Unit 203 The analysis of the mechanics of fluids

Unit summary

This unit is concerned with the properties of fluids and the principles of fluid mechanics. Additionally it covers fluid systems analysis, performance studies and the application of system design.

Aims

The unit aims to develop understanding and analytic skills in fluid properties, fluid mechanics and the application of these to simple fluid systems.

Prerequisites

It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination.

Learning outcomes

There are **four** outcomes to this unit. The candidate will be able to:

- Understand basic fluid mechanics related to compressible and incompressible fluids.
- Understand fluid flow and perform fluid flow calculations.
- Analyse the mechanics of particles immersed in a fluid.
- Analyse the principles and applications of turbo-machinery.

Guided learning hours

It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills

This unit contributes towards the Key Skills in the following areas:

N4.1

Develop a strategy for using application of number skills over an extended period of time.

N4.2

Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- deductive and inferential reasoning;
- algebraic manipulation.

N4.3

Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.3.1 Undertake research into engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
2.2.2 Solve production problems with engineering solutions
4.1.1 Determine the operational requirements of engineering products or processes
4.2.2 Solve operational problems with engineering solutions
4.3.2 Evaluate operational processes
6.1.1 Analyse the risks arising from engineering products and processes
6.2.1 Assure the quality of engineering products or processes
8.1.1 Maintain and develop own engineering expertise

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Outcome 1 Understand basic fluid mechanics related to compressible and incompressible fluids.

Knowledge requirements
The candidate knows how to:

1 define compressible and incompressible fluids

2 derive and solve conservation equations for

- a continuity
- b momentum
- c energy

and any combination of these

3 apply conservation equations to engineering systems

4 describe the kinematics of fluid motion in terms of

- a streamlines
- b streamtubes
- c particle paths
- d streaklines

5 define

- a irrotational and rotational flows
- b circulation
- c vorticity

6 develop stress-strain relations for

- a Newtonian fluids
- b non-Newtonian fluids

7 determine and apply geometric, kinematic and dynamic similarity conditions in fluid systems

8 solve problems using

- a Buckingham $\prod$ theorem
- b dimensional analysis

9 derive the principal dimensionless parameters of fluid flow

- a Reynolds number
- b Froude number
- c Mach number
- d pressure, lift and drag coefficients
- e roughness ratio

and perform calculations involving these

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Outcome 2 Understand fluid flow and perform fluid flow calculations.

Knowledge requirements
The candidate knows how to:

1 solve compressible fluid flow problems involving
   a speed of weak pressure waves
   b stagnation pressure
   c fluid temperature
   d fluid density
2 solve problems involving isentropic flow of a perfect gas in ducts of varying cross-sectional area in terms of Mach number and including choked flow.
3 describe the formation of a normal shock in convergent-divergent nozzles
4 determine and apply laminar flow in pipes and on and between flat plates
5 calculate the velocity distribution in laminar flow
6 calculate the volumetric flow rate in laminar flow
7 apply laminar flow to hydrodynamic lubrication
8 analyze laminar flow using
   a boundary layer theory
   b displacement and momentum thicknesses
   c skin friction coefficient
9 solve problems using the momentum integral equation
10 calculate the drag on a flat plate in laminar flow
11 describe the factors affecting boundary layer transition
12 analyze turbulent boundary layers in terms of
   a power law
   b logarithmic velocity distribution
   c laminar sub-layer
   d skin friction on a flat plate
13 calculate the drag on a flat plate in turbulent flow
14 determine and apply the effects of surface roughness on fluid flow
15 describe boundary layer separation and the formation of wakes
16 solve problems involving steady flow in pipes of
   a Newtonian fluids
   b non-Newtonian fluids
17 analyse the relationship in steady flow between friction factor, Reynolds number and relative roughness

18 analyse simple pipe networks using iterative calculations

19 apply Euler and Bernoulli equations to incompressible inviscid fluid flows

20 determine and apply the stream function and velocity potential function in steady two-dimensional flows

21 determine and apply flows of incompressible fluids resulting from simple combinations of a

- a uniform stream
- b source
- c sink
- d doublet
- e point vortex

22 determine and apply inviscid flow around a circular cylinder with circulation including the calculation of

- a pressure distribution
- b lift force

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Outcome 3 Analyse the mechanics of particles immersed in a fluid.

Knowledge requirements
The candidate knows how to:

1 analyse the behaviour of single particles in a fluid in terms of
   a Stokes Law for spherical particles
   b drag coefficient
   c Reynolds number effects
   d terminal velocity
2 investigate particles in fluid systems forming
   a sedimentation of uniform size
   b sedimentation of varying size range
3 analyse flow in packed beds using
   a Darcy's law
   b Carmen-Kozeny equation

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Outcome 4 Analyse the principles and applications of turbo-machinery.

Knowledge requirements
The candidate knows how to:

1 use one dimensional theory to analyse the performance of
   a turbines
   b pumps
   c fans
2 assess axial and centrifugal flow machines
3 apply dynamic similarity to turbo-machines in terms of
   a flow, head and power coefficients
   b specific speed
   c characteristic performance curves
   d net positive-suction head (NPSH)
4 analyse turbo-machinery systems in terms of
   a system load line
   b pump and turbine operating conditions

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Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Chemical Engineering: Fluid Flow, Heat Transfer and Mass Transfer v. 1	Coulson, Richardson	Butterworth-Heinemann	0750644443
Engineering Fluid Mechanics	Robertson, Crowe	Wiley	0471173061
Fluid Mechanics	Streeter, Wylie, Bedford	McGraw Hill	0070665788
Fluid Mechanics	White	McGraw Hill	0071168486
Fluid Mechanics	Douglas, Gasiorek	Prentice Hall	0582414768
Introduction to Fluid Mechanics	Fox, McDonald	Wiley	0471124648
Mechanics of Fluids	Massey, Ward-Smith	Nelson Thornes	0748740430
Other useful texts			
Elementary Fluid Mechanics	Vennard, Street, Watters	John Wiley	0471013102
Fluid Flow for Chemical Engineers	Holland, Bragg	Butterworth-Heinemann	
Solving Problems in Fluid Mechanics Vol. 1	Douglas, Matthews	Longman Higher Education	0582239877
Solving Problems in Fluid Mechanics Vol. 2	Douglas, Matthews	Longman Higher Education	0582239885
Mechanics of Fluids	Duncan, Thom, Young	Arnold	0713132418 o/p