Unit 201 Applied thermodynamics

Unit summary
This unit is about thermodynamics when applied to industrial power and refrigeration systems.

Aims
The unit aims to provide the candidate with the knowledge required to understand the performance and behaviour of thermodynamic power and refrigeration systems and the component parts of these 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 **five** outcomes to this unit. The candidate will be able to:

- Understand and apply the working relationships involved in the behaviour and performance of power and refrigeration cycles
- Solve realistic problems involving the steady flow of compressible fluids
- Analyse and solve problems associated with rotodynamic compressors and turbines and gas turbine cycles
- Analyse and solve problems associated with reciprocating compressors and expanders and internal combustion engines
- Understand the fundamental principles of mixtures of gases and vapours and of combustion processes

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.

PS4.1
Develop a strategy for using skills in problem solving over an extended period of time.

PS4.2
Monitor progress and adapt a strategy, as necessary, to achieve the quality of outcomes required when tackling **one** complex problem with at least three options.

PS4.3
Evaluate an overall strategy and present the outcomes from personal work using a variety of methods.

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
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 and apply the working relationships involved in the behaviour and performance of power and refrigeration cycles

Knowledge requirements
The candidate will be able to:

1 analyse steam turbine power cycles including
   a effects of superheating
   b reheating and regenerative feed heating
   c use of back pressure and pass-out turbines
2 analyse gas turbine power cycles including
   a effects of intercooling
   b reheating and heat exchange
   c influence of
      i component efficiencies
      ii pressure ratio
      iii cycle temperatures
3 analyse vapour compression refrigeration cycles including
   a effect of expansion by throttling
   b effects of working fluid state at
      i compressor inlet
      ii condenser outlet
      iii choice of refrigerant
4 explain the elements of simple ammonia-water absorption cycle
5 apply the principles of the heat pump and evaluate its application possibilities

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Outcome 2 Solve realistic problems involving the steady flow of compressible fluids

Knowledge requirements
The candidate will be able to:

1 determine one-dimensional steady flow of gases and vapours through nozzles and diffusers and evaluate the effects of
   a critical pressure ratio
   b friction

2 analyse and solve problems involving adiabatic flow through long pipes

3 identify stagnation properties at a point in a fluid stream in terms of
   a pressure
   b temperature
   c enthalpy

4 analyse and solve problems involving simple jet propulsion systems in terms of
   a momentum thrust
   b pressure thrust
   c specific impulse

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Outcome 3 Analyse and solve problems associated with rotodynamic compressors and turbines and gas turbine cycles

Knowledge requirements
The candidate will be able to:

1 solve problems involving positive-displacement expanders and compressors
- a reversible reciprocating machines
- b isothermal and isentropic efficiencies
- c reciprocating air compressors
  - i volumetric efficiency
  - ii multi-stage working with intercooling
- d the steam engine as an expander
- e rotary positive displacement compressors

2 solve problems involving turbines and turbo-compressors
- a mean-diameter treatment of kinematics and momentum transfer
- b radial and axial-flow machines
- c impulse and 50% reaction blading in axial-flow turbines
- d sources of internal losses
- e overall, stage and polytropic efficiencies reheat factor

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Outcome 4 Analyse and solve problems associated with reciprocating compressors and expanders and internal combustion engines

Knowledge requirements
The candidate will be able to:

1 analyse reciprocating internal combustion engines
   a air-standard cycles underlying reciprocating engine processes
      i Otto
      ii Diesel
      iii Stirling
      iv others
2 determine the cycle efficiency and mean effective pressure as criteria of performance of reciprocating internal combustion engines
3 explain the practical working of reciprocating internal-combustion engines
4 determine factors limiting the performance of
   a spark ignition engines
   b compression-ignition engines
5 determine the effects of variable specific heat and dissociation on engine cycle efficiency
6 determine the relationship between air-standard cycles and reciprocating internal-combustion engine processes

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Outcome 5 Understand the fundamental principles of mixtures of gases and vapours and of combustion processes

Knowledge requirements
The candidate will be able to:

1 analyse mixtures of gases and vapours and the relationship between specific and molar properties

2 determine the effects of mixtures of gases and vapours on the performance of

- a cooling towers
- b condensers

3 analyse air-conditioning plant

4 use psychrometric charts

5 analyse combustion processes in terms of

- a stoichiometry
- b internal energy of reaction
- c enthalpy of reaction and formation

6 apply First Law of thermodynamics to chemical reactions

7 explain chemical dissociation and determine its effect in reactions involving perfect gases

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Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Thermodynamic and Transport Properties of Fluids: S I Units	Rogers, Mayhew	Blackwell	0631197036
Engineering Thermodynamics, Work and Heat Transfer	Rogers, Mayhew	Longman	0582053765
Applied Thermodynamics for Engineering Technologists	Eastop, McConkey	Longman	0582091934