Unit 202 The analysis of heat and mass transfer

Unit summary
This unit is about heat and mass transfer in stationary and flowing systems.

Aims
The unit aims to provide the candidate with the knowledge required to understand and analyse heat transfer and mass transfer systems employed in industrial processes.

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

- Predict rates of heat transfer and mass transfer by in simple geometries.
- Predict heat and mass transfer coefficients in flowing systems using correlations appropriate for both forced and free convection.
- Analyse the performance of heat exchangers, wetted-wall columns, packed towers, plate columns, humidification and drying equipment, and evaporators.

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
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
6.1.1 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 Predict rates of heat transfer and mass transfer by in simple geometries.

Knowledge requirements
The candidate knows how to:

1 perform material and energy balances

2 determine heat transfer by conduction
- a steady-state conduction through
  - i slabs
  - ii compound walls
  - iii cylinders

3 unsteady-state conduction in homogeneous solids

4 determine heat transfer by convection
- a natural convection
- b heat transfer in fluids
- c film and overall heat transfer coefficients
- d forced convection
  - i inside pipes
  - ii outside pipes
  - iii around tube bundles
  - iv fins

5 determine heat transfer by radiation
- a Laws of radiant heat transfer
- b radiation from gases
- c geometric factors
- d absorptivity
- e flame temperature and furnace design

6 analyse heat transfer involving change of phase

7 understand and calculate
- a condensation on vertical and horizontal surfaces
  - i filmwise
  - ii dropwise
- b nucleate and film boiling
- c critical heat flux

8 analyse vaporization and evaporators involving

- a natural circulation
- b forced circulation
- c surface effects
- d evaporators with single and multiple effects

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Outcome 2 Predict heat and mass transfer coefficients in flowing systems using correlations appropriate for both forced and free convection.

Knowledge requirements
The candidate knows how to:

1 define mass transfer as a transport process
2 apply Fick's law
3 determine molecular diffusivity
4 analyse steady-state molecular diffusion
5 determine film and penetration theory of mass transfer
6 understand diffusion
  a eddy diffusivity
  b boundary layer diffusivity
7 analyse mass transfer in two-phase fluid systems
  a counter-current flow
  b co-current flow
8 analyse coefficients of mass transfer
  a film
  b overall
9 determine mass transfer between fluids and solids
10 understand the fundamentals of continuous separation processes
  a operating and equilibrium lines
  b multistage and differential-contact separation
  c concepts of theoretical stage
  d stage efficiency and transfer units
11 analyse simultaneous heat and mass transfer
  a relationship between heat, mass and momentum transfer
  b jH and jD factors
  c psychometry
12 analyse humidification and dehumidification
  a direct contact water and gas cooling
  b air-conditioning
  c drying

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Outcome 3 Analyse the performance of heat exchangers, wetted-wall columns, packed towers, plate columns, humidification and drying equipment, and evaporators.

Knowledge requirements
The candidate knows how to:

1 appraise heat exchangers
- a type of construction
- b mean temperature difference
- c effectiveness and number of transfer units

2 assess the economic factors of heat exchange systems
- a design of main types
- b costings

3 appraise the application of mass transfer processes
- a distillation
  - i design
  - ii transfer process
- b absorption
  - i design
  - ii transfer process
- c extraction
  - i design
  - ii transfer process

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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
Introduction to Heat Transfer	Incropera, De Witt	John Wiley	0471386499
Transport Phenomena	Beek, Mutzall, Van Heuven	John Wiley	0471999903
Engineering Calculations in Radiative Heat Transfer	Gray, Muller	Pergamon Press	0080177867 o/p
Fluid Mechanics and Transfer Processes Chapters 13-18	Kay, Nedderman	Cambridge Uni. Press	0521303036 o/p