Unit 4011: Fluid Mechanics

Unit Code: T/651/0724

Level: 4

Credits: 15

Introduction

Fluid mechanics is an important subject to scientists and 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 and design flying machines, while civil engineers typically concentrate on water supply, sewerage, and irrigation.

This unit introduces students to the fluid mechanics principles and techniques used in mechanical engineering. In particular, 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 learn about the concept and measurement of viscosity in fluids, and the characteristics of Newtonian and non-Newtonian fluids; fluid flow phenomena, including energy conservation, estimation of head loss in pipes and viscous drag; and 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:

LO1 Determine the behavioural characteristics of static fluid systems

LO2 Examine the operating principles and limitations of viscosity measuring devices

LO3 Investigate dynamic fluid parameters of real fluid flow

LO4 Explore the operating principles and efficiencies of hydraulic machines.

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 systems and 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:

Dimensional analysis (the Buckingham π theorem)

Dynamic and kinematic viscosity definitions

Characteristics of Newtonian fluids

Effects of temperature on viscosity

Classification of non-Newtonian fluids.

Operating principles and limitations:

Operating principles of viscometers

Rheometers for Non Newtonian fluids

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 lift-induced drag

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 different types of hydraulic machinery

Environmental concerns surrounding hydraulic machines.

Use of relevant problem-solving tools within the context of a chosen scenario/sector e.g. root cause analysis (RCA), process failure modes effects analysis (PFMEA), fishbone, practical problem solving (PPS) and advanced product quality planning (APQP).

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Determine the behavioural characteristics of static fluid systems		
P1 Determine force and centre of pressure on submerged surfaces. **P2** Examine the parameters of hydraulic devices that are used in the transmission of force.	**M1** Carry out appropriate calculations on force and centre of pressure on submerged surfaces.	**D1** Explain the use and limitations of manometers to measure pressure.
LO2 Examine the operating principles and limitations of viscosity measuring devices		
P3 Examine 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.	**M2** Explain, with examples, the effects of temperature and shear forces on Newtonian and non-Newtonian fluids.	**D2** Illustrate the results of a viscosity test on a Newtonian fluid at various temperatures with those given on a data sheet and explain discrepancies.
LO3 Investigate dynamic fluid parameters of real fluid flow		
P5 Determine parameters of a flowing fluid using Bernoulli's Equation. **P6** Investigate the flow of a fluid using Reynold's numbers and the significance of this information.	**M3** Explain the effect of aerodynamic drag and lift on aerofoils.	**D3** Analyse the head losses accumulated by a fluid when flowing in a pipeline for various applications.
LO4 Explore the operating principles and efficiencies of hydraulic machines		
P7 Determine the efficiency of a water turbine. **P8** Calculate the input power requirements of centrifugal pumps. **P9** Explore operating efficiencies and applications of two different hydraulic machines.	**M4** Analyse the limitations that exist within different types of water turbine.	**D4** Critically analyse the arguments concerning the ecological impact of hydroelectric power.

Recommended Resources

Note: See HN Global for guidance on additional resources.

Print Resources

Cengel Y.A. and Cimbala J.M. (2018) *Fluid Mechanics: Fundamentals and Applications.* 4th Ed: McGraw-Hill Education

Elger D.F., Williams B.C. and Crowe C.T. (2022) Engineering fluid mechanics. John Wiley & Sons.

Han J. and wright L. (2020) *Experimental Methods in Heat Transfer and Fluid Mechanics.* 1st Edition. CRC Press.

Hibbeler R.C. (2020) *Fluid Mechanics in SI Units.* 2nd edition. Pearson.

Mott R.L. and Untener A. (2023) *Applied Fluid Mechanics, Global Edition.* 7th edition. Pearson.

Rathakrishnan E. (2022) *Encyclopaedia of Fluid Mechanics.* 1st Edition. CRC Press.

Rathakrishnan E. (2022) *Fluid mechanics: An introduction.* PHI Learning Pvt. Ltd.

Rodrigues J.F. and Sequeira A. (2020) *Mathematical Topics in Fluid Mechanics.* CRC Press.

Shivamoggi B.K. (2022) *Introduction to Theoretical and Mathematical Fluid Dynamics.* Wiley.

Uddin N. (2023) *Fluid Mechanics: A Problem-Solving Approach.* 1st Edition. CRC Press.

White F. and Xue H. (2020) *Fluid Mechanics.* 9th Edition. McGraw-Hill.

Journals

Note: Example journals listed below provide a broad range of articles related to unit content and those relevant for the qualification. Staff and students are encouraged to explore these journals and any other suitable journals to support the development of academic study skills, and subject specific knowledge and skills as part of unit level delivery.

Annual Review of Fluid Mechanics

Experiments in Fluids

Fluid Dynamics

Journal of Applied Fluid Mechanics

Journal of Fluid Mechanics

Links

This unit links to the following related units:

Unit 4024: Electro, Pneumatic and Hydraulic Systems

Unit 5023: Thermofluids.