SAULT COLLEGE OF APPLIED ARTS AND TECHNOLOGY

SAULT STE. MARIE, ON

COURSE OJITJJME

COURSE TITLE: MECHANICS OF FLUIDS

CODE NO.: MCH 219-4 **SEMESTER:** **five**

PROGRAM: AVIATION TECHNOLOGY - FLIGHT

AUTHOR: G. DISANO

DATE: **MAY 1995** **PREVIOUS OUTLINE DATED:** JANUARY 1993

APPROVED ______________________ DEAN

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DATE

MECHANICS 0F_FLUIDS
COURSE NAME

MCH 219-4
CODE NO.

TOTAL CREDITS ____

PREREQUISITE(S): PHYSICS PHY-125; APPLIED MECHANICS - STATICS MCH-110; APPLIED MECHANICS - DYNAMICS MCH-111

I. PHILOSOPHY/GOALS: The course is designed to place emphasis on basic principles and their applications, in a practical way, as opposed to a theoretical approach- Problems assigned at the end of each new concept assist the student in understanding the subject matter.

II. STUDENT PERFORMANCE OBJECTIVES (OUTCOMES):

Upon successful completion of this course the student will: '

1) in his/her own words write definitions for the concepts introducec
2) answer questions requiring a knowledge of the concepts presented;
3) respond to questions requiring extrapolation of the course conteni
4) solve problems requiring an understanding of the course theory.

III. TOPICS TO BE COVERED: Approximate Time **Frames (Optional)**

1} Fundamental Concepts and Fluid Properties
2) Fluid Statics
3) Energetics of Steady Flow - Fluid Dynamics
4) Fluid Dynamic Applications
5) Steady Flow - Incompressible Fluids in Pipes

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Continued ....

MECHANICS OF FLUIDS
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V. EVALUATION METHODS: (INCLUDES ASSIGNMENTS, ATTENDANCE REQUIREMENTS, ETC.)

See attached sheet: GRADE REQUIREMENTS

Vi. PRIOR LEARNING ASSESSMENT:

Students who wish to apply for advanced credit in the course should consult the instructor. Credit for prior learning will be given upon successful completion of the following:

VII. REQUIRED STUDENT RESOURCES

Granet, Irving; FLUID MECHANICS FOR ENGINEERING TECHNOLOGY, Third edition. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 1989.

VIII. ADDITIONAL RESOURCE MATERIALS AVAILABLE IN THE COLLEGE LIBRARY:

Book Section You will find the college's collection of fluid mechanics books on the second floor of the college library. They are located on the shelves under the Call Number TA 357.

Periodical Section

Audiovisual Section

IX. SPECIAL NOTES

The course outline as listed on pages 4 and 5, and the learning activities as detailed on pages 7 through 24 describe the sub-topics to be covered under each of the five main topic headings. Some subtopics may be deleted from the outline at the discretior of the instructor and/or others may be introduced.

Portions of topic V are optional; however, time permitting, they will be covered. This creates the possibility for some latitude in the grading scheme as described on page 6.

COURSE OUTLINE

MECHANICS OF FLUIDS

MCH 219

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Aviation Technology - Flight

Reference Text: 'Fluid Mechanics for Engineering Technology[1], 3rd editio

TOPIC NO.	PERIODS	TOPIC DESCRIPTION	REFERENCE
I		Fundamental Concepts	Chapters 1,2
		a) Temperature	
		b) Absolute Temperature	
		c) Density, Specific Weight, Specific Volume and Specific Gravity	
		d) Pressure	
		e) Surface Tension	
		f) Compressibility	
		g) Viscosity	
II		Fluid Statics	Chapter 3
		a) Pressure Relationships	
		b) Pressure Measurement	
		c) Manometers	
		d) Buoyancy on submerged bodies	
		e) Forces on submerged surfaces	
		f) location of the Centre of Pressure	
		g) Stresses in cylinders and spheres	
III		Fluid Dynamics	Chapter 4
		a) Conservation of Mass - the Continuity Principle	
		b) Force, Mass and Acceleration	
		c) Work and Energy	
		d) Conservation of Energy- Bernoulli[1]s equation	
IV		Fluid Dynamic Applications	Chapters 5,8
		a) general considerations	
		b) applications of Bernoulli's equation	
		c) Torricelli's theorem	
		d) siphons	
		e) pressure and velocity measurements	
		f) Piezometers	
		g) Pitot Tubes	
		h) Venturi Meters	

Continued ..•.

<u>Steady Flow -</u> Chapter 6
<u>Incompressible Fluids in Pipes</u>

a) Laminar and Turbulent Flow
b) Reynolds' numbers
c) Laminar Flow in tubes
d) Boundary Layer OPTIONAL
e) pressure loses in pipe flow - the Hagen-Poiseuille equation OPTIONAL
f) Stoke's law and Stoke's equation OPTIONAL
g) Poiseuille's law and Poiseuille's equation

GRADE REQUIREMENTS

MCH219

MECHANICS OF FLUIDS

(Aviation Technology - Flight)

Your final grade in MCH 219 will be determined on the basis of four tests to be administered during the semester. Each test will examine your knowledge of a number of topics and will be administered within one week of completing those topics. The topics covered in each of the four tests are as follows:

Test #1 ______ Topic No. I

Test #2 ______ Topic No. II

Test #3 ______ Topic No. Ill

Test #4 ______ Topics No. IV & V

The four tests are of equal weight (i.e. each of the four tests is worth 257o of your final grade). As a result, provided you have received a passing grade in each of the four tests, your final grade will simply be an average of your four test results. In order to obtain your letter grade the following percentage-letter grade equivalents will be used:

A+	907> - 1007o	(Consistently outstanding achievement)
A	807o - 897o	(Outstanding achievement)
B	707o - 79%	(Consistently above average achievement)
C	557o - 697,	(Satisfactory or acceptable achievement)
X or R	07o - 547_0	(Incomplete or Repeat)

If your final average is below 557_0, or if you have received a failing grade in one or more of the unit tests, whether you receive an 'X' (Incomplete) or an *R' (Repeat) grade is entirely at the instructor's discretion. The decision will be based upon your final average (e.g. 32% would result in an R grade while 507o might result in an X grade); your attendance during the semester; your attitude while in the class-room; your perceived level of effort during the semester; etc..

In any case, should you find yourself with an X grade at the end of the semester, in order to upgrade your mark to a passing grade you will be required to write a make-up examination covering the entire course content. Should you receive a passing grade on the make-up examination (557o or higher) your X grade will be upgraded. The best you can do after receiving an X grade as a result of a failing average is a C! If you were required to write the make-up examination as a result of having failed one test you may substitute the exam result for this test result.

Prior to administering any test you will be notified a full week in advance. Should you for any reason not be able to be in attendance on a day for which a test has been scheduled it is your responsibility to notify the instructor prior to the test! If your reasons are acceptable a date will be set during which you may write a substitute test for the one you have missed.

G. Disano, May 1995

LEARNING ACTIVITIES

i FUNDAMENTAL CONCEPTS

a) Temperature and b) Absolute Temperature

1) Write 2 definitions for the concept of temperature.

2) List and describe several examples of physical indicators of temperature.

3) List the four most commonly used temperature scales along with the proper abbreviations for each of the 'units of temperature[1] on each scale.

4) On each of the temperature scales above, recall the value of each of the following temperatures: the *boiling point' of water, the 'freezing point' of water and the temperature known as 'absolute zero[1]-

5) State the mathematical relationship that exists between (i) the Celsius and the Fahrenheit temperature scalesj- (ii) the Celsius and the Kelvin temperature scales; and, (iii) the Fahrenhei and the Rankine temperature scales.

6) Explain what is meant by the concept of 'absolute zero[1] making reference to the terms 'temperature' and 'thermal energy' in your explanation.

7) Explain what is meant by an 'absolute temperature scale' in terms of the value of absolute zero and the algebraic sign of temperature readings on the scale.

8) Given a temperature on any one of the four temperature scales of learning activity I-a-3, convert this temperature to an equivalent temperature on each of the remaining three temperature scales.

c) Density, Specific Weight, Specific Volume and Specific Gravity

1) Write a definition for the term 'fluid[1].

2) List the 2 states of matter that together form the classification known as 'fluids'.

3) Write a definition for the term 'mass density'.

4) Write the equation for the term 'mass density'.

5) List the proper units for 'mass density' in each of the S.I. metric, C.G.S. metric and Imperial systems of measure.

Continued ....

IV. LEARNING ACTIVITIES

6) Write a definition for the term 'weight density', 'unit weight' or 'specific weight'.

7) Write the equation for the term 'weight density'.

8) List the proper units for 'weight density' in each of the S.I. metric, C.G.S. metric and Imperial systems of measure.

9) Write the equation that relates mathematically 'mass density[1] and 'weight density[1].

10) Write a definition for the term 'specific volume'.

11) Write the equation for the term 'specific volume.

12) List the proper units for 'specific volume' in each of the S.I. metric, C.G.S. metric and Imperial systems of units.

13) Write a definition for the term 'specific gravity*.

14) Write 2 equations for the term 'specific gravity'.

15) List the values for the 'mass density', the 'weight density" and the 'specific gravity' of pure water at its temperature of maximum density in each of the S.I. metric, C.G.S. metric and Imperial systems of measure.

d) <u>Pressure</u>

1) Write the general equation for the term 'pressure[1].

2) List the units used to measure pressure in the S.I. metric, C.G.S. metric and Imperial systems of measure.

3) Identify the relationships that exist among the various units of pressure measurement including: lb/in?, kPa, N/m^2, atmosphere, mb, in. of Hg, cm of Hg, mm of Hg, ft of water, m of water, etc..

4) Write the 2 equations used to determine the pressure exerted by a column of liquid.

5) List at least 8 equivalent values for standard atmospheric pressure.

6) Describe what is meant by the term 'vacuum' paying particular attention to the distinction between 'partial vacuum' and 'total vacuum[1].

Continued ....

IV. LEARNING ACTIVITIES

7) Write a definition for the term 'gauge pressure[1].
8) Write a definition for the term 'absolute pressure'.
9) Write the equation that relates 'absolute pressure', 'gauge pressure[1] and 'atmospheric pressure'.

e) Surface Tension

1) Briefly describe the phenomenon and explain, in simple terms, wnat causes 'surface tension' at the boundary between a liquid and its surroundings.
2) List the units used to measure 'surface tension' in the S.I- metric, C.G.S. metric and Imperial systems of measure.
3) Write a definition which quantitatively describes the phenomenon of 'surface tension'.
4) Write the general equation for the term 'surface tension'.
5) Describe the relationship that exists between the surface tension and the temperature of a given liquid.
6) Given the appropriate data in the form of a problem, calculate the surface tension for various liquids in contact with various surfaces.
7) Define the term "wetting" fluid for a fluid in contact with a given surface in terms of the 'contact angle'.
8) Define the term "non-wetting" fluid for a fluid in contact with a given surface in terms of the 'contact angle[1].
9) Derive the equation used to determine the rise 'h' in a tube of diameter 'd', open at both ends, when the lower end is immersed in a fluid of mass density [v]/^ or weight density*!*/* for which the surface tensic is*cf' [a]^d the contact angle is*©'.
10) Derive the equation used to determine tae height 'h' that a liquid will rise between two infinite parallt plates separated by a distance 'd' when the parallel plates are immersed in the liquid. The liquid has *i* weight density of 'V[1] or a mass density of ' /D' , a surface tension of ' Cf ' and a contact angle of '©'.

Continued . ...

IV. LEARNING ACTIVITIES

f) Compressibility

1) Write a definition for the term 'compressibility'.

2) Write the equation which relates the 'modulus of elasticity' or 'bulk modulus', the 'stress' and the 'strain'.

3) Describe the compressibility of water and how it compares to other materials, such as "mild" steel for example.

g) Viscosity

1) Write a definition for the term 'viscosity'.

2) Describe how the viscosity of liquids and gases vary as a function of temperature.

3) Write a definition for the viscosity known as 'absolute' or 'dynamic' viscosity.

4) Write the equation for the term 'absolute' or 'dynamic' viscosity.

5) List the proper units for 'dynamic' or 'absolute' viscosity in each of the S.I. metric, C.G.S. metric and Imperial systems of measure.

6) Explain the meaning of the units of dynamic or absolute viscosity known as the 'poise' and the 'centipoise'.

7) State the value of the dynamic or absolute viscosity of pure water being certain to indicate the temperature of the water having this value.

8) Explain the meaning of the term 'relative viscosity'

9) Write a definition for the term 'kinematic viscosity

10) List the proper units for 'kinematic viscosity' in each of the S.I. metric, C.G.S. metric and Imperial systems of measure.

11) Explain the meaning of the unit of kinematic viscosity known as the 'stoke'.

12) Write the equation for the term 'kinematic viscosity

13) Solve the example problems as presented in class dealing with the above learning activities I-a to I-g.

14) Read chapters 1 and 2 of the suggested reference text.

15) Answer the questions and solve the problems as assigned from chapters 1 and 2 of the suggested reference text.

Continued ....

LEARNING ACTIVITIES (Continued from L.A. I-g-15, page 11)

II FLUID STATICS

a) Pressure Relationships & b) Pressure Measurement

1) Recall from learning activity I-d-1 the definition and the general equation for the term 'pressure'.

2) Recall from learning activity I-d-2 the units used to measure pressure in the S.I. metric, C.G.S. metric and Imperial systems of measure.

3) Recall from learning activity I-d-4 the two equations used to determine the pressure exerted by a column of liquid of given depth and given mass density or given unit weight.

4) State the angle at which the resultant pressure on any plane exposed to a fluid at rest will contact that- surface.

5) Answer the questions and solve the problems as presented on problem sheets 2, 3, 4 and 5.

6) Solve the problems as assigned from pages 133 and 134 in 'Schaum's Outline Series - College Physics'.

7) Write a verbal statement of Pascal's law and demonstrate an understanding of the law by applying it to examples as presented in class.

8) Discuss the relationship that exists, if it exists at all, between the pressure at a given depth in a given liquid at rest and the shape of the containing vessel.

9) Explain what is meant by the term 'pressure head[1].

10) Write two equations for pressure head - one in terms of the mass density and one in terms of the unit weight.

11) Recall from learning activity I-d-5 at least 8 equivalent values for standard atmospheric pressu

12) Recall from learning activity I-d-6 the terra vacu paying particular attention to the distinction between 'partial vacuum' and 'total vacuum'.

13) Write a definition for the term 'gauge pressure'.

14) Write a definition for the term 'absolute pressure'.

15) Write the equation that relates 'absolute pressure', 'gauge pressure' and 'atmospheric pressure'.

Continued ....

LEARNING ACTIVITIES

16) Describe the construction of and the operation of a simple mercury barometer.

17) Draw a simplified sketch of a simple mercury barometer.

18) List three reasons why water is not a suitable liquid for use as the indicating fluid in a Torricelli barometer.

19) List three reasons why mercury is an ideal liquid for use as the indicating fluid in a Torricelli barometer.

20) Explain what is meant by the term 'vapour pressure'.

21) List the factors which affect the magnitude of the vapour pressure produced by a liquid.

22) Describe the effect that vapour pressure has on the reading obtained from a Torricelli barometer.

23) Describe the relationship that exists between the vapour pressure of a liquid and the temperature of that liquid.

24) State the vapour pressure of water, in feet of water, when the temperature of the water is 212°F.

25) Explain why water "boils", under standard atmospheric pressure, when the temperature of the water is at 212°F.

26) Describe the construction of and explain the operation of a simple 'piezometer'.

27) List and explain the three reasons why a simple piezometer is limited in its range of applications.

28) Describe how a simple modification to the design of a simple piezometer effectively eliminates one of the limitations described in learning activity II-b-27 above.

29) Solve the problems as presented on problem sheets 6, 7 and 8.

30) Solve the example problems as presented in class dealing with simple piezometers.

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IV. t FARMING ACTIVITIES

c) Manometers

1) Describe the construction of and explain the operation of an 'open manometer*.
2) Describe how the use of the open manometer overcomes the limitations that affect the range of operation of a simple piezometer as presented in learning activity II-b-27 above.
3) List at least 6 liquids which are commonly used as the indicating liquid in open manometers.
4) Solve the example problems as presented in class dealing with open manometers.
5) Solve the problems as presented on problem sheet 9.
6) Describe the construction of and explain the operation of a 'differential manometer'.
7) Solve the problems as presented on problem sheets 10 and 11.
8) Draw a sketch illustrating the major components of a 'Bourdon pressure gauge*.
9) Explain the operation of a 'Bourdon pressure gauge'.

d) Buoyancy on Submerged Bodies

1) Explain the cause of the force of buoyancy on a body partially immersed or fully submerged in a fluid.
2) Derive from first principles a mathematical statement of 'Archimedes' principle'.
3) Write a verbal statement of 'Archimedes' principle
4) Describe the relationship that exists between the specific gravities of an object and the fluid in which it is immersed, and the net force experience by the body.
5) Answer the questions as presented on the question sheet titled "Questions of a Curious Nature".
6) Solve the problems as presented on problem sheets 12 and 13.

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IV. LEARNING ACTIVITIES

e) Forces on Submerged Surfaces & f) Centre of Pressure

1) Derive the equation used to calculate the total force acting on a vertical rectangular plate submerged in a fluid with the top of the plate level with the surface of the fluid.

2) Recall from your semester II dynamics course (MCH 111) the meaning of the terms 'centroid' and 'centre of gravity'.

3) Solve the example problems as presented in class dealing with the calculation of the total force acting on a vertical plate when the top of the plate is level with the surface of the fluid.

4) Calculate the total force acting on a vertical plate when the top of the plate is some distance below the surface of the fluid.

5) Calculate the total force acting on a vertical plate when the top of the plate is level with the free surface of a fluid on one side and above the free surface of a fluid on the other side.

6) Calculate the total force acting on an inclined plate whose top edge is either level with or below the free surface of a fluid.

7) Explain what is meant by the term 'centre of pressure'.

8) Derive the equation for the 'centre of pressure' of a submerged plane in terms of it's 'moment of inertia .about the centre of gravity of the area', the location of the 'centroid' below the surface, and the area of the plane.

9) Explain why the 'centre of pressure' for a plane submerged in a fluid always lies below the 'centroid' for that plane.

10) For the following geometric shapes, given the necessary equations, calculate: (i) the area, (ii) the location of the centroid; and (iii) the moment of inertia about the centroid of the area.

(a) square, (b) rectangle, (c) trapezoid,
(d) triangle, (e) circle, (f) ellipse, (g) quarter circle, & (h) semicircle.

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Continued ....

t **FARMING ACTIVITIES**

11) Calculate the magnitude, direction and location of the resultant force acting on a flat plate, immersed or submerged in a fluid; the plate being in any orientation.

12) Recognize the difference between hydrostatic forces acting on flat surfaces and hydrostatic forces acting on curved surfaces.

13) Sol ve the example problems as presented in class dealing with hydrostatic forces acting on curv-d surfaces.

g) Stresses in Cylinders and Spheres

1) Define the term 'stress' as it pertains to the effects of forces in mechanical systems.

2) Define the term "thin-walled"' cylinder.

3) Write the equation for 'longitudinal stress' in a "thin-walled" cylinder.

4) Write the equation for 'circumferential stress' in a "thin-walled" cylinder.

5) Define the term "thin-walled" sphere.

6) Write the equation for the stress induced by internal pressure in a "thin-walled" sphere.

7) Read chapter 3 of the suggested reference text.

8) Answer the questions and solve the problems as assigned from chapter 3 of the suggested reference text.

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LEARIIIMG ACTIVITIES

III FLUID DYNAMICS

a) Conservation of Mass - the Continuity Principle

1) Explain what is meant by the term 'laminar' flow- Your explanation should make use of the concept of "path lines".

2) Describe the velocity distribution across the diameter of a pipe of uniform cross section which has a fluid flowing through it with laminar flow.

3) Describe the correlation that exists between the convergence and the divergence of path lines for a fluid flowing with laminar flow in pipes having non-parallel sides, and the velocity of the fluid in each path line.

4) List the five conditions which tend to produce laminar flow.

5) State the conditions of an example of a fluid flowing which might be exhibiting laminar flow.

6) Explain what is meant by the term 'turbulent' flow. Your explanation should make use of the concept of "path lines".

7) Describe the velocity distribution across the diameter of a pipe of uniform cross section which has a fluid flowing through it with turbulent flow.

8) With reference to learning activities III-a-2 and III-a-7 above, explain why it is much more acceptable to make use of an 'average" value of fluid velocity when dealing with 'turbulent' flow as opposed to the case of 'laminar[1] flow.

9) List the five conditions which will produce turbulent flow.

10) State the conditions of an example of a fluid flowing which would be exhibiting turbulent flow.

11) Explain what is meant by the term 'flow rate' or 'discharge[1].

12) List the three different types of flow rate or discharge that one could consider when examining the term "quantity".

Continued ....

IV. LEARNING ACTIVITIES

13) List several examples of units in both the S.I. metric and Imperial systems of units for the three types of flow rate or discharge listed in learning activity III-a-12 above.

14) Write the equation used to determine the 'volumetric[1] flow rate or discharge of a fluid flowing through a pipe or tube.

15) Write the equation used to determine the 'mass' flow rate or discharge of a fluid flowing through a pipe or tube.

16) Write the equation used to determine the 'weight' flow rate or discharge of a fluid flowing through a pipe or a tube.

17) Write the equations that relate the [f]volumetric flow rate', 'mass flow rate[1] and 'weight flow rate* .

18) Solve the example problems as presented in class dealing with volumetric flow rate, mass flow rati and weight flow rate of fluids of given specific gravities flowing through pipes of given interna' diameters with given fluid velocities.

19) Write a verbal statement of the 'Continuity Principle' and demonstrate an understanding of the law by applying it to examples as presented in class.

20) Write a mathematical statement of the 'Continuit; Principle' and demonstrate an understanding of the equation by applying it to problems as presented in class.

b) Force, Mass and Acceleration & c) Work and Energy

1) Recall from PHY-125 the definition for 'mass'.

2) Recall from PHY-125, MCH-110 or MCH-111 the definition for 'force[1].

3) Recall from PHY-125, MCH-110 or MCH-111 the definition for 'acceleration[1].

4) Recall from PHY-125, MCH-110 or MCH-111 the verbal statement and the mathematical statement (the equation) for Newton's second law of motion

5) Recall from PHY-125 or MCH-111 the definition for 'work[1] and the equation for 'work[1].

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IV. 1 FARMING ACTIVITIES

6) Recall the definition for the concept of 'energy[1].

7) Write the units for energy in each of the Imperial S.I. metric and C.G.S. metric systems of units.

8) Recall that the two most common forms of mechanic* energy are 'kinetic energy' and 'potential energy

9) List the two forms of 'potential' energy that a flowing fluid may possess.

10) Write a definition for the term 'kinetic energy'.

11) Write two equations for the 'kinetic energy' possessed by a moving body - one in terms of its mass and the other in terms of its weight.

12) Derive two equations for 'velocity head[1] - one th< kinetic energy per unit mass and the other the kinetic energy per unit weight.

13) List the units for each of the equations for velocity head recalling that we shall use one of the equations in the Imperial system and the other in the S.I. metric system. j

14) Write a definition for the term gravitational potential energy[1] or what we shall call *elevatioi energy[1].

15) Write two equations for 'elevation energy' - one in terms of its mass and the other in terms of it weight.

16) Derive two equations for 'elevation head[1] - one the elevation energy per unit mass and the other the elevation energy per unit weight.

17) List the units for each of the equations for elevation head recalling that we shall use one of the equations in the Imperial system and the other in the S.I. metric system.

18) Write a definition for the 'pressure potential energy[1] possessed by a flowing fluid.

19) Write the equation for 'pressure energy' possesse by a given mass or weight of fluid.

20) Derive two equations for 'pressure head[1] - one the pressure energy per unit mass and the other the pressure energy per unit weight.

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Continued ....

LEARNING ACTIVITIES

21) List the units for each of the equations for pressure head recalling that we shall use one of the equations in the Imperial system and the other in the S.I- metric system.

22) Explain what is meant by the term 'total head' possessed by a flowing fluid.

23) Write two equations for the total head possessed by a flowing fluid - one in terms of the 'mass density[1] which we shall use in the S.I. metric system and the other in terms of the 'weight density[1] which we shall use in the Imperial system.

24) Solve the example problems as presented in class involving the calculation of the total head of a flowing fluid in both the Imperial system and the S.I. metric system.

d) The Conservation of Energy - Bernoulli's Equation

1) Recall from PHY-125 the 'Law of Conservation of Energy[1].

2) Write a verbal statement of 'Bernoulli's Energy Theorem[1] explaining fully the meaning of the theorem in terms of the law of conservation of energy for a flowing fluid.

3) Explain the meaning of the term 'head loss' and list several factors which are responsible for 'head loss' in a flowing fluid.

4) Write a mathematical expression for Bernoulli's energy equation involving the weight density of the flowing fluid. Realize that even though this equation could be used in both the Imperial and the S.I. metric systems, we shall use it to solve problems in the Imperial system.

5) Write a mathematical expression for Bernoulli's energy equation involving the mass density of the flowing fluid. Realize that even though this equation could be used in both the Imperial and the S.I. metric systems, we shall use it to solve problems in the S.I. metric system.

6) Solve the problems as presented on problem sheets 14, 15, 16, 17 and 18.

7) Read chapter 4 of the suggested reference text.

8) Answer the questions and solve the problems as assigned from chapter 4 of the suggested reference text.

Continued ....

LEARNING ACTIVITIES

IV FLUID DYNAMIC APPLICATIONS

a) General Considerations & b) Applications of Bernoulli's equation

1) Review the contents of learning activities III-d-1 to III-d-8 above.

2) Use the Bernoulli's energy equation to solve for pressure and velocity at any point in a fluid flow.

c) Torricelli's theorem

1) Write a verbal statement of 'Torricelli's theorem[1] explaining fully the meaning of the theorem in terms of the law of conservation of energy for a flowing fluid.

2) Write a mathematical statement (an equation) for 'Torricelli's theorem* explaining fully the meaning of each of the variables in the equation. You may wish to illustrate Torricelli's theorem equation by means of a neat sketch showing the meaning of each of the variables.

3) Solve the example problems as presented in class involving the application of Torricelli's theorem,

d) Siphons

1) By applying Bernoulli's energy equation solve problems involving the application of siphons to transfer liquid from one location and elevation to another.

e) pressure and velocity measurements -

- f) Piezometers

1) Review the contents of learning activities II-b-26 to II-b-30.

- g) Pitot tubes

1) Describe the construction of and the application of the 'Pitot tube[1]'in its simplest form.

2) Write the equation that applys when using the 'Pitot tube[1] in its simplest form. Recall the equation that describes Torricelli's theorem from learning activity IV-c-2 above. Discuss any similarities that may exist between these two equations.

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IV. LFARNING ACTIVITIES

3) Explain why the simple Pitot tube as presented in learning activity IV-g-1 above would not be suitable for application in pipes containing flowing fluids.

4) Draw a neat sketch showing a more advanced version of a Pitot tube which eliminates the two limitations of the simple Pitot tube as presented in learning activity IV-g-3 above.

5) Write the equation that is used to determine the velocity of a pressurized fluid flowing in a pipe using the Pitot tube as presented in learning activity IV-g-4 above. Explain the meaning of each of the variables in the equation.

5) Solve the example problems as presented in class involving Pitot tube calculations.

6) Read Section 8-9-2, "The Pitot Tube and Pitot-Static Tube" in the text book - pages 260 to 264.

7) Answer the questions and solve the problems as assigned from chapter 8 of the suggested reference text involving Pitot tubes.

8) Solve the problems as presented on problem sheets 25 and 26.

h) Venturi meters

1) Draw a neat sketch of the device known as the 'Venturi tube' being certain to label all of the major components of the tube.

2) Rearrange the equation of Bernoulli to show that an increase in 'kinetic energy[1] is equal to a decrease in the sum of the 'gravitational potential energy' and the 'pressure energy[1] for a flowing fluid.

3) Write a verbal statement and a mathematical statement (an equation) for the principle known as the 'Venturi principle'.

4) Draw a neat sketch of a 'Venturi meter[1] illustrating all of the major components of the device.

5) Write the equation that relates the velocity head at the inlet of the Venturi meter to the velocity head in the throat.

Continued ....

LEARNING ACTIVITIES

6) Write the equation that relates the "actual" volumetric flow rate to the "theoretical" volumetric flow rate as determined by the Venturi meter calculation.

7) Explain what is meant by the 'meter coefficient'.

8) Solve the example problems as presented in class involving Venturi meter calculations.

9) Solve the problems as presented on problem sheets 19 and 24.

10) Answer the questions and solve the problems as assigned from chapters 4 and 8 of the suggested reference text involving Venturi meters.

11) Draw neat sketches of the three instruments discussed in class that are used to measure the volumetric flow rate through a pipe - the 'Venturi tube' , the 'flow nozzle' and the 'orifice plate'. Your diagrams should illustrate the similarities among the three instuments.

12) Discuss the general principles by which all three of the instruments listed in learning activity IV-h-11 above operate.

13) List the ranges in which the meter coefficients fall for each of the instruments listed in learning activity IV-h-11,

14) Explain why of the three instruments listed above the Venturi tube has the highest meter coefficients - i.e. the range of meter coefficients closest to 1.0l

V **STEADY FLOW** - INCOMPRESSIBLE FLUIDS IN PIPES

a) Laminar and Turbulent flow

1) Review the contents of learning activities III-a-1 to III-a-10.

b) Reynolds' numbers & c) Laminar Flow in Tubes

1) List the four variables as determined by Osborne Reynolds which determine the character of flow of a fluid in a pipe.

2) Write two equations for Reynolds' numbers - one in terms of the absolute viscosity of the fluid and the other in terms of the kinematic viscosity.

Continued ....

IV. I FARMING ACTIVITIES

3) Draw a schematic diagram of the apparatus as used by Reynolds to determine when the character of the flow of a fluid through a pipe was laminar, turbulent or at the 'critical velocity'.

4) List the ranges of values of Reynolds' numbers that correspond to flow in a pipe that is: (a) laminar; (b) turbulent; and (c) within the "transition region".

5) Solve the example problems as presented in class dealing with Reynolds[1] number calculations and the determination of the character of flow in a pipe.

d) <u>Boundary Layer</u>

1) Explain what is meant by the term 'boundary layer'.

2) Draw a sketch illustrating how the velocity profile of a fluid flowing through a pipe changes as the value of the Reynolds[1] number decreases.

3) Describe the character of the flow of a fluid flowing over a flat plate held parallel to the direction of the flow. Be certain to use terms such as 'boundary layer[1], 'laminar sublayer[1], 'turbulent boundary layer[1] and 'buffer layer' in your description.

e) <u>Pressure Loses in Pipe Flow - the Hagen-Poiseuille equation</u>

1) Write the equation known as the Hagen-Poiseuille equation and indicate the condition that must be satisfied in order to use the equation.

2) Write the equation used to determine the "friction head loss" for a fluid flowing through a pipe.

3) Solve the example problems as presented in class dealing with the calculation of pressure drops in straight horizontal lengths of pipe carrying fluids flowing with laminar flow.

4) Write the equation used to calculate the pressure loss in a pipe known as the Darcy-Weisbach equation.

5) Explain the meaning of each of the variables in the Darcy-Weisbach equation including the variable known as the 'friction factor'.

Continued ....

LEARNING ACTIVITIES

6) Write the equation that expresses the relationship between the 'friction factor' and the 'Reynolds' number' for a fluid flowing through a pipe.

7) Solve the problems as presented from chapter 6 of the suggested reference text involving Reynolds' numbers and laminar flow calculations.

8) Solve the problems as presented on problem sheet number 27.

f) Stoke's law and Stoke's equation

1) Write a mathematical statement (an equation) for Stoke's law. Explain fully the meaning of each of the variables.

g) Poiseuille's law and Poiseuille's equation

1) List the four variables or factors that determine the magnitude of the volumetric flow rate through a tube.

2) Write the equation known as Poiseuille's equation explaining fully the meaning of each of the variables.

3) Solve the example problems as presented in class involving the application of Poiseuille's equation.

4) Solve the problems as assigned on problem sheets 22 and 23.

Continued ....

Course Analysis Form

Course Title and No.: MECHANICS OF FLUIDS MCH 219-4

Learning Outcomes	Broad Areas of Content	Indicator of Importance (if applicable)	Indicators of Success
Upon successful completion of this course the student will: 1) in his/her own words write definitions for the concepts introduced; 2) answer questions requiring a knowledge of the concepts presented; 3) respond to questions requiring extrapolation of the course content; 4) solve problems requiring an understanding of the course theory; 5) apply the knowledge to other related courses such as hydraulics.	The 5 learning outcomes listed to the left are each to be applied to the following five major topic headings which form the course outline for MCH 219. I FUNDAMENTAL CONCEPTS II FLUID STATICS III FLUID DYNAMICS IV FLUID DYNAMIC APPLICATIONS V STEADY FLOW - INCOMPRESSIBLE FLUIDS IN PIPES		The challenge process consists of writing & passing a three hour comprehensive examination- The challenge exam will consist of the following components: 1) the writing of definitions for course concepts; 2) answering questions requiring a knowledge of the course content; 3) responding to questions requiring extrapolation of the course content; 4) solving problems requiring an understanding of the course theory. The exam will cover the 5 major topic headings which form the course outline for MCH219. Refer to pages 4 & 5 for a breakdown of the topics listed to the left under Broad Areas of Content- A successful challenge requires a minimum grade of 55% on the exam.

Assessment Process

Your final grade In MCH219 will be determined on the basis of four tests to be administered during the semester. Each test will examine your knowledge of a number of topics and will be administered within one week of completing tnose topics.

Assessment Tools

The four tests as outlined in the "assessment process" above are of equal weight. In other words, each of the four tests is worth 25% of your final grade.

Supports

Requirements for successful completion of course

Provided you have received a passing grade in each of the four tests, your final grade will simply be an average of the four test results. IrTorder to obtain your letter grade the percentage-letter grade equivalents listed on page 6 (Grade Requirements) will be used.

A challenge process for this course can be made available lo learners within a reasonable period of lime following a learner's request.

SIGNATURES:

AO&SU)

Professor

Date

Frogiani<CooixUiutor **or Chair**

June 5, 1995.

Date

(04/01/94)