**ESSEX COUNTY COLLEGE**

**Engineering Technologies and Computer Sciences Division**

**MET 215 – Fluid Mechanics**

**Course Outline**

**Course Number & Name:**  MET 215 Fluid Mechanics

**Credit Hours:**  3.0 **Contact Hours:**  4.5 **Lecture:** 2.0 **Lab:**  2.5 **Other:**  N/A

**Prerequisites**:  Grade of “C” or better in PHY 101

**Co-requisites:** MTH 114 and MET 211 **Concurrent Courses:** None

**Course Outline Revision Date:**  Fall 2010

**Course Description**: This course covers the basic concepts and applications of fluid systems, including essentials of fluid properties, fluid statics, Bernoulli's Theorem, fluid measurements, and losses through flow in pipes. The laboratory work will deal with models and operational systems as well as exercises involving the underlying principles of hydraulic and pneumatic mechanisms.

**Course Goals:** Upon successful completion of this course, students should be able to do the following:

1. describe the nature of fluids and analyze fluid mechanics systems;

2. explain and measure the viscosity of fluids;

3. explain and perform pressure measurement;

4. explain forces due to static fluids;

5. describe and analyze buoyancy and stability;

6. describe the flow of fluids and calculate related characteristics;

7. explain and apply the general energy equation;

8. explain minor losses in fluid systems;

9. describe open channel flow and calculate related characteristics; and

10. compute forces due to fluids in motion.

**Measurable Course Performance Objectives (MPOs)**: Upon successful completion of this course, students should specifically be able to do the following:

1. Describe the nature of fluids and analyze fluid mechanics systems:

* 1. *differentiate between a gas and liquid;*
  2. *define pressure;*
  3. *identify the units of basic quantities of time, length, force, and mass in the SI system;*

**Measurable Course Performance Objectives (MPOs)** (continued):

* 1. *identify the units of basic quantities of time, length, force; and mass in the US Customary system;*
  2. *properly set up equations to ensure consistency of units;*
  3. *describe the relationship between force and mass;*
  4. *define density, specific weight, and specific gravity;*
  5. *identify relationships between specific weight, specific gravity, and density and solve problems using these relationships;* and
  6. *define surface tension*

2. Explain and measure the viscosity of fluids:

2.1 *define dynamic viscosity;*

2.2 *define kinematic viscosity;*

* 1. *identify the units of viscosity in both the SI system and the US Customary system ;*
  2. *describe the differences between a Newtonian fluid and a non-Newtonian fluid;*
  3. *describe and apply the methods of viscosity measurement using the rotating-drum viscometer, the capillary-tube viscometer, the falling-ball viscometer, and the Saybolt Universal viscometer;*
  4. *describe the variation of viscosity with temperature for both liquids and gases;*
  5. *define viscosity index;* and
  6. *describe the viscosity of lubricants using the SAE viscosity grades and the ISO viscosity grades*

1. Explain and perform pressure measurement:
   1. *define the relationship between absolute pressure, gage pressure, and atmospheric pressure;*
   2. *describe the degrees of variation of atmospheric pressure near the Earth’s surface;*
   3. *describe the properties of air at standard atmospheric pressure;*
   4. *describe the properties of the atmosphere at elevations from sea level to 30,000 meters;*
   5. *discuss the relationship between change in elevation and change in pressure in a fluid;*
   6. *describe how a manometer works and explain how it is used to measure pressure;*
   7. *describe and use a U-tube manometer, a differential manometer, a well-type manometer and an inclined well-type manometer;*
   8. *describe a barometer and explain how it indicates the value of a local atmospheric pressure;*
   9. *describe various types of pressure gages and pressure transducers;*
   10. *identify the basic components of the hydraulic/pneumatic (bench) trainer;* and
   11. *operate the hydraulic/pneumatic (bench) trainer*

4. Explain forces due to static fluids:

* 1. *compute forces exerted on a plane area by a pressurized gas;*
  2. *compute the force exerted by any static fluid acting on a horizontal plane area;*
  3. *compute the resultant force exerted on a rectangular wall by a static liquid;*
  4. *define the term “center of pressure”;*
  5. *compute the resultant force exerted on any submerged plane area by a static liquid;* and
  6. *determine and sketch area in its proper location and direction the vector representing the resultant force on any submerged object*

**Measurable Course Performance Objectives (MPOs)** (continued):

5. Describe and analyze buoyancy and stability:

5.1 *write the equation for the buoyant force;*

5.2 *analyze the case of bodies floating in a fluid;*

* 1. *apply the principle of static equilibrium to solve for the forces involved in buoyancy problems;*
  2. *describe the conditions that must be met for a body to be stable when completely submerged in a fluid;*
  3. *describe the conditions that must be met for a body to be stable when floating on a fluid;* and
  4. *define the term “metacenter” and compute its location*

6. Describe the flow of fluids and calculate related characteristics:

6.1 *define volume flow rate, weight flow rate, and mass flow rate and identify their standard units;*

6.2 *define study flow and explain the principle of continuity;*

6.3 *write the continuity equation and apply it to relate volume flow rate, area and velocity of flow between two points in a fluid flow system;*

6.4 *determine the desired size of pipe or tubing for carrying a given flow rate of fluid at a specified velocity;*

6.5 *determine recommended velocities* *of flow and typical volume flow rates for various types of systems;*

6.6 *define potential energy, kinetic energy, and flow energy as they relate to fluid flow systems;*

6.7 *apply the principle of conservation of energy to develop Bernoulli’s equation and state the* *restrictions on its use;*

6.8 *define the terms “pressure head”, “elevation (potential) head”, “velocity head”, and “total head”;*

6.9 *apply Bernoulli’s equation to fluid flow systems;* and

6.10 *explain Torricelli’s theorem and apply it to compute the flow rate of fluid from a tank and the* *time required to empty a tank*

7. Explain and apply the general energy equation:

7.1 *identify and discuss the conditions under which energy losses occur in fluid flow systems;*

7.2 *identify and discuss the means by which* *energy can be added to a fluid flow system;*

7.3 *identify and discuss the means by which* *energy can be removed from a fluid flow system;*

7.4 *expand* *Bernoulli’s equation to form the general energy equation by considering energy losses, energy additions, and energy removals;*

7.5 *apply the general energy equation to a variety of practical problems;*

7.6 *compute the power added to a fluid by pumps;*

7.7 *define the efficiency of pumps;*

7.8 *compute the power required to drive pumps;*

7.9 *compute the power delivered by a fluid to a fluid motor;*

7.10 *define the efficiency of fluid motors;* and

7.11 *compute the power output from a fluid motor*

8. Explain minor losses in fluid systems:

8.1 *identify the sources of minor losses;*

8.2 *define resistance coefficient;*

**Measurable Course Performance Objectives (MPOs)** (continued):

8.3 *determine the energy loss for flow through the following types of minor losses;*

a. *sudden enlargement of flow path*

b. *exit loss when fluid leaves a pipe and enters a static reservoir*

c. *gradual enlargement of the flow path*

d. *sudden contraction of the flow path*

e. *gradual contraction of the flow path*

f. *entrance loss when fluid enters a pipe from a static reservoir*

8.4 *define the term “vena contracta”;*

8.5 *define and use the “equivalent length technique” to compute energy loss in valves, fittings, and pipe bends;*

8.6 *describe the* *energy losses that occur in a typical fluid power systems;* and

8.7 *discuss how the flow coefficient Cv is used to evaluate energy losses in some types of valves*

9. Demonstrate knowledge of open channel flow:

9.1 *compute the hydraulic radius for open channels;*

9.2 *describe uniform flow and varied flow;*

9.3 *use Manning’s equation to analyze uniform flow;*

9.4 *define the slope of an open channel and compute its value;*

9.5 *compute the normal discharge for an open channel;*

9.6 *compute the normal depth for an open channel;*

9.7 *design an open channel to transmit a given discharge with uniform flow;*

9.8 *define Froude number;*

9.9 *describe critical flow, subcritical flow, and supercritical flow;*

9.10 *define the specific energy of the flow in open channels;*

9.11 *define the terms critical depth, alternate depth, and sequent depth;*

9.12 *describe the term hydraulic jump;* and

9.13 *describe weirs and flumes as they are used for measuring flow in open channels and perform necessary computations*

10. Compute forces due to fluids in motion:

10.1 *use Newton’s second law of motion, F = ma, to develop the force equation, which is used to compute the force exerted by a fluid as its direction of motion or its velocity is changed;*

10.2 *relate the force equation to impulse-momentum;*

10.3 *use the force equation to compute the force exerted on a stationary object that causes the change in direction of a fluid flow stream;*

10.4 *use the force equation to compute the force exerted on bends in pipelines;* and

10.5 *use the force equation to compute the force on moving objects, such as vanes of a pump impeller.*

**Methods of Instruction**: Instruction will consist of lectures, problem solving, and laboratory exercises.

**Outcomes Assessment:** Selected homework, quiz, test, and exam questions are blueprinted to course objectives. A checklist rubric is used to evaluate lab reports and the term project reports for the presence of course objectives. Data is collected and analyzed to determine the level of student performance on these assessment instruments in regards to meeting course objectives. The results of this data analysis are used to guide necessary pedagogical and/or curricular revisions.

**Course Requirements:** All students are required to:

1. Maintain regular attendance and participate in classroom discussions.

2. Complete homework assignments and lab reports on time and read all assigned textbook pages.

3. Sit for all quizzes, tests and exams that are scheduled and participate in all lab exercises.

**Methods of Evaluation:** Final course grades will be computed as follows:

**% of**

**Grading Components final course grade**

* **Quizzes and class participation**  **5 – 10%**

A perusal of quizzes and class discussion will indicate the extent to which students master course objectives.

* **Homework**  **10 – 15%**

A perusal of homework problems will indicate the extent to which students master course objectives.

* **4 or more Tests** (dates specified by the instructor) **30 – 40%**

Tests will show evidence of the extent to which students meet course objectives, including but not limited to identifying and applying concepts, analyzing and solving problems, estimating and interpreting results and stating appropriate conclusions using correct terminology.

**• 4 or more Lab Reports 15 – 25%**

Lab reports will show evidence of the extent to which students can apply course concepts to physical problems, analyze errors, and compose a technical report. Labs are designed to reinforce student mastery of course objectives.

**• Term Project 10 – 20%**

The term project will show evidence of the extent to which students can apply course concepts to real world problems, design a solution, and compose a technical report.

**Methods of Evaluation:** Final course grades will be computed as follows:

**% of**

**Grading Components final course grade**

**• Team work 5 – 10%**

Collaboration between colleagues, an essential component of engineering practice in industry, will be practiced as students complete their lab and term projects.

* **Final Exam** (comprehensive)  **25 – 35%**

The same objectives apply as with tests, but it is anticipated that students will provide increased evidence of synthesizing a combination of concepts.

Note: The instructor will provide specific weights, which lie in the above-given ranges, for each of the grading components at the beginning of the semester.

**Academic Integrity:** Dishonesty disrupts the search for truth that is inherent in the learning process and so devalues the purpose and the mission of the College. Academic dishonesty includes, but is not limited to, the following:

* plagiarism – the failure to acknowledge another writer’s words or ideas or to give proper credit to sources of information;
* cheating – knowingly obtaining or giving unauthorized information on any test/exam or any other academic assignment;
* interference – any interruption of the academic process that prevents others from the proper engagement in learning or teaching; and
* fraud – any act or instance of willful deceit or trickery.

Violations of academic integrity will be dealt with by imposing appropriate sanctions. Sanctions for acts of academic dishonesty could include the resubmission of an assignment, failure of the test/exam, failure in the course, probation, suspension from the College, and even expulsion from the College.

**Student Code of Conduct:** All students are expected to conduct themselves as responsible and considerate adults who respect the rights of others. Disruptive behavior will not be tolerated. All students are also expected to attend and be on time for all class meetings. No cell phones or similar electronic devices are permitted in class. Please refer to the Essex County College student handbook, *Lifeline*, for more specific information about the College’s Code of Conduct and attendance requirements.

**Course Content Outline:** based on the text **Applied Fluid Mechanics**, 6thedition, by Robert Mott; published by Prentice Hall, 2006.

**Week**

**(2 meetings**

**@135 minutes) Topic**

1 Introduction: Units and dimensions, the concept of a fluid, viscosity and other secondary properties, physical, thermodynamics and transport properties

2 General Description of Fluid Motion: Laminar flow, turbulent flow, ideal flow, adiabatic flow, steady and unsteady flows, uniform and non-uniform flows

3 Lab 1: Connect, operate and disconnect hydraulic circuit, **Test 1**

4 – 5 **Lab 1 Report due** (week 4), Fluid Statics: Pressure and pressure gradient, equilibrium and hydro-static pressure distribution,pressure measuring devices, hydrostatic forces; plane surfaces, hydrostatics of compressible fluid, buoyancy and stability

6 Lab 2: Draw hydraulic schematics from pictorial circuits, **Test 2**

7 – 8 **Lab 2 Report due** (week 7), Dynamics of Fluids: Definitions, conservation of mass (continuity equation), Bernoulli's (Energy) equation, and the momentum theorem

9 Lab 3: Connect hydraulic circuits to operate needle valves, directional control valves, pumps, and motors, **Test 3**

10 **Lab 3 Report due**, Term project assigned – design a hydraulic circuit for flow and speed control, Application of Bernoulli's Equation to Flow Measurement**:** Types of orifices, orifice in a tank, measurement of coefficients, energy loss at an orifice, pipe orifice, the Venturi meter, effect of meter inclination, factors affecting the coefficient of discharge, the notch or weir, dynamically similar flow, the rectangular notch, and the effects of errors in head

11 Application of Bernoulli's Equation to Flow Measurement(continued), Lab 4: Connect hydraulic circuits to operate cylinders and compute force output

12 **Lab 4 Report due**, Flow Under a Varying Head: Analytical solution, numerical methods, and the hodograph

13 Steady Flow in Pipes: The friction factor, degradations other than friction, sudden enlargement, sudden contraction, bends, valves, long pipes, graphical presentation of degradation, the siphon, pipes in series and parallel, dynamically similar flow

**Week**

**(2 meetings**

**@135 minutes) Topic**

14 Steady Flow in Pipes (continued), **Test 4**

15 **Term Project due**

**Final Exam**