Module 1

Chapter 1 : Modes of Heat Transfer and Heat Conduction 1-1 to 1-68

Syllabus : Modes of Heat Transfer : Mechanism of conduction, Convection and radiation heat transfer and it's Governing laws. Generalized heat conduction equation in rectangular, cylindrical and spherical coordinates (only equations for cylindrical and spherical coordinates, no derivation). Steady state heat conduction through plane wall, composite wall, cylinder, composite cylinder, sphere and composite sphere. Thermal contact resistance. Critical radius of insulation in cylinder and sphere.

1.1 Thermodynamics and Heat Transfer 1-1

1.1.1 Application Areas of Heat Transfer 1-2

1.2 Modes of Heat Transfer 1-2

1.3 Mechanism of Heat Transfer by Conduction 1-3

1.4 Basic Definitions Relating to Heat Transfer 1-3

1.4.1 Heat Transfer Rate and Heat Flux 1-4

1.4.2 Steady State 1-4

1.4.3 Unidirectional Heat Flow 1-4

1.5 Fourier's Law of Heat Conduction 1-4

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1.5.2 Units of Thermal Conductivity, k 1-5

1.5.3 Definition of Thermal Conductivity of a Material 1-5

1.5.4 Thermal Conductivity of Materials 1-5

1.5.5 Important Points Regarding Thermal Conductivity of Materials 1-6

1.6 Heat Conduction through a Wall/Slab 1-9

1.6.1 Heat Conduction in a Thick wall with Variable Thermal Conductivity 1-9

1.6.2 Thermal Diffusivity, α 1-9

1.7 Analogy between Heat Conduction and Electricity (Concept of Thermal Resistance in Heat Transfer) 1-10

1.7.1 Thermal Conductance (C) 1-10

1.8 Convection 1-10

1.8.1 Coefficient of Convective Heat Transfer 1-11

1.8.2 Newton's Law of Cooling 1-12

1.9 Radiation 1-12

1.9.1 Emissive Power (E) 1-13

1.9.2 Emissivity (ε) 1-13

1.10 Laws of Radiation 1-13

1.10.1 Wien's Law 1-13

1.10.2 Kirchoff's Law 1-13

1.10.3 Stefan-Boltzmann Law 1-13

1.11 Assumptions in Heat Conduction and General Heat Conduction Equation in Cartesian Co-ordinates 1-17

1.11.1 General Differential Heat Conduction Equation in Rectangular/Cartesian Co-ordinates 1-17

1.11.2 Thermal Diffusivity, α 1-18

1.11.3 Special Cases of General Heat Conduction Equation 1-19

1.12 Heat Conduction Equation in Cylindrical Co-ordinates 1-19

1.12.1 Steady State One Dimensional Heat Conduction Equation (Poisson's Equation) 1-19

1.13 General Heat Conduction Equation in Spherical Co-ordinates 1-20

1.14 Boundary and Initial Conditions 1-20

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1.14.1.2 Convection Boundary Conditions 1-21

1.14.1.3 Heat Flux Boundary Conditions 1-21

1.14.1.4 Initial Boundary Conditions 1-21

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1.16 One Dimensional Steady State Heat Conduction through Plane Wall or Infinite Slab without Heat Generation 1-22

1.16.1 Heat Transfer by Convection 1-24

1.17 One Dimensional (Radial) Steady State Heat Conduction through Hollow Cylinder without Heat Generation 1-24

1.17.1 Logarithmic Mean Area (LMA) for Hollow Cylinder 1-25

1.18 One Dimensional (Radial) Steady State Heat Conduction through Hollow Sphere without Heat Generation 1-26

1.19 Overall Heat Transfer Coefficient, U 1-27

1.20 Analogy between Heat Conduction and Electricity 1-27

1.20.1 Procedure of Applying Electrical Analogy to Heat Transfer Problems 1-28

1.21 Heat Transfer Problem for Composite Wall having Resistances in Series 1-28

1.22 Heat Transfer Problem for Composite Slab having Resistance in Parallel 1-29

1.22.1 Thermal Contact Resistance 1-30

1.23 Heat Transfer through a Composite Cylinder with Conduction and Convection 1-30

1.24 Combined Heat Transfer by Conduction and Convection in Compound Sphere 1-31

1.25 Thermal Insulation 1-31

1.26 Critical Thickness of Insulation 1-32

1.26.1 Important Aspects of Critical Radius of Insulation 1-33

1.27 Critical Thickness of Insulation in case of Spheres 1-34

Module 2

Chapter 2 : Heat Transfer from Extended Surfaces (FINS) and Unsteady State Heat Transfer 2-1 to 2-44

Syllabus : Heat transfer from Extended Surfaces: Types of extended surfaces and its significance. Governing differential equation for fin (Finite, Infinite, and Insulated tips) and its solution. Fin efficiency and effectiveness. Analysis of Thermometric well. **Unsteady state heat transfer:** Lumped heat capacity Analysis. Applications of unsteady state heat transfer, Thermal time constant.

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2.2 Extended Surfaces-Fins 2-1

2.3 Types of Fins and Applications 2-2

2.4 Analysis of Fins of Uniform Cross-Sectional Area (Rectangular Plate Fin / Pin Fin) 2-3

2.4.1 Case I : Analysis of Infinitely Long Fin 2-4

2.4.2 Case II : Adequately Long Fin with Insulated End Tip 2-5

2.4.3 Case III : Analysis of Short Fin 2-6

2.5 Effectiveness of Fins (E or ∈) 2-7

2.5.1 Overall Fin Effectiveness (E_0) 2-8

2.6 Fin Efficiency (η) 2-8

2.6.1 Concept of Corrected Fin Length 2-8

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2.8 Concept and Application of Unsteady State Heat Transfer 2-27

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2.9.1 Analysis of Quenching of Billet by Lumped Heat Capacity Method 2-29

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2.10 Time Constant and Response of Thermocouple 2-31

2.11 Use of Heisler Charts in Transient Heat Conduction Problems 2-31

Module 3

Chapter 3 : Convection 3-1 to 3-57

Syllabus : Convection : Free and Forced convection.

External Flow : Velocity Boundary layer and Thermal Boundary layer, Laminar and turbulent flow over a flat plate.

Internal Flow : Velocity Boundary layer and Thermal Boundary layer, Laminar and Turbulent flow in tubes. **General thermal analysis:** Constant heat flux and constant surface temperature.

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3.2 Basic Definitions Related to Convection 3-1

3.2.1 Applications 3-2

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3.4 Differential Equation of Heat Convection 3-3

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3.12.2.1 To Show that Nu = C Re m Pr n in Forced Convection 3-14

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3.16.1 Co-Relations for Flow Across the Sphere 3-19

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Chapter 4 : Boiling and Condensation 4-1 to 4-8

Introduction to Different boiling regimes, Film condensation, Drop wise Condensation.

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4.2 Condensation 4-1

4.3 Boiling 4-3

4.3.1 Modes/Methods of Boiling 4-3

4.4 Regimes of Pool Boiling 4-4

4.4.1 Critical Heat Flux 4-6

4.5 Forced Convection Boiling 4-6

Chapter 5 : Radiation 5-1 to 5-45

Syllabus : Basics laws of radiation and heat exchange between two bodies.

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5.2 Theories of Radiation 5-1

5.2.1 Wave or Maxwell Theory 5-1

5.2.2 Quantum Theory or Planck's Theory 5-2

5.3 Total Emissive Power of a Surface (E) 5-2

5.4 Basic Concepts and Definitions 5-2

5.4.1 Properties of Radiation 5-3

5.4.2 Types of Surfaces/Bodies 5-3

5.4.3 Surface Emission Properties 5-4

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5.5.2 Wien's Displacement Law 5-6

5.5.3 Stefan Boltzmann's Law 5-7

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5.7 Intensity of Radiation (I) and Solid Angle (ω) .. 5-9

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5.11 Application of Electrical Analogy to Thermal Radiation Heat Exchange Problems 5-19

5.11.1 Two Parallel Infinite Plane Surfaces 5-19

5.11.2 Radiation Heat Exchange between Two Concentric Infinitely Long Grey Cylinders 5-19

5.11.3 Radiation Heat Exchange between Two Concentric Spheres 5-20

5.12 Radiation Shields 5-20

Module 4

Chapter 6 : Mass Transfer and Heat Exchangers 6-1 to 6-63

Syllabus : Mass Transfer : Introduction to Mass Transfer, governing equations of mass transfer. Mass transfer coefficient.

Heat Exchangers : Types of heat exchangers, Overall heat transfer coefficient, LMTD, Effectiveness, Effectiveness – Number of Transfer Unit (ε- NTU) method, Correction factor for multi pass (up to 2 passes on shell and tube side) and cross flow heat exchanger.

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6.3.2 Velocities 6-4

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6.3.3 Fluxes 6-4

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6.7 Molecular Diffusion Through a Stagnant Gas Film (Isothermal Evaporation From Liquid into Air From Surface) 6-11

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6.10.1 Factors Considered in Design of Heat Exchangers 6-19

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6.11.2 Heat Exchangers According to Heat Transfer Process 6-21

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6.17 Heat Pipe..... 6-39
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Module 5

Chapter 7 : Constructional Features and Working of IC Engines 7-1 to 7-40

Syllabus : Introduction to I.C. Engine and its Classification. Working of Four stroke and Two-stroke engines, Valve Timing Diagram. Fuel air cycle, Actual Cycle.

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7.1.2 Applications of I.C. Engines..... 7-2
7.2 Engine Components..... 7-3
7.2.1 Materials for Main Components of I.C. Engine..... 7-5
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7.2.4 Valve Mechanism for Overhead Valves in Engine Cylinder..... 7-6
7.2.5 Camshaft..... 7-7
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7.5.2 Working of Four Stroke C.I. Engine or Diesel Engines..... 7-13
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7.7.1 Working of Two Stroke S.I. (Petrol) Engine..... 7-16
7.7.2 Working of Two Stroke C.I. (Diesel) Engine..... 7-18
7.8 Comparison between Two Stroke and Four Stroke Engines..... 7-20
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7.10 Theoretical and Actual (p-V) Diagrams for 4-Stroke Petrol Engine..... 7-21
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Chapter 8 : Fuel Supply, Ignition and Combustion In S.I. Engines 8-1 to 8-52

Syllabus : Introduction to Fuel Supply, Ignition, Combustion and knocking in SI Engines. MPFI in SI Engine.

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Module 6

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