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P.E.S. College of Engineering, Mandya - 571 401

(An Autonomous Institution affiliated to VTU, Belagavi)

Fourth Semester, B.E. - Automobile Engineering

Semester End Examination; June - 2017

Heat Transfer

Time: 3 hrs *Max. Marks: 100*

***Note**: i) Answer **FIVE** full questions, selecting **ONE** full question from each unit.*
ii) Use of heat transfer data hand book is permitted.

UNIT - I

1 a. Discuss the modes of heat transfer with their governing laws and equations. 12

b. A 10 cm diameter copper ball is to be heated from100°C to an average temperature of 150°C in 30 minutes. Taking the average density and specific heat of copper in this temperature range to be ρ = 8590 kg/m^3 and Cρ = 0.395 kJ/ kg°C respectively. Determine: 8

i) The total amount of heat transfer to the copper ball

ii) The average rate of heat transfer to the ball

iii) The average heat flux.

2 a. Derive a one-dimensional time dependent heat conduction equation in cylindrical coordinates. Also get the expression for constant thermal conductivity and steady state. 12

b. Write the mathematical expressions for different kinds of boundary conditions for a hollow cylinder. 8

UNIT - II

3 a. Derive an expression for the critical radius appropriate for the insulation of a cylinder. 8

b. A steel tube with 50 mm inside diameter, 76 mm outside diameter and thermal conductivity 15 W/m.K is covered with an insulative covering of thickness 20 mm and thermal conductivity 0.2 W/m.K. A hot gas at temperature of 330°C and heat transfer coefficient of 400 W/m^2.K flows inside the tube. The outer surface of the insulation is exposed to cooler air at 30°C with heat transfer coefficient of 60 W/m^2.K. 12

i) Calculate the heat loss from the tube to the air for 10 m length of the tube

ii) Calculate the temperature drop resulting from the thermal resistances of the gas flow, the steel tube, insulation layer and the outside air.

4 a. Starting from the general 1-D fin equation, derive an expression for heat transfer rate through a circular fin of uniform cross-section assuming it to be a long fin. 8

b. Fins, 12 in number with tips insulated, having thermal conductivity 75 W/m.K and 0.75 mm thickness protrude 25 mm from a cylindrical surface of 50 mm diameter and 1 m length placed in an atmosphere of 40°C. If the cylindrical surface is maintained at 150°C and the heat transfer coefficient is 23 W/m^2.K, Calculate: 12

i) The rate of heat transfer by the fins

ii) The percentage increase in heat transfer due to fins

iii)The temperature at the centre of fins

iv) The fin efficiency v) The fin effectiveness.

UNIT - III

5 a. Derive an expression for the dimensionless temperature for lumped system analysis. 8

b. A 50 mm thick iron plate [k = 60 W/m.K, ρ = 7850 kg/m^3, Cρ = 460 J/kg.K, α = 1.6 x 10^{-5} m^2/s] is initially at temperature 225°C. Suddenly both surfaces are exposed to an ambient fluid at 25°C with a heat transfer coefficient 500 W/m^2.K. Using the transient temperature charts , calculate : 12

i) The centre temperature at 2 min after the start of cooling

ii) The temperature at a depth of 10 mm from the surface at 2 min after the start of cooling

iii) The energy removed from the plate per square meter during this period.

6 a. Distinguish between hydrodynamic and thermal boundary layers. 8

b. Air at 20°C and at atmospheric pressure is flowing over a flat plate at a velocity of 4.5 m/s. If the plate is 0.28 m wide and at 56°C, estimate the following quantities at *x* = 0.28 m. The properties of air at the bulk mean temperature of 38°C are [k = 0.02732 W/m.K, ρ = 1.1374 kg/m^3, C_P = 1005 J/kg.K , v = 16.768x10^{-6} m^2/s and P_r = 0.7]. Calculate: 12

i) Velocity and thermal boundary layer thicknesses

ii) Local and average convective heat transfer coefficients

iii) Rate of heat transfer by convection

iv) Total drag force on the plate.

UNIT - IV

7 a. Define the following dimensionless numbers. Also give their physical significance: 8

i) Prandtl number ii) Nusselt number.

b. A nuclear reactor with its core constructed of parallel vertical plates 2.2 m high and 1.45 m wide has been designed on free convection heating of liquid bismuth. The maximum temperature of the plate surface is limited to 960°C, while the lowest allowable temperature of bismuth is 340°C. Calculate the maximum possible heat dissipation from both sides of each plate. Take the properties of bismuth at the bulk mean temperature of 650°C as [k = 13.02 W/m.K, ρ = 10^4 kg/m^3, C_P = 150.7 J/kg.K, μ = 5.2x10$^-$4 kg/m.s] for the convection coefficient the appropriate correlation is Nu = 0.13 (Gr.Pr)$^{1/3}$. 12

8 a. What is meant by fouling in heat exchangers? List and discuss the various forms of fouling. 8

b. A counter flow heat exchanger is employed to cool 0.55 kg/s (C_p = 2450 J/kg.K) of oil from 125°C to 45°C by the use of water (C_p = 4180 J/kg.K). The inlet and out let temperature of cooling water are 15°C and 75°C respectively. The overall heat transfer coefficient is 1450 W/m^2.K Using NTU method , calculate the following : 12

i) The mass flow rate of water ii) The surface area required

iii) The effectiveness of heat exchanger.

UNIT - V

9 a. Derive an expression for the radiant exchange between two infinite parallel gray surfaces. 10

b. Define intensity of radiation and solid angle. Show that the emissive power of a black body is Π-times the intensity of the emitted radiation. 10

10 a. State : 9

i) Wein's displacement law ii) Kirchhoff's law iii) Plank's law.

b. Consider too large parallel plates; one at 1000 K with emissivity 0.8 and the other is at 300 K with emissivity 0.6. A radiation shield is placed between them. The shield has emissivity of 0.1 on the side facing hot plate and 0.3 on the side facing cold plate. Calculate percentage reduction in radiation heat transfer as a result of radiation shield. 11

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