. (Includes software CD)
ISBN:

B. Alternative Textbooks

Kreider, Curtiss and Rabl. *Heating and Cooling of Buildings*, 2nd Edition. ____: McGraw Hill, 2002.

C. Supplemental Print Materials

None.

D. Supplemental Online Materials

None.

Course Title: MEEN 4312: Fluid Mechanics

Semester Credit Hours: 3 (3,0)

I. Course Overview

This course introduces students to additional topics in fluid dynamics. Piping systems are studied in series and in parallel. Boundary layers and bluff body flows are studied to determine how to calculate drag and lift on smooth and bluff bodies. Flow through fluid machinery is studied to learn the fundamentals of the design of fluid machinery. Compressible flow is studied to learn the effects of compressibility on fluid flow.

II. PMU Competencies and Learning Outcomes

Critical thinking and problem solving are the cornerstones of this course, which addresses a number of problems in the field of fluid mechanics. The course builds professional competencies as it extends prior knowledge in fluid mechanics, thermodynamics, physics, and calculus. Frequent written homework assignments build communications skills. No formal oral presentations or group assignments are included in the course.

III. Detailed Course Description

In this course, students learn to solve problems related to piping systems in series and/or parallel. They are introduced to the concept of a boundary layer and to pressure and viscous forces acting on a body due to a flowing fluid. Students learn to solve problems relating to lift and drag. Flow through turbomachines is considered, and students learn the fundamental principles of flow through pumps, fans, turbines, and compressors and how to do a simple design for such flows. The students learn about how compressibility affects flow. They learn to solve problems relating to area change, friction, shock waves, and heat transfer in compressible flows.

IV. Requirements Fulfilled

This course is an elective for majors in mechanical engineering.

V. Required Prerequisites

- GEEN 3311: Introduction to Fluid Mechanics
- MEEN 3322: Thermodynamics II

VI. Learning Outcomes

- To teach students to learn how to treat piping systems in parallel and in series.

  Students are able to design simple systems like a pump with the accompanying piping, piping systems in parallel or series and understand the difference.

- To teach the students to learn the importance of the flow in a boundary layer.

  Students understand the concept and importance of a boundary layer. They are able to solve simple problems related to boundary layers, such as the determination of friction drag and the concept of boundary layer separation.

- To teach the students to learn the concepts of flow over bluff bodies and streamlined bodies and to appreciate their differences.

  Students understand the difference between pressure and viscous drag and know when to use either or both concepts and know how to calculate drag.

- To teach the students to learn the fundamentals of flow through fluid machines.

  Students understand the concepts of turbomachines and know how to determine the head developed and the power required in the operation of a turbomachine.

- To teach the students to learn the influence of compressibility on flow, including flows with area change, friction, shock wave, and heat transfer.

  Students understand the concepts of compressible fluid flow; how to calculate flow in isentropic conditions, with friction, with heat transfer, and shock waves.

VII. Assessment Strategy

The course is a lecture in which the students are expected to be participants in classroom discussion. There are regular homework assignments, and students receive feedback from the instructor regarding their performance on the homework. The major part of the course grade is based on the performance of the student from tests taken in an in-class setting.

- Examinations – in-class exams are given to test the student's ability to solve problems using the principles of fluid mechanics and to assimilate the material from previous courses, particularly, physics, mathematics, thermodynamics, and the fundamentals of fluid mechanics.
- Homework – problems are assigned for individual student submission.

VIII. Course Format

This course is a lecture course meeting three hours per week in a lecture room setting. The students are required to work on homework problems in an out-of-class setting.

Classroom Hours (3 hours per week)	**Class:**	3
	Lab:	0

IX. Topics to Be Covered

A. Piping systems
   1. Pipes in series
   2. Pipes in parallel
B. External flows-boundary layers
   1. Laminar boundary layers, exact solutions from differential equations
   2. Laminar boundary layers, momentum integral approach
   3. Turbulent boundary layers, momentum integral approach
C. Flow over bodies
   1. Viscous drag on a plate parallel to the flow direction
   2. Pressure drag on a plate normal to the flow direction
   3. Pressure drag and viscous drag on a bluff body
D. Fluid machinery
   1. Classification of pumps and fans; development of pump laws from dimensional analysis
   2. Turbomachinery analysis and equations
   3. Performance characteristics
   4. Analysis of pumping systems
E. Compressible flow
   1. Review of relevant thermodynamics
   2. Isentropic flow equations, flow with area change
   3. Flow in a duct with friction
   4. Flow in a duct with heat transfer
   5. Shock waves
   6. Flow in a channel with a shock wave

X. Laboratory Exercises

This course does not require a separate lab.

XI. Technology Component

Students are required to use their laptop computers in completing and submitting their homework assignments. Examinations are taken in the classroom using no electronic assistance. Computer solutions using MATLAB are required.

XII. Special Projects/Activities

There are no special projects associated with this course.

XIII. Textbooks and Teaching Aids

A. Required Textbook

Fox, R.W., A.T. McDonald, and P.J. Pritchard. *Introduction to Fluid Mechanics*, 6th Edition. ____: J. Wiley and Sons, 2004.
ISBN:

B. Alternative Textbooks

None.

C. Supplemental Print Materials

None.

D. Supplemental Online Materials

None.

Course Title: **MEEN 4315: Principles of Building Energy Analysis**

Semester Credit Hours: 3 (3,0)

I. Course Overview

The course uses current ASHRAE building load calculation methods to analyze building energy use. Both the heat balance (HB) and radiant time series (RTS) methods are used to calculate building loads. The course uses competencies from thermodynamics, heat transfer, and mathematics courses, and complements the MEEN 4311: Principles of HVAC course. Either the loads course or the HVAC course may be taken first.

II. Competencies Addressed

Critical thinking and problem solving skills are emphasized in this course. A design project builds skills in teamwork, communication (oral and written), and the use of computer technology.

III. Detailed Course Description

This course considers solar radiation loads, heating and cooling loads, analysis of building use using ASHRAE building load calculation methodologies, the heat balance (HB), and radiant time series (RTS) methods. Psychometric analysis and thermal comfort also are included.

IV. Requirements Fulfilled

This course is an elective for majors in mechanical engineering. It is a companion course to the required course MEEN 4311: Principles of Heating, Ventilating, and Air Conditioning (HVAC). It may be taken prior to, after, or in parallel with the HVAC class.

V. Required Prerequisites

Successful completion of:

- MEEN 3322: Thermodynamics II

Concurrent registration in:

- MEEN 4321: Heat Transfer

VI. Learning Outcomes

- To learn the various methods of calculating building loads.
- To develop the skills to calculate energy loads in buildings.

VII. Assessment Strategy

This course lends itself to the assignment of short problems as well as longer, design-oriented problems. Both approaches are used to assess the student's mastery of the course material. The students are divided into teams, assigned a team leader, and solve a load analysis problem for a real building. Computer software programs are used for the load analysis, a written report is required, and an oral presentation is made.

- Examinations ─ In class exams are given to test critical thinking and problem solving skills
- Design project ─ Semester project requires analysis, design, a written report, and an oral presentation
- Homework ─ Periodic assignments are given to test the student's problem solving skills and their ability to apply principles taught in previous courses, notably Thermodynamics II and Heat Transfer

VIII. Course Format

The course is lecture style, meeting three hours per week. A major design project is assigned, but the majority of this work is done outside of class.

Classroom Hours (3 hours per week) **Class:** 3
Lab: 0

IX. Topics to Be Covered

A. Elements of heat transfer as it relates to buildings
   1. Conduction
   2. Convection
   3. Radiation
B. Heat balance method
C. Radiant time series
D. Thermodynamic processes in buildings
E. Solar radiation ─ impact on cooling loads
F. Principles of load calculations
G. Detailed residential heat balance methods
H. Cooling/heating load calculations

X. Laboratory Exercises

This course does not have a lab.

XI. Technology Component

This is a problem-solving course, which lends itself to the use of computers and software packages for solving problems. The building load analyses require computer solutions outside of class, and the design project requires team members to make extensive use of computer facilities. Students also learn of the various commercial software codes for calculating building loads and should be able to apply their knowledge to the use of these codes as well.

XII. Special Projects / Activities

After they gain a fundamental knowledge of the inputs that go into calculating building energy loads, students are divided into teams and assigned a building to analyze. The students are asked to calculate the envelope loads, solar heat gain, loads from people, ventilation loads, the overall heating and cooling loads, and the HVAC system size required to meet the building loads.

XIII. Textbooks and Teaching Aids

A. Required Textbook

Kreider, J., P. Curtiss, and A. Rabl. *Heating and Cooling of Buildings*, 2nd Edition. Dubuque, Iowa: McGraw Hill, 2001. (Selected chapters)
ISBN: 0-072-49676-2

B. Alternative Textbooks

McQuiston, Faye, J. D. Parker, and J. D. Spitler. *Heating, Ventilating and Air Conditioning*, 5th Edition. New York, New York: John Wiley and Sons, 2000. (Includes software CD)
ISBN: 0-471-35098-2

C. Supplemental Print Materials

None.

D. Supplemental Online Materials

None.

Course Title: MEEN 4321: Heat Transfer

Semester Credit Hours: 3 (3,0)

I. Course Overview

This course introduces the concepts of heat transfer, including conduction, convection, and radiation. Students learn to solve problems concerning transfer across solid surfaces, heat transfer through moving and stationary fluids, and heat transfer through space.

II. PMU Competencies and Learning Outcomes

Critical thinking and problem solving is the cornerstones of this course as students are introduced to conduction, convection, and radiation as three distinct means of heat transfer. This course builds professional capabilities as it extends prior knowledge from calculus, physics, thermodynamics, and fluid mechanics. Frequent written homework assignments build communications skills. No formal oral presentations or group assignments are included in the course.

III. Detailed Course Description

This course uses the concepts of conduction, convection, and radiation within the context of the laws of thermodynamics to teach students to solve problems involving changes in temperature, energy, and velocity. Students are expected to have a thorough understanding of calculus, physics, thermodynamics and the fundamentals of fluid mechanics to be successful in this course.

IV. Requirements Fulfilled

This course is required for majors in mechanical engineering.

V. Required Prerequisites

- GEEN 3311: Introduction to Fluid Mechanics
- MEEN 3322: Thermodynamics II

VI. Learning Outcomes

- To teach students the underlying physical phenomena and the methods of solving problems in the fundamental modes of heat transfer and the analysis of typical problems in which the modes operate in combination.
  - Students understand the phenomena of heat conduction and be able to analyze problems in one-dimensional heat conduction with and without internal heat generation.
  - Students understand how to solve elementary steady heat conduction problems in two dimensions and appreciate how numerical solutions can be used in complex geometries.

- Students understand the origin of dimensionless groups and be able to use experimental correlation results to calculate heat convection rates in a variety of cases.
- Students know how boundary layer theory plays a role in understanding the mechanisms of heat convection.
- Students are able to solve elementary problems in radiative exchange.
- Students are able to solve problems where convection, conduction and radiation interact in simple geometries.

- To introduce the design of heat transfer systems, particularly heat exchangers.

  Students are able to design simple systems to produce a desired result. Specifically, simple heat exchangers satisfying elementary constraints are considered.

VII. Assessment Strategy

The is a lecture course in which the students are expected to be participants in classroom discussion. There are regular homework assignments, and students receive feedback from the instructor regarding their performance on the homework. The major part of the course grade is based on the performance of the student from tests taken in an in-class setting.

- Examinations – in-class exams are given to test the student's ability to solve problems using thermodynamics and to assimilate the material from previous courses, particularly, chemistry, physics, and mathematics.
- Homework – problems are assigned for individual student submission. Computer solutions using MATLAB are required as a part of the homework assignments.

VIII. Course Format

This course is a lecture course meeting three hours per week in a lecture room setting. Students are required to work on homework problems in an out-of-class setting.

Classroom Hours (3 hours per week) **Class:** 3
Lab: 0

IX. Topics to Be Covered

A. Review of concepts of thermodynamics, differential equations, dimensions and unit systems. Scope of course and introduction to the physics of the modes of heat transfer and lumped capacity systems
B. Heat conduction in one dimension, radiation, heat convection, combined modes of heat transfer and electrical analogies
C. Introduction to heat exchangers. Effectiveness and NTU concepts. Single stream heat exchangers

D. One-dimensional heat conduction in non-planar geometries. Internal heat generation
E. Fins and fin optimization
F. Multidimensional heat conduction
G. Unsteady heat conduction in slabs cylinders and spheres. Product solutions
H. Equations of motion and energy. Reduction to boundary layer equations
I. Dimensionless groups and dimensional analysis and modeling
J. Forced convection in external and internal flows. Natural convection. Boundary layers. Viscous dissipation
K. Thermal radiation. Planck's and Wien's laws. Thermal exchange between black and/or gray surfaces
L. Heat Exchangers. Counterflow, parallel flow and crossflow examples. Design issues

X. Laboratory Exercises

This course does not require a separate lab.

XI. Technology Component

The students use their laptop computers in completing and submitting homework assignments. Examinations are taken in the classroom using no electronic assistance. Computer solutions using MATLAB are required.

XII. Special Projects/Activities

There are no special projects associated with this course.

XIII. Textbooks and Teaching Aids

A. Required Textbook

A. F. Mills, *Heat Transfer*, 2nd Edition. ___: Prentice-Hall, 1998. ISBN:

B. Alternative Textbooks

None.

C. Supplemental Print Materials

None.

D. Supplemental Online Materials

None.

Course Title: **MEEN 4322: Power Generation**

Semester Credit Hours: 3 (3,0)

I. Course Overview

The course provides a broad knowledge of systems in modern power plants and is an application of engineering sciences, principally thermodynamics and fluid mechanics. The energy conversion processes is emphasized, with concentration on gas turbine combined cycle plants and traditional oil or gas-fired power generation.

II. Competencies Addressed

Because energy continues to be of major importance to the entire world, this course has the opportunity to give the students a global awareness of energy consumption; the importance of coal, oil, natural gas, and nuclear energy; the role of renewables; and the importance of energy efficiency. Extensive Internet sources are available to obtain this energy information, which help students build technology competencies as they gain a global perspective on energy. The course is technical, and the students are required to demonstrate their mastery of thermodynamics, fluid mechanics, materials science, and mathematics in demonstrating their critical thinking and problem solving skills.

III. Detailed Course Description

The course covers the various systems and cycles normally used in producing electrical power. There is an overview of the various types of plants, fossil fuel, nuclear, hydro, and solar power plants, but the main emphasis is on gas turbine, combined cycle plants and traditional steam-generation plants burning natural gas or oil. The steam generation systems, the condenser systems, combustion, pump and fan operation, and emission controls are covered in the course.

IV. Requirements Fulfilled

This course is required for majors in mechanical engineering.

V. Required Prerequisites

Successful completion of:

- GEEN 3311: Introduction to Fluid Mechanics
- MEEN 3322: Thermodynamics II

Concurrent registration in

- MEEN 4321: Heat Transfer (co-requisite)

VI. Learning Outcomes

- To learn about the various energy systems used to produce electrical power.
- To learn the importance of energy and energy efficiency in a global sense.
- To develop the skills to design a modern power generation plant.

VII. Assessment Strategy

The course is a required, senior-level class for mechanical engineering majors. It requires students to apply their critical thinking and problem-solving skills to engineering problems. Homework and examinations are used to demonstrate these skills. An awareness of the global societal needs for energy and the uses of energy by different countries require Internet research. A class design project emphasizes teamwork, leadership, and communication skills.

- Examinations ─ In-class examinations test the student's ability to apply problem-solving and critical-thinking skills.
- Homework ─ Out of class assignments utilize concepts from thermodynamics, fluid mechanics, heat transfer, and materials science for problem solving. Also, assignments on energy production and consumption throughout the world require the use of the Internet to find the latest energy data.
- Project ─ A project is assigned for groups of six to eight students to design a power plant, write a report, and present to the class. This project addresses many of the competencies, including teamwork, leadership, critical thinking, problem solving, oral and written communication.

VIII. Course Format

The course is a lecture only class, but assignments are made for out of class homework, Internet searches, and projects.

Classroom Hours (3 hours per week)	**Class:** 3
	Lab: 0

IX. Topics to Be Covered

A Introduction to power generation and energy needs for World, U.S., Europe, Islamic countries, third world countries
B. Modern power plant layouts, including coal-fired, gas-fired combined cycle, nuclear, and renewable energy
C. Thermodynamic principles, including Carnot cycle, Rankine cycle, Brayton cycle, and combined cycles
D. Combustion processes

E. Steam generation / boiler systems
    1. Direct-fired
    2. Waste heat recovery
    3. Boiler components
    4. Efficiency
    5. Auxiliaries
F. Steam turbine systems
    1. Heat balance
    2. Second law considerations
    3. Performance
    4. Capacity
    5. System selection
G. Gas turbine systems, components, efficiency, component selection
H. Combined cycle power plants and cogeneration
    1. Efficiencies
    2. Heat balance
    3. System considerations
I. Fans
    1. Types
    2. Performance
    3. Operating characteristics
    4. Design consideration
J. Pumps, pump characteristics, pump selection, applications to power plants
K. Condensers, thermal design, heat transfer, condenser selection
L. Cooling towers, types, selection, design performance
M. Power plant emissions, controls, monitoring

X. Laboratory Exercises

This course does not require a separate laboratory.

XI. Technology Component

Students use technology through Internet-related research projects. Energy technologies are developing fast, and textbooks cannot keep pace. Renewable energy projects, both solar and wind, for example, are being installed throughout the world, and by researching the Internet, students can find out which projects are being installed, capacity, cost, and other factors. This type of technical literature search is beneficial to the students because it teaches them to stay abreast of current technologies and train them to use the Internet to obtain up-to-date information and data.

XII. Special Projects / Activities

Two project activities are assigned. The first deals with global energy issues, and the second is a multi-week design project.

A. Project One

A project intended to introduce the students to the “big picture” of energy including global energy issues, energy consumption worldwide, supply and demand, energy efficiency, consumption in U.S., European Common Market, Islamic countries, and developing countries. The purpose is to give the students a global view of energy. This project could be given to individuals or small teams, and could be broken down into various topics and reported on by each team.

B. Project Two

A design project assigned to large project teams of six to eight students in a multi-week project to design a power plant. The students are assigned design requirements such as site, type of plant, size, and cost limitations, and are asked to provide a conceptual system design.

XIII. Textbooks and Teaching Aids

A. Required Textbook

Li, Kam W. and Paul Priddy. *Power Plant System Design*, New York, New York: John Wiley & Sons, 1985.
ISBN: 0-471-88847-8

B. Alternative Textbooks

1. Black and Veatch. *Power Plant Engineering*. New York, New York: Chapman & Hall, 1995.
   ISBN:
2. Culp, A. W. *Principles of Energy Conversion*, 2^{nd} Edition. New York, New York: McGraw-Hill Book Company, 1990.
   ISBN: 0-070-14902X
3. Flynn, Damian, Editor. *Thermal Power Plant Simulation and Control*. London, UK: Institution of Electrical Engineers, 2003.
   ISBN: 0-852-96419-6

C. Supplemental Print Materials

None.

D. Supplemental Online Materials

None.

Course Title: MEEN 4331: Internal Combustion Engines

Semester Credit Hours: 3 (3,0)

I. Course Overview

This course is an application of the thermal sciences applied to internal combustion engines. The thermodynamic engine cycles is reviewed and intake and exhaust processes are covered. Both spark-ignition (the Otto cycle) and compression-ignition (the Diesel cycle) engines are analyzed.

II. PMU Competencies and Learning Outcomes

Critical thinking and problem solving are the cornerstones of this course, as students are introduced to all of the aspects of the internal combustion engine. This course builds professional competencies as it extends prior knowledge from the thermal sciences and chemistry. Frequent written homework assignments build communications skills. No formal oral presentations or group assignments are included in the course.

III. Detailed Course Description

In this course, students learn to solve problems involving the fluid mechanics, thermodynamics, and heat transfer of the internal combustion engine. Students are expected to have a thorough understanding of thermodynamics, fluid mechanics, heat transfer, and chemistry to be successful in this course.

IV. Requirements Fulfilled

This course is an elective for majors in mechanical engineering.

V. Required Prerequisites

- MEEN 3322: Thermodynamics II
- MEEN 4321: Heat Transfer (co-requisite)

VI. Learning Outcomes

- To learn the fundamental concepts of internal combustion engines and the parameters associated with them.
- To become familiar with the various processes that are included in an internal combustion engine cycle.
- To be able to analyze fluid flow and heat transfer that occur during the engine cycle.
- To be able to analyze the combustion process that occurs during the engine cycle.

VII. Assessment Strategy

The course is a lecture in which the students are expected to be participants in classroom discussion. There are regular homework assignments, and students receive feedback from the instructor regarding their performance on the homework. The major part of the course grade is based on the performance of the student from tests taken in an in-class setting.

- Examinations – in-class exams are given to test the student's ability to solve problems using thermodynamics and to assimilate the material from previous courses, particularly, chemistry, physics, and mathematics.
- Homework – problems are assigned for individual student submission.

VIII. Course Format

This course meets three hours per week in a lecture room setting. Students are required to work on homework problems in an out-of-class setting.

Classroom Hours (3 hours per week)	**Class:**	3
	Lab:	0

IX. Topics to Be Covered

A. Review of concepts of fluid mechanics, thermodynamics, and heat transfer as they apply to the internal combustion engine
B. The Otto and Diesel cycles for internal combustion engines
C. Analysis of the spark-ignition engine (the Otto cycle)
D. Analysis of the compression-ignition engine (the Diesel cycle)
E. The combustion process in the engine
F. The air and fuel intake process
G. The combustion-products exhaust process
H. Second-law analysis of the internal combustion engine

X. Laboratory Exercises

This course does not require a separate lab.

XI. Technology Component

Students use their laptop computers in completing and submitting their homework assignments. Examinations are taken in the classroom using no electronic assistance. Computer solutions using MATLAB are required as part of homework assignments.

XII. Special Projects/Activities

There are no special projects associated with this course.

XIII. Textbooks and Teaching Aids

A. Required Textbook

To be determined.

B. Alternative Textbooks

None.

C. Supplemental Print Materials

None.

D. Supplemental Online Materials

None.

Course Title: **MEEN 4332: Turbomachinery**

Semester Credit Hours: 3 (3,0)

I. Course Overview

This course applies the thermal sciences to the design of pumps, fans, compressors, and turbines. Similarity and scaling laws are developed. Radial and axial flow machines are analyzed. Blade design for both pumps and turbines are considered. Design of centrifugal pumps and axial flow compressors is studied.

II. PMU Competencies and Learning Outcomes

Critical thinking and problem solving is the cornerstones of this course, as students learn to solve problems involving the fluid mechanics, thermodynamics, and heat transfer of turbomachinery. This course builds professional competencies as it extends prior knowledge from the thermal sciences. Frequent written homework assignments build communication skills. No formal oral presentations or group assignments are included in the course.

III. Detailed Course Description

This course introduces students to turbomachines including pumps, fans, compressors and turbines. Students are expected to have a thorough understanding of thermodynamics, fluid mechanics, heat transfer, and chemistry to be successful in this course.

IV. Requirements Fulfilled

This course is an elective for majors in mechanical engineering.

V. Required Prerequisites

- MEEN 3322: Thermodynamics II
- MEEN 4321: Heat Transfer (co-requisite)

VI. Learning Outcomes

- To learn the fundamental concepts of turbomachines and the parameters associated with them.
- To become familiar with the various processes that represent a turbomachine.
- To be able to analyze the fluid flow and heat transfer that occur during flow through a turbomachine.
- To develop an understanding of blade design for both pumps and compressors.

VII. Assessment Strategy

The course is a lecture in which the students are expected to be participants in classroom discussion. There are regular homework assignments, and students receive feedback from the instructor regarding their performance on the homework. The major part of the course grade is based on the performance of the student from tests taken in an in-class setting.

- Examinations – in-class exams are given to test the student's ability to solve problems using thermodynamics and to assimilate the material from previous courses, particularly, chemistry, physics, and mathematics.
- Homework – problems are assigned for individual student submission.

VIII. Course Format

This course is a lecture course meeting three hours per week in a lecture room setting. The students are required to work on homework problems in an out-of-class setting.

Classroom Hours (3 hours per week)	**Class:**	3
	Lab:	0

IX. Topics to Be Covered

A. Review of concepts of fluid mechanics, thermodynamics, and heat transfer as they apply to turbomachines
B. Similarity and scaling laws for pumps and turbines
C. Flow through a centrifugal pump
D. Flow through a turbine
E. Analysis of blade design for pumps and turbines
F. Design of fans
G. Design of axial flow compressors

X. Laboratory Exercises

This course does not require a separate lab.

XI. Technology Component

Students use their laptop computers in completing and submitting their homework assignments. Examinations are taken in the classroom using no electronic assistance. Computer solutions using MATLAB are required as part of homework assignments.

XII. Special Projects/Activities

There are no special projects associated with this course.

XIII. Textbooks and Teaching Aids

A. Required Textbook

To be determined.

B. Alternative Textbooks

None.

C. Supplemental Print Materials

None.

D. Supplemental Online Materials

None.

Course Title: **MEEN 4341: Corrosion Engineering**

Semester Credit Hours: 3 (3,0)

I. Course Overview

This course covers the causes and mechanisms of aqueous corrosion, including electrochemistry and thermodynamics of corrosion. Materials selection and design for minimization of corrosion, as well as corrosion protection are included. Selected case studies are discussed.

II. PMU Competencies and Learning Outcomes

The course builds critical thinking and problem solving abilities as it extends the student's knowledge gained in prior courses. A design project builds teamwork skills and enhances written and oral communication skills. Literature review for the design project involves use of the Internet and builds technology competencies.

III. Detailed Course Description

This course covers electrochemistry of corrosion; corrosion types; corrosion prevention; materials selection, and design to minimize corrosion. It relies heavily on courses the student has previously taken, including chemistry, thermodynamics, mathematics, electrical circuits, and the materials courses.

IV. Requirements Fulfilled

This course is an elective for majors in mechanical engineering.

V. Required Prerequisites

- MEEN 3322: Thermodynamics II
- MEEN 3212: Materials Engineering and Selection

VI. Learning Outcomes

- To learn about the mechanisms and causes of corrosion.
- To develop skills for materials selection and protection to minimize impacts of corrosion.

VII. Assessment Strategy

The course includes homework, examinations, and a design project. The homework and examinations assess the individual's abilities to assimilate the knowledge gained in chemistry, thermodynamics, and the materials science courses and to demonstrate their critical thinking and problem solving skills. A design project gives students an opportunity to conduct Internet research, write a report, and give an oral presentation.

- Homework – assesses the student's critical thinking and problem-solving skills. The nature of the topic Corrosion Engineering is such that case studies and other Internet-related research can also be assigned outside of class.
- Examinations – focus primarily on problem solving and critical thinking
- Design project – the class is divided into teams, assigned team leaders, and given a small design project involving materials selection or corrosion protection. The design project would include Internet research, materials selection, a written and an oral report. An example of a project might include the design of a valve for a down hole sour gas well application or cathodic protection of a pipeline.

VIII. Course Format

The course is a three-hour lecture class per week, with outside class assignments.

Classroom Hours (3 hours per week)

Class: 3
Lab: 0
Computer aided: (as required)

IX. Topics to Be Covered

A. Review of chemistry, periodic table, Redox reactions
B. Electrochemistry
C. Chemical thermodynamics
D. Types of corrosion
E. Materials selection and design
F. Corrosion protection/prevention
G. Case studies

X. Laboratory Exercises

This course does not have a separate lab.

XI. Technology Component

The course involves significant use of the Internet in researching case studies and in the design project. Computer work is required outside of class for some of the homework assignments and for the design project.

XII. Special Projects/Activities

A design project require teamwork, a written and oral report, and extensive use of the computer and Internet outside of class.

XIII. Textbooks and Teaching Aids

A. Required Textbook

Jones, D. A. *Principles and Prevention of Corrosion*. New York, New York: MacMillan, 1987.
ISBN:

B. Alternative Textbooks

None.

C. Supplemental Print Materials

1. *Corrosion, Metals Handbook*, Vol. 13, 9th Edition. ___: ASM International, 1987.
   ISBN:
2. Fontana, M. G. *Corrosion Engineering*. ___: McGraw Hill, 1986.
   ISBN:

D. Supplemental Online Materials

None.

Course Title: **MEEN 4392: Advanced Control Systems**

Semester Credit Hours: 3 (3,0)

I. Course Overview

This course covers mathematical modeling, analysis, design, and synthesis of systems, including mechanical, electrical, hydraulic and thermal subsystems. Topics include Newtonian mechanics, multiple degrees of freedom vibrations, and control system design.

II. Competencies Addressed

This course builds professional competencies by extending prior knowledge to the analysis and synthesis of advanced control system design. Critical thinking and problem solving are developed using skills gained in courses covering mathematics, MATLAB programming, computational methods, and engineering design. The course builds technology competence through the use of computers. It improves communication skills through oral and written reports. Team projects enhance teamwork and leadership skills.

III. Detailed Course Description

The course teaches the students how to model mechanical, electrical, hydraulic, and thermal subsystems and to design control systems. The course covers classical dynamics, multiple degrees of freedom vibrations, transient and steady-state performance, and control system design specifications.

IV. Requirements Fulfilled

This course is an elective for majors in mechanical engineering.

V. Required Prerequisites

- MEEN 3332: Computational Methods
- MEEN 3392: Engineering Design II

VI. Learning Outcomes

- To learn the various analytical and numerical methods for modeling dynamic systems.
- To develop the skills necessary to design dynamic system controls.

VII. Assessment Strategy

This course has several means of assessing the student’s performance. These include homework, examinations, and small mini-projects to be completed by teams of students throughout the semester. Written and oral reports are required.

- Homework ─ Problems are assigned to give students the opportunity to apply their problem-solving skills.
- Examinations ─ Problem solving and critical thinking are assessed by in-class examinations, requiring the students not only to apply the new knowledge gained in this course but also the knowledge from prior courses such as MEEN 3392: Engineering Design II and MEEN 3332: Computational Methods.
- Mini-projects ─ Three to four small projects are assigned throughout the semester, to be done in teams of three or four students. The projects require the students to analyze, solve, and report on their findings. Computer labs and software programming using MATLAB is a part of each project.

VIII. Course Format

The primary mode of instruction involves three hours of lecture per week, but mini-projects and homework require extensive use of computing facilities outside of class time.

Classroom Hours (3 hours per week)	**Class:**	3
	Lab:	0

IX. Topics to Be Covered

A. Input-output modeling
B. State and state-equations concepts and their solutions
C. Multiple degrees of freedom vibrations
D. Modeling of electromechanical systems using classical Newtonian mechanics and Kirchoff's laws
E. Frequency response
F. Classical dynamics
G. Steady state and transient performance specifications as related to design
H. Loop shaping design and feedback systems

X. Laboratory Exercises

This course does not require a separate laboratory.

XI. Technology Component

Students use their personal laptop computers extensively to solve homework problems and for the mini-projects. MATLAB and other software are used.

XII. Special Projects / Activities

A series of mini-projects is assigned, which require the use of personal computers and the formation of teams. The projects require computer usage outside of class and involve both modeling and design of dynamic systems control.

XIII. Textbooks and Teaching Aids

A. Required Textbook

Franklin, G. F., J. D. Powell, and A. E. Naeini. *Feedback Control of Dynamic Systems*, 4th Edition. Englewood Cliffs, New Jersey: Prentice-Hall, 2002.
ISBN: 0-130-32393-4

B. Alternative Textbooks

None.

C. Supplemental Print Materials

None.

D. Supplemental Online Materials

None.