SAULT COLLEGE OF APPLIED ARTS AND TECHNOLOGY

SAULT STE. MARIE, ONTARIO

COURSE OUTLINE

COURSE TITLE:	FLUID MECHANICS II		
CODE NO. :	MCH225	**SEMESTER:**	SIX
PROGRAM:	MECHANICAL TECHNOLOGY		
AUTHOR:	MARK S. SEELER		
DATE:	JAN 2011	**PREVIOUS OUTLINE DATED:**	
APPROVED:	*"Corey Meunier"*		
	CHAIR		**DATE**
TOTAL CREDITS:	FIVE		
PREREQUISITE(S):	MCH125 - MECHANICS OF FLUIDS MCH320 – MACHINE DYNAMICS		
HOURS/WEEK:	THREE		

I. COURSE DESCRIPTION:

A course is an extension of MCH125 and will cover topics pertaining to energy as it relates to fluid, dimensional analysis, the use of boundary layers, flow in conduits including turbulent and laminar flow, pressure/velocity and flow measurements.

II. LEARNING OUTCOMES AND ELEMENTS OF THE PERFORMANCE:

Upon successful completion of this course, the student will demonstrate the ability to:

1. Review of Fluid Mechanics I and The Energy Principle

Potential Elements of the Performance:

- Derive the energy equation
- Demonstrate knowledge of how the control volume approach is applied to the first law of thermodynamics
- Understand and explain the concepts of flow work and shaft work
- Write, understand and apply the basic and more general form of the energy equation
- Apply forms of the energy equation for situations such as steady flow of an incompressible fluid in a pipe, non-viscous flow and incompressible flow
- Applications of the Energy, Momentum and Continuity Equation in combination and understanding of the concept of abrupt expansion and forces on transition
- Understand and Explain the concept of hydraulic and energy grade lines

2. Dimensional Analysis and Similitude

Potential Elements of the Performance:

- Understanding of why there is a need for dimensional similitude
- Demonstrate dimensions through the utilization of dimensions in equations
- Understanding of the Buckingham Theorem and its application regarding dimensional and dimensionless terms
- Apply various methods of dimensional analysis:
    a) The Step by Step Method
    b) The Exponent Method
- Summarize and Explain the steps (process) of dimensional analysis

- Understand the limitations of dimensional analysis
- Identify common dimensionless numbers
- Explain and understand the scope of similitude as it applies to developing conclusions from models including geometric similitude and dynamic similitude
- Explain the significance of the pressure coefficient using examples
- Approximate and solve problems with High Reynolds Numbers

3. Surface Resistance

Potential Elements of the Performance:

- Understand and apply principles of surface resistance with uniform laminar flow for situations such as:
  a) flow produced by a moving plate
  b) liquid flow down an inclined plane
  c) flow between stationary parallel plates
  d) fully developed flow between parallel plates using the Navier-Stokes equation
- Define and explain Qualitative properties of a boundary layer, flow pattern in a boundary layer and shear stress distribution along a boundary layer
- Apply quantitative relations of the laminar boundary layer using the boundary layer equations
- Discuss and demonstrate understanding of shear stress, shearing resistance for a given surface of a given size and shear stress coefficients that relate to laminar boundary layers
- Apply quantitative relations of the turbulent boundary layer
- Discuss and Demonstrate understanding velocity distribution in the turbulent boundary layer along a smooth wall, Prandt's Mixing Length Theory, Power Law Theory for velocity distribution, the momentum equation applied to boundary layers, thickness of the turbulent boundary layer on a flat plate and shearing resistance of the turbulent boundary layer on a flat plate
- Describe and apply boundary layer control

4. Flow in Conduits

Potential Elements of the Performance:

- Understand and apply concepts of shear stress distribution across a pipe section
- Describe and demonstrate understanding of laminar flow in pipes and criterion for laminar or turbulent flow in a pipe

- In regards to turbulent flow in a pipe, discuss turbulence and its influence in pipe flow
- Differentiate between velocity distribution and resistance in smooth pipes and rough pipes
- Demonstrate knowledge of applying explicit equations to calculate Q (flow rate) and D (diameter)
- Explain and apply concepts in regards to flow at pipe inlets and losses from fittings including flow though and elbow, transition losses and grade lines
- Demonstrate and apply knowledge of pipe systems for simple pumps in a pipeline, pipes in parallel and pipe networks
- Explain and apply equations for turbulent flow in non-circular conduits such as uniform flow in open channels

5. Flow Measurements and Turbo Machinery

Potential Elements of the Performance:

- Identify and Explain the following tools and procedures to measure pressure and velocity:
  a) Stagnation tube
  b) The vane and propeller anemometer
  c) Cup anemometer
  d) Hot wire and hot film anemometer
  e) Laser Doppler anemometer
  f) Marker methods
- Identify and Explain the following tools and procedures to measure flow rates:
  a) Direct volume or weight measurements
  b) Velocity-area integration
  c) Orifices
  d) Head loss for orifices
  e) Venture meters
  f) Flow nozzles
  g) Electromagnetic flow meters
  h) Ultrasonic flow meters
  i) Turbine flow meters
  j) Vortex flow meters
  k) Rotameter
  l) Rectangular weir
- Describe and understand propeller theory
- Understand and apply axial flow pumps in regards to pressure change, head and discharge coefficients for pumps, and the range of application of axial flow machines
- Understand and apply concepts of radial flow machines

III. TOPICS:

1. Review of Fluid Mechanics I and The Energy Principle
2. Dimensional Analysis and Similitude
3. Surface Resistance
4. Flow in Conduits
5. Flow Measurements and Turbo Machinery

IV. REQUIRED RESOURCES/TEXTS/MATERIALS:

Crowe, Clayton T., Engineering Fluid Mechanics, 7th Ed., John Wiley and Sons, Inc, ISBN 0-471-38482-8

V. EVALUATION PROCESS/GRADING SYSTEM:

Type of Grading	Duration	Mark Breakdown	Topics
Term Test 1	**2.0 hours**	**20%**	**Energy Principle/ Dimensional Analysis and Similitude**
Term Test 2	**2.0 hours**	**20%**	**Surface Resistance/ Flow In Conduits**
Final Exam	**3.0 hours**	**30%**	**All course Material**
Quiz	**0.5 hours x4**	**10%**	**All course Material**
Laboratories	**10.0 hours**	**20%**	**All Experiment assignments and attendance**

The following semester grades will be assigned to students:

Grade	Definition	*Grade Point Equivalent*
A+	90 – 100%	4.00
A	80 – 89%	
B	70 - 79%	3.00
C	60 - 69%	2.00
D	50 – 59%	1.00
F (Fail)	49% and below	0.00

CR (Credit)	Credit for diploma requirements has been awarded.
S	Satisfactory achievement in field /clinical placement or non-graded subject area.
U	Unsatisfactory achievement in field/clinical placement or non-graded subject area.
X	A temporary grade limited to situations with extenuating circumstances giving a student additional time to complete the requirements for a course.
NR	Grade not reported to Registrar's office.
W	Student has withdrawn from the course without academic penalty.

VI. SPECIAL NOTES:

Attendance:
Sault College is committed to student success. There is a direct correlation between academic performance and class attendance; therefore, for the benefit of all its constituents, all students are encouraged to attend all of their scheduled learning and evaluation sessions. This implies arriving on time and remaining for the duration of the scheduled session.

VII. COURSE OUTLINE ADDENDUM:

The provisions contained in the addendum located on the portal form part of this course outline.

APPENDIX

MECHANICAL ENGINEERING TECHNOLOGY - 4043
Mechanics of Fluids II – MCH225

DISTRIBUTION OF HOURS

Sequence/Type	Topics	# of Hours
Lecture	Review of Fluid Mechanics I & The Energy Principle	8
Experiment		2
Lecture	Dimensional Analysis and Similitude	8
Experiment		2
Lab		2
Test		2
Lecture	Surface Resistance	8
Experiment		2
Lecture	Flow In Conduits	8
Experiment		2
Lab		2
Test		2
Lecture	Flow Measurements and Turbo-Machinery	12
Experiment		2
Lab		2
Testing	Final Exam	3
	Sub-Totals	
	Lectures	44
[p	Labs/Experiments	16
	Testing	4
	Exam	**3**
	Total	**67**

SAULT COLLEGE

MECHANICAL ENGINEERING TECHNOLOGY - 4043

Mechanics of Fluids II – MCH225

COURSE PLAN – Based on the text **Engineering Fluid Mechanics**, 7th ed., by Crowe, Roberson and Elger)

Week/Hours	Topic/Chapter	Concepts Covered	In Class Lab (equipment needed)
Week 1/2/3 (8 hours Lecture and 2 hour Experiment)	**Review of Fluid Mechanics I concepts and The Energy Principle Chapter 7 :**	1. **Review of Areas Covered in Fluid Mechanics I** 2. **Derivation of the Energy Equation:** Controlled volume approach applied to the first law of thermodynamics, flow work, shaft work, Basic Form of the Energy Equation 3. **Simplified Forms Of the Energy Equation:** Steady Flow Energy Equation, Energy Flow for Steady flow of an incompressible fluid in a pipe, Energy Equation for Non-viscous, one dimensional, Incompressible flow 4. **Application of the Energy, Momentum and Continuity Equation in Combination:** Abrupt Expansion, Forces on Transitions, 5. **Concept of the Hydraulic and Energy Grade Lines**	Experiment 1 – 2 hour experiment
Week 3/4/5 (8 Hours Lecture and 2 hour experiment)	Chapter 8: Dimensional Analysis and Similitude	1. **The Need for Dimensional Analysis** 2. **Dimensions and Equations** 3. **The Buckingham II Theorem** 4. **Dimensional Analysis:** The Step-by-Step Method, The Exponent Method, Recapitulation of the Process of Dimensional Analysis, Limitations of Dimensional Analysis 5. **Common Dimensionless Numbers** 6. **Similitude:** Scope of Similitude,	Experiment 2 – 2 hour experiment

		Geometric Similitude, Dynamic Similitude 7. **Model Studies for Flows Without Free-Surface Effects** 8. **Significance of the Pressure Coefficient** 9. **Approximate Similitude at a High Reynolds Number**	
Week 6 (2 hour lab and 2 hour term test)	**Review of Chapters 7 and 8**	1. **Review Lab and Term Test**	Lab #1 – in class review 2 hours
Week 7/8/9 (8 Hour Lecture and 2 hour experiment)	**Surface Resistance Chapter 9:**	**1. Surface Resistance with Uniform Laminar Flow:** Flow Produced by a Moving Plate, Liquid Flow down an inclined plane, Flow Between Stationary Parallel Plates, Fully Developed Flow Between Parallel Plates Using the Naiver-Stokes Equations **2. Qualitative Description of the Boundary Layer:** Flow Pattern in a Boundary Layer, Shear Stress Distribution Along the Boundary, **3. Quantitative Relations of the Laminar Boundary Layer:** Boundary Layer Equations, Shear Stress, Shearing Resistance for a given Surface of Given Size, Shear Stress Coefficients **4. Quantitative Relations of the Turbulent Boundary Layer:** Velocity Distribution in the Turbulent Boundary Layer Along the Smooth Wall, Prandtl's Mixing Length Theory, Power Law Theory for Velocity Distribution, Momentum Equation Applied to Boundary Layer, Thickness of the Turbulent Boundary Layer on a Flat Plate,	Experiment 3 - 2 hour experiment

		Shearing Resistance of the Turbulent Boundary Layer on a Flat Plate **5. Boundary Layer Control**	
Week 9/10/11 (8 Hours Lecture and 2 hours Experiment)	**Flow in Conduits Chapter 10:**	1. **Shear Stress Distribution Across a Pipe Section** 2. **Laminar Flow in Pipes** 3. **Criterion for Laminar or Turbulent Flow in a Pipe** 4. **Turbulent Flow in a Pipe**: Turbulence and its Influence in Pipe Flow, Velocity Distribution and Resistance in Smooth Pipes, Velocity Distribution and Resistance in Rough Pipes, Explicit Equation for Q and D 5. **Flow at Pipe Inlets and Losses from Fittings**: Flow in a pipe inlet, Flow through an elbow, Transition Losses and Grade Lines, 6. **Pipe Systems**: Simple Pump in a Pipeline, Pipes in Parallel, Pipe Networks, 7. **Turbulent Flow in Non-Circular Conduits:** Basic Development, Uniform Flow in Open Channels, The Chezy and Manning Equation, Manning Equation Traditional System of Units, Best Hydraulic Section, Flood Flows, Uniform Flow in Culverts and Sewers	Experiment 4 – 2 hour experiment
Week 12 (2 hour lab and 2 hour term test)	**Review of Chapters 9 and 10**	1. **Review Lab and Term Test**	Lab #2 – in class review 2 hours
Week 13/14/15/16 (12 Hours Lecture and 2 hours of experiment and 2 hours of	**Flow Measurements Chapter 13 and Turbo-machinery Chapter 14**	1. **Instruments for the measurement of velocity and Pressure:** Stagnation Tube, Flow Direction with Stagnation-Type Tubes, Static Tube, The Vane and Propeller Anemometer, Cup Anemometer, Hot wire and Hot	Experiment 5 – 2 hour experiment and Lab #3 review 2 hours

review lab)		Film Anemometer, Laser Doppler Anemometer, Marker Methods, 2. **Instruments and Procedures for Measurement of Flow Rates:** Direct Volume or Weight Measurements, Velocity-Area Integration, Orifices, Head Loss for Orifices, Venturi Meter, Flow Nozzles, Electromagnetic Flow meter, Ultrasonic Flow Meter, Turbine Flow Meter, Vortex Flow Meter, Rotameter, Rectangular Weir, 3. **Propeller Theory:** Blade Analysis, 4. **Axial Flow Pumps:** Pressure Changes, Head and Discharge Coefficients for Pumps, Range of Application of Axial Flow Machines, 5. **Radial Flow Machines:** Centrifugal Pumps,	