Unit 11: Fluid Mechanics

Unit code	**R/615/1485**
Unit level	**4**
Credit value	**15**

Introduction

Fluid mechanics is an important subject to engineers of many disciplines, not just those working directly with fluid systems. Mechanical engineers need to understand the principles of hydraulic devices and turbines (wind and water); aeronautical engineers use these concepts to understand flight, while civil engineers concentrate on water supply, sewerage and irrigation.

This unit introduces students to the fluid mechanics techniques used in mechanical engineering. The hydraulic devices and systems that incorporate the transmission of hydraulic pressure and forces exerted by a static fluid on immersed surfaces.

Topics included in this unit are: pressure and force, submerged surfaces, fluid flow theory, aerodynamics, and hydraulic machinery.

On successful completion of this unit students will be able to work with the concept and measurement of viscosity in fluids, and the characteristics of Newtonian and non-Newtonian fluids; examine fluid flow phenomena, including energy conservation, estimation of head loss in pipes and viscous drag; and examine the operational characteristics of hydraulic machines, in particular the operating principles of various water turbines and pumps.

Learning Outcomes

By the end of this unit students will be able to:

1. Determine the behavioural characteristics of static fluid systems.
2. Examine the operating principles and limitations of viscosity measuring devices.
3. Investigate dynamic fluid parameters of real fluid flow.
4. Explore dynamic fluid parameters of real fluid flow.

Essential Content

LO1 **Determine the behavioural characteristics of static fluid systems**

Pressure and force:

How Pascal's laws define hydrostatic pressure.

Pressure with the use of manometers.

Transmission of force in hydraulic devices.

Submerged surfaces:

Determining thrust on immersed surfaces.

Moments of area and parallel axis theorem.

Calculating centre of pressure with moments of area.

LO2 **Examine the operating principles and limitations of viscosity measuring devices**

Viscosity in fluids:

Dynamic and kinematic viscosity definitions.

Characteristics of Newtonian fluids.

Temperature effects on viscosity.

Classification of non-Newtonian fluids.

Operating principles and limitations:

Operating principles of viscometers.

Converting results acquired from viscometers into viscosity values.

LO3 **Investigate dynamic fluid parameters of real fluid flow**

Fluid flow theory:

Energy present within a flowing fluid and the formulation of Bernoulli's Equation.

Classification of fluid flow using Reynolds numbers.

Calculations of flow within pipelines.

Head losses that occur within a fluid flowing in a pipeline.

Viscous drag resulting from fluid flow and the formulation of the drag equation.

Aerodynamics:

Application of prior theory of fluid flow to aerodynamics.

Principles of aerofoils and how drag induces lift.

Flow measuring devices and their operating principles.

LO4 **Explore the operating principles and efficiencies of hydraulic machines**

Hydraulic machinery:

Operating principles of different types of water turbine.

Reciprocating and centrifugal pump theory.

Efficiencies of these different types of hydraulic machinery.

Environmental concerns surrounding hydraulic machines.

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Determine behavioural characteristics of static fluid systems</td><td rowspan="2">D1 Explain the use and limitations of manometers to measure pressure.</td></tr>
<tr><td>P1 Describe force and centre of pressure on submerged surfaces.
P2 Carry out appropriate calculations on force and centre of pressure on submerged surfaces.</td><td>M1 Determine the parameters of hydraulic devices that are used in the transmission of force.</td></tr>
<tr><td colspan="2">LO2 Examine the operating principles and limitations of viscosity measuring devices</td><td rowspan="2">D2 Illustrate the results of a viscosity test on a Newtonian fluid at various temperatures with that which is given on a data sheet and explain discrepancies.</td></tr>
<tr><td>P3 Explain the operation and constraints of different viscometers that quantify viscosity in fluids.
P4 Carry out appropriate calculations on the effect of changes in temperature and other constraints on the viscosity of a fluid.</td><td>M2 Explain, with examples, the effects of temperature and shear forces on Newtonian and non-Newtonian fluids.</td></tr>
<tr><td colspan="2">LO3 Investigate dynamic fluid parameters of real fluid flow</td><td rowspan="2">D3 Determine the head losses accumulated by a fluid when flowing in a pipeline for various applications.</td></tr>
<tr><td>P5 Determine parameters of a flowing fluid using Bernoulli’s Equation.
P6 Define the flow of a fluid using Reynold’s numbers and the significance of this information.</td><td>M3 Explain the effect of aerodynamic drag and lift on aerofoils.</td></tr>
<tr><td colspan="2">LO4 Explore the operating principles and efficiencies of hydraulic machines</td><td rowspan="2">D4 Describe and analyse the arguments concerning the ecological impact of hydroelectric power.</td></tr>
<tr><td>P7 Determine the efficiency of a water turbine.
P8 Calculate the input power requirements of centrifugal pumps.</td><td>M4 Identify the limitations that exist within different types of water turbine.</td></tr>
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Recommended Resources

Textbook

MASSEY, B.S. and WARD-SMITH, J. (2011) *Mechanics of Fluids*. 9th Ed. Oxford: Spon Press.

Journals

Journal of Fluid Mechanics. Cambridge University Press.

Annual Review of Fluid Mechanics. Annual Reviews, California.

Electronic

Khan Academy

www.khanacademy.org/science/physics/fluids

Links

This unit links to the following related units:

Unit 29: Electro, Pneumatic and Hydraulic Systems

Unit 64: Thermofluids