UNIT 1

PART A

1. What is Fourier's Law of heat conduction?
2. What is temperature gradient?
3. What is coefficient of Thermal conductivity?
4. Give some examples of heat transfer in engineering.
5. Define Temperature field.
6. Define heat flux.
7. Define thermal Diffusivity.
8. What is Laplace equation for heat flow?
9. What is Poisson's equation for heat flow?
10. What critical radius of insulation?
11. Give examples for initial & boundary conditions.
12. What is a Fin?
13. Define efficiency of the fin.
14. Define effectiveness of the fin.
15. Give examples of use of fins in various engineering applications.
16. What is meant by Transient heat conduction?
17. Give governing differential equation for the one dimensional transient heat flow.
18. What is Biot number?
19. What is Newtonian heating or cooling process?
20. Give examples for Transient heat transfer.
21. What is meant by thermal resistance?
22. What is meant by periodic heat transfer?
23. What are Heisler chart?
24. What is the function of insulating materials?

PART - B

25. A pipe consists of 100 mm internal diameter and 8 mm thickness carries steam at 170°C. The convective heat transfer coefficient on the inner surface of pipe is 75 W/m2C. The pipe is insulated by two layers of insulation. The first layer of insulation is 46 mm in thickness having thermal conductivity of 0.14 W/m^{0}C. The second layer of insulation is also 46 mm in thickness having thermal conductivity of 0.46 W/m^{0}C. Ambient air temperature = 33°C. The convective heat transfer coefficient from the outer surface of pipe = 12 W/m2C. Thermal conductivity of steam pipe = 46 W/m^{0}C. Calculate the heat loss per unit length of pipe and determine the interface temperatures. Suggest the materials used for insulation. (16)

26. A long rod is exposed to air at 298°C. It is heated at one end. At steady state conditions, the temperatures at two points along the rod separated by 120 mm are found to be 130°C and 110°C respectively. The diameter of the rod is 25mm ID and its thermal conductivity is 116 W/m^{0}C. Calculate the heat transfer coefficient at the surface of the rod and also the heat transfer rate. (16)

27. (i) A furnace wall consists of three layers. The inner layer of 10 cm thickness is made of firebrick (k =1.04 W/mK). The intermediate layer of 25 cm thickness is made of masonry brick (k = 0.69 W/mK) followed by a 5 cm thick concrete wall (k = 1.37 W/mK). When the furnace is in continuous operation the inner surface of the furnace is at 800°C while the outer concrete surface is at 50°C. Calculate the rate of heat loss per unit area of the wall, the temperature at the interface of the firebrick and masonry brick and the temperature at the interface of the masonry brick and concrete. (8)

(ii) An electrical wire of 10 m length and 1mm diameter dissipates 200Win air at 25ºC. The convection heat transfer coefficient between the wire surface and air is 15W/m2K. Calculate the critical radius of insulation and also determine the temperature of the wire if it is insulated to the critical thickness of insulation. (8)

28 (i) An aluminium rod (k =204 W/mK) 2 cm in diameter and 20 cm long protrudes from a wall which is maintained at 300°C. The end of the rod is insulated and the surface of the rod is exposed to air at 30°C. The heat transfer coefficient between the rod\'s surface and air is 10 W/m2K. Calculate the heat lost by the rod and the temperature of the rod at a distance of 10 cm from the wall. (7)

(ii) A large iron plate of 10 cm thickness and originally at 800°C is suddenly exposed to an environment at 0°C where the convection coefficient is 50 W/m2K. Calculate the temperature at a depth of 4 cm from one of the faces 100 seconds after the plate is exposed to the environment. How much energy has been lost per unit area of the plate during this time? (9)

29 (i) Explain the different modes of heat transfer with appropriate expressions. (6)

(ii) A composite wall consists of 10 cm thick layer of building brick, k = 0.7 W/mK and 3 cm thick plaster, k = 0.5 W/mK. An insulating material of k = 0.08 W/mK is to be added to reduce the heat transfer through the wall by 40%. Find its thickness. (10)

30 Circumferential aluminium fins of rectangular profile (1.5cmwide and 1mm thick) are fitted on to a 90 mm engine cylinder with a pitch of 10 mm. The height of the cylinder is 120 mm. The cylinder base temperature before and after fitting the fins are 200°C and 150°C respectively. Take ambient at 30°C and h(average) =100 W/m2K. Estimate the heat dissipated from the finned and the unfinned surface areas of cylinder (16)

31. (i) Derive the heat conduction equation in cylindrical co-ordinates using an elemental volume for a stationary isotropic solid. (8)

(ii) A 3 cm OD steam pipe is to be covered with two layers of insulation each having a thickness of 2.5 cm. The average thermal conductivity of one insulating material is 5 times that of the other. Determine the percentage decrease in heat transfer if better insulating material is next to pipe than it is the outer layer. Assume that the outside and inside temperatures of composite insulation are fixed. (8)

32. (i) Explain briefly the concept of critical thickness of insulation and state any two applications of the same. (8)

(ii) A 6 cm long copper rod (k = 300 W/mK) 6mm in diameter is exposed to an environment at 20°C. The base temperature of the rod is maintained at 160°C. The heat transfer co-efficient is 20 W/m2K. Calculate the heat given by the rod and efficiency and effectiveness of the rod.

(8)

33. (i) Define the Biot and Fourier numbers. (4)

(ii) What is meant lumped capacity? What are the physical assumptions necessary for a lumped capacity unsteady state analysis to apply? (4)

(iii) A slab of Aluminum 5 cm thick initially at 200°C is suddenly immersed in a liquid at 70°C for which the convection heat transfer co-efficient is 525 W/m2K. Determine the temperature at a depth of 12.5 mm from one of the faces 1 minute after the immersion. Also calculate t he energy removed per unit area from the plate during 1 minute of immersion. Take p = 2700 bar,
Cp = 0.9 kJ/kgK, k=215 W/mK, α= 8.4X 10-5 m2/s. (8)

34. A composite wall is formed of a 2.5 cm copper plate (k = 355 W/mK), a 3.2 mm layer of asbestos (k = 0.110 W/mK) and a 5 cm layer of fiber plate (k = 0.049 W/mK). The wall is subjected to an overall temperature difference of 560°C (560°C on the Cu plate side and 0°C on the fiber plate side). Estimate the heat flux through this composite all and the interface temperature between asbestos and fiber plate. (16)

35. A steel tube k=43.26 W/mK of 5.08 cm ID and 7.62 cm OD is covered with 2.54 cm thick of asbestos insulation with k=0.208 W/mK. The inside surface of the tube receives heat by convection from a hot gas at a temperature of 316°C with heat transfer coefficient h=284 W/m2K while the outer surface of Insulation is exposed to atmosphere air at 38°C with heat transfer coefficient of 17 W/m2K. Calculate heat loss to atmosphere for 3 m length of the tube and temperature drop across each layer. (16)

36. (i) A plane wall 20 cm thickness generates heat at the rate of 5 x 104 W/m3 when an electric current is passed through it. The convective heat transfer coefficient between each face of the wall and the ambient air is 60 W/m2K. Determine

(a) The surface temperature (4)

(b) The maximum temperature in the wall. Assume ambient air temperature to be 25°C and the thermal conductivity of the wall material to be 16 W/mK. (4)

(ii) A steel ball 100 mm diameter was initially at 50ºC and is placed in air which is at 35°C. Calculate time required to attain 400°C and 300°C. ksteel = 35 W/mK, Cp = 0.46 kJ/kgK, ρ = 7800 kg/m3, h = 10 W/m2K. (8)