University of Macau
Department of Electromechanical Engineering
MECH 307 - Fluid Mechanics
Syllabus
2nd Semester 2011/2012
Part A – Course Outline

Compulsory course in Electromechanical Engineering

Course description:

Introduction to fluid mechanics, Pressure distribution in a fluid, Integral relations for a control volume, Differential relations for a fluid particle, Dimensional analysis and similarity, Viscous flow in Ducts, Boundary-layer flows, External flow.

Prerequisites:

- None

Textbook(s) and other required material:

- John M. Cimbala, Yunus A. Çengel. ***Essentials of Fluid Mechanics: Fundamentals and Applications***, McGraw-Hill, 2008.

References:

- Frank M. White. Fluid Mechanics, 6th Edition, McGraw-Hill
- Irving H. Shames. Mechanics of Fluids, 3rd Edition, McGraw-Hill
- Robert W. Fox, Alan T. McDonald. Introduction to Fluid Mechanics, 3rd Edition, John Wiley & Sons

Course objectives:

1. Understand the fundamental theories and principles of fluid mechanics. [a]
2. Perform basic calculations for analysis of simple and complex system involving fluid flow. [b, e]
3. Obtain hand-on experience in conducting flow experiment and analyzing and interpreting date. [b]
4. Possess the problem-solving skills, background and confidence necessary to educate themselves continually throughout their career. [a, e]

Topics covered:

1. **Introduction** - Introduction, The No-slip Condition; A Brief History of Fluid Mechanics; Classification of Fluid Flows, System and Control volume, Dimensions and Units
2. **Properties of Fluids –** Continuum; Density; Specific Gravity; Compressibility and Speed of Sound; Viscosity, Surface Tension
3. **Pressure and Fluid Statics -** Pressure at a point; Pressure Variation, Pressure Measurement Devices; Hydrostatic Forces on submerged Plane surface; Hydrostatic Forces on submerged Curved surface; Buoyancy
4. **Fluid Kinematics** - Fluid Kinematics; Lagrangian and Eulerian Description; Vorticity and Rotationality The Reynolds Transport Theorem
5. **Control volume analysis** - Conservation of mass applied to a Control Volume; Mechanical Energy and Efficiency; Bernoulli equation; General Energy Equation; Momentum Analysis of Flow System; Newton's Law; Forces Acting on a Control Volume; The Linear Momentum Equation
6. **Dimensional Analysis and Modelling -** Dimensional Homogeneity; Dimensional Analysis and Similarity ; Buckingham PI theorem; Experimental Testing and Modeling
7. **Internal Flow -** Viscous Flow in Pipes; The Entrance Region; Laminar and Turbulent Flows in Pipes; Pressure Drop; Head Loss; Moody Chart; Types of Fluid Flow Problems; Minor Losses; Flow Rate Measurement
8. **Differential Analysis of Fluid Flow –** The Continuity Equation; Alternative Form of Continuity Equation; Incompressible Flow; The Stream Function; The Navier-Stokes Equation; Exact Solution of the Continuity and Navier-Stokes Equations; Fully Developed Couette Flow with and without Applied Pressure Gradient; Fully Developed Flow over a Round Pipe – Poiseuille Flow;

Approximate Solution of the Continuity and Navier-Stokes Equations;
Potential Flows; Uniform Stream; Line Source or Line Sink,
Line Vortex, Doublet; Irrotational Flows Formed by Superposition;
Superposition of a Line Sink and a Line Vortex; Superposition of a Uniform Stream and Doublet – Flow over a Circular Cylinder; The Boundary Layer Approximation; Laminar and Turbulent Boundary Layer

9. **External Flow: Drag and Lift -** Flow over immersed bodies; Friction and Pressure Drag;
Drag Coefficients of Common Geometries; Parallel Flow over Flat plates; Flow over Cylinders and Spheres;
Lift

Class schedule and credits:

Timetabled work in hours per week			No of teaching weeks	Total hours	Total credits	No / Duration of exam papers
Lecture	Tutorial	Practice				
3.5	1	0.5	14	70	4	1 / 3 hours

Topic Outline:

Week	Date	Tentative Lecture / Topic
1		Introduction, The No-slip Condition, A Brief History of Fluid Mechanics
		Classification of Fluid Flows, System and Control volume, Dimensions and Units
		Properties of Fluids, Continuum, Density, Specific Gravity
2		Compressibility and Speed of Sound, Viscosity, Surface Tension
		Pressure and Fluid Statics, Pressure, Pressure Measurement Devices
		Hydrostatic Forces on submerged Plane surface
3		Hydrostatic Forces on submerged Curved surface
		Buoyancy
		Holiday: Lunar New Year Recess
4		Fluid Kinematics, Lagrangian and Eulerian Description
		Vorticity and Rotationality
		The Reynolds Transport theorem
5		Conservation of mass applied to a Control Volume
		Mechanical Energy and Efficiency
		The Bernoulli Equation
6		General Energy Equation,
		Momentum Analysis of Flow System, Newton’s Law
		Forces Acting on a Control Volume
7		The Linear Momentum Equation
		Dimensional Homogeneity
		Dimensional Analysis and Similarity
8		Buckingham Pi Theorem
		Experimental Testing and Modeling
		Mid-term
9		The Entrance Region, Viscous Flow in Pipes
		Pressure Drop, Head Loss
		Moody Chart, Types of Fluid Flow Problems
10		Minor Losses
		Flow Rate Measurement
		Differential Analysis of Fluid Flow, The Continuity Equation
11		Alternative Form of Continuity Equation, Incompressible Flow
		The Stream Function, The Navier-Stokes Equation
		Exact Solution of the Continuity and Navier-Stokes Equations
12		**Holiday: Ching Mind Festival**
		Fully Developed Couette Flow with and without Applied Pressure Gradient

		Fully Developed Flow over a Round Pipe – Poiseuille Flow
13		Approximate Solution of the Continuity and Navier-Stokes Equations
		Potential Flows, Uniform Stream, Line Source or Line Sink,
		Line Vortex, Doublet, Irrotational Flows Formed by Superposition
14		Superposition of a Line Sink and a Line Vortex, Superposition of a Uniform Stream and Doublet – Flow over a Circular Cylinder
		The Boundary Layer Approximation
		Laminar and Turbulent Boundary Layer
15		Friction and Pressure Drag
		Drag Coefficients of Common Geometries
		Holiday: Good Friday (Easter Recess: 4/21-4/25)
16		Parallel Flow over Flat plates
		Flow over Cylinders and Spheres
		Lift
		Study Period
		Final Exam

Contribution of course to meet the professional component:

This course prepares students to work professionally in the area of **fluid mechanics**.

Relationship to EME programme objectives and outcomes:

This course primarily contributes to Electromechanical Engineering Programme outcomes that develop student abilities to:
(a) an ability to apply knowledge of mathematics, science, and engineering;
(e) an ability to identify, formulate, and solve engineering problems.

The course secondarily contributes to Electromechanical Engineering programme outcomes that develop student abilities to:
(b) an ability to design and conduct experiments, as well as to analyze and interpret data.

Course content:

Maths	Basic Sciences	Engineering Science	Engineering Design and Synthesis	Complementary Studies	Computer Studies	Total 100%
10	10	50	20	5	5	100

Persons who prepared this description:

Prof. Vai Kuong Sin

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Part B – General Course Information and Policies

2nd Semester 2011/2012

Instructor:	Prof. Vai Kuong Sin	Office:	N318
Office Hour:	MW 3:30 – 5:30PM or by appointment	Phone:	(853) 8397-4368
Email:	vksin@umac.mo		

Time/Venue:
TBA

Assessment:
Final assessment will be determined on the basis of:

Homework:	10%
Lab Report:	10%
In-class Quizzes:	20%
Mid-term:	30%
Final Exam:	30%

Grading System:
The credit is earned by the achievement of a grade from 'A' to 'D'; 'F' carries zero credit.

Grades are awarded according to the following system:

Letter Grades	Grade Points	Percentage
A	4.0 (Excellent)	93-100
A-	3.7 (Very good)	88-92
B+	3.3	83-87
B	3.0 (Good)	78-82
B-	2.7	73-77
C+	2.3	68-72
C	2.0 (Average)	63-67
C-	1.7	58-62
D+	1.3	53-57
D	1.0 (Pass)	50-52
F	0 (Fail)	Below 50

Comment:
All students are expected to attend all lectures, quizzes, and examinations. Although classroom attendance does not mathematically contribute to the final course grade, active class participation is expected of all students and may help to boost up the course grade in those "borderline cases" between failing and passing. It is your responsibility to read the relevant chapters in the text before and after class and to ask questions during class discussion. In order to be successful in this course, you should get as much practice as possible in solving problems outside the class hours. This must be done on a timely and regular basis, as a good understanding of the material covered in any particular section of this course depends heavily on an equally good understanding of the material covered in previous sections.

Homework Policy:
All homework must be an individual effort unless specifically noted. Your work must be neat, with answers clearly noted and supporting information provided. Late homework will <u>not</u> be accepted in general.

Quizzes:
Quizzes will be closed book and notes. The format will primarily be problems that are similar to homework problems.

Note:

- Cheating in any form will not be tolerated. STUDENTS WHO CHEAT ON ANY ASSIGNMENT OR DURING ANY QUIZ OR EXAMINATION WILL BE ASSIGNED A FAILING GRADE FOR THE COURSE AND MAY RESULT IN SUSPENSION OR EXPULSION FROM THE UNIVERSITY. Therefore avoid all appearance of improper behavior. Students who witness cheating should report the incident to the instructor as soon as possible.
- Photocopies of the textbooks are illegal and are violation of the Macao copyright laws.

Appendix - Rubric for Programme Outcomes

Rubric for (a)	5 (Excellent)	3 (Average)	1 (Poor)
Understand the theoretic background	Students understand theoretic background and the limitations of the respective applications.	Students have some confusion on some background or do not understand theoretic background completely	Students do not understand the background or do not study at all
Use a correct model and formulation correctly	Students choose a model correctly and properly apply correct techniques	Students choose a wrong model sometime, use a wrong formula, or a different technique	Students use a wrong model and wrong formula, or do not know how to model
Compute the problem correctly	Students use correct techniques, analyze the problems, and compute them correctly	Students sometime solve problem mistakenly using wrong techniques	Students do not know how to solve problems or use wrong techniques completely

Rubric for (b)	5 (Excellent)	3 (Average)	1 (Poor)
Conduct experiments	Student successfully completes the experiment, records the data, analyzes the experiment's main topics, and explains the experiment concisely and well.	Student successfully completes the experiment, records the data, and analyzes the experiment's main topics.	Student either does not complete the experiment successfully, or completes it successfully but does not record the correct data.
Design experiments	Student understands what needs to be tested and designs an appropriate experiment that takes into account the limitations of the equipment and measurement accuracy.	Student understands what needs to be tested and designs an appropriate experiment, but may not fully understand the limitations of the measurements.	Student does not understand what needs to be tested and/or does not design an appropriate experiment.

Rubric for (e)	5 (Excellent)	3 (Average)	1 (Poor)
Identify applications in engineering systems	Students understand problem and can identify fundamental formulation	Students understand problem but cannot apply formulation.	Students cannot identify correct terms for engineering applications
Modeling, problem formulation and problem solving	Students choose and properly apply the correct techniques	Students model correctly but cannot select proper technique or model incorrectly but solve correctly accordingly	Students at loss as to how to solve a problem