Unit 106 Thermodynamic, fluid and process engineering

Unit summary

This unit is concerned with the design and analysis of processes in engineering involving fluid flow and energy transfer.

Aims

This unit aims to develop knowledge and skills required for design and analysis of fluid flow and energy transfer systems. It is also intended to aid the candidate in problem solving on existing thermodynamic systems or when involved in the modification or extension of existing systems.

Prerequisites

Calculus of several variables, vector algebra.

Phase diagrams.

Newtonian mechanics, concepts of impulse and momentum, elementary hydrostatics and thermodynamics.

Learning outcomes

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

- Understand the principles of thermodynamics and solve related problems
- Understand the principles of fluid mechanics and solve related problems
- Solve problems involving thermodynamic and fluid mechanics systems

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:

1.4.4 Evaluate designs for engineering products or processes
2.2.2 Solve production problems with engineering solutions
6.2.1 Assure the quality of engineering products or processes
7.2.3 Evaluate projects
8.1.1 Maintain and develop own engineering expertise

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Outcome 1 Understand the principles of thermodynamics and solve related problems

Knowledge requirements
The candidate knows how to:

1 apply the First Law of Thermodynamics to
- a closed system processes
  - i constant volume process
  - ii constant pressure process
  - iii isothermal process
  - iv adiabatic process
- b open or flow process
  - i steady flow process

2 define reversible thermodynamic processes

3 define irreversible thermodynamic processes

4 define equilibrium in thermodynamic processes

5 use formulae to solve problems involving
- a non-flow energy equation applied to reversible and irreversible processes
- b steady flow energy equation applied to reversible and irreversible processes

6 relate the Kelvin-Planck and Clausius statements of Second Law of Thermodynamics to cyclic processes

7 define the thermodynamic temperature scale and relate it to the Carnot cycle

8 define and evaluate entropy
- a temperature – entropy diagram
- b reversible steady flow process
- c irreversible processes

9 apply the Second Law of Thermodynamics to
- a heat pumps
- b isentropic processes
- c Carnot and Rankine cycles

10 define and determine isentropic efficiency

11 use
   a h-s diagrams (enthalpy-entropy)
   b T-s diagrams (temperature- entropy)
   c p-v diagrams (pressure-volume)
12 determine properties of a perfect gas
13 determine the thermodynamic properties internal energy, enthalpy and entropy using
   a specific heats for perfect gases
   b tables of properties
14 determine phase changes for pure substances using
   a p-v-T diagrams
   b Gibbs phase rule
   c phase equilibrium
   d Clausius-Clapeyron equation

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Outcome 2 Understand the principles of fluid mechanics and solve related problems

Knowledge requirements
The candidate knows how to:

1 define terms and solve hydrostatic problems involving
   a pressure
   b density
   c static force balances
   d Archimedes' principle
   e stability of floating bodies
2 solve fluid systems problems involving
   a velocity in one-dimension
   b acceleration in one-dimension
   c Newton's Second law of motion
   d momentum changes
   e impulse functions
   f by applying conservation equations for mass, energy and momentum
3 solve problems involving fluids in motion for
   a steady uniform flow
   b steady non-uniform flow
4 measure fluid flow rates using
   a orifice plate
   b venturi
5 solve problems involving Bernoulli's Equation
6 define Newton's law of viscosity
7 apply viscosity in fluid mechanics problems
8 define laminar and turbulent flows
9 determine and apply the effects of pipe-wall friction on fluid flow
10 determine and apply Reynolds number in fluid flow problems
11 relate pipe-wall friction factor to Reynolds number and wall roughness

12 relate viscosity to

- a streamlined flow
- b boundary layers
- c separation
- d wakes
- e vortices

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Outcome 3 Solve problems involving thermodynamic and fluid mechanics systems

Knowledge requirements
The candidate knows how to:

1 solve practical flow and non-flow problems for steady state thermodynamic processes

2 apply fluid mechanics to the solution of practical flow and non-flow problems for steady state processes

3 solve practical problems involving gas and vapour power cycles

4 solve practical problems involving mass and energy balances for inert components

5 in a steady state

6 solve practical problems in simple reaction or combustion systems involving

- a stoichiometry
- b mass balances
- c heats of reaction

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Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Applied Thermodynamics for Engineering Technologists Chapters 1, 2, 3, 4, (not 4.6), 5, 7 (not 7.7, 7.13), 8.1, 8.2, 8.3, 9.1, 14.1, 14.2, 14.3, 14.4.	Eastop, McConkey	Longman Higher Education	0582091934
Fluid Mechanics Chapters 1, 2.1 to 2.7, 3, 5, 6, 7.	White	McGraw Hill	0071168486
Thermodynamic and Transport Properties of Fluids	Rogers, Mayhew, Basil	Blackwell Science	0631197036
Engineering Thermodynamics, Work and Heat Transfer o/p Chapters 1, 2, 3, 4, 5, 6, 8 (not 8.6), 9, 10, 11.1 to11.3, 12.1, 12.2, 12.6. 12.7, 12.8, 12.9, 13.1, 13.2, 13.2, 15.1, 15.2, 15.3, 15.4, 15.	Rogers, Mayhew	Longman Higher Education	0582053765
Mechanics of Fluids Chapter (1 (not 1.6), 2, 3, 4, 5, 6 (not 6.7, 6.8), 7 (not 7.7, 7.8, 7.9).	Massey Van Nostrand	Stanley Thornes	0748740430