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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; May/June - 2018

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 handbook is permitted.

UNIT - I

1 a. State and explain the modes of heat transfer with governing laws and equations. 12

b. An electrically heated plate dissipates heat by convention at a rate of 8000 W/m^2 into the ambient air at 25°C. If the surface of the hot plate is at 125°C. Calculate the heat transfer coefficient for convection between the plate and the air. 4

c. Discuss with an example heat transfer in combined mode. 4

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

b. With neat sketches, write down the mathematical representation of boundary condition 2^{nd} and 3^{rd} kind for one-dimensional heat conduction in rectangular coordinates. 8

UNIT - II

3 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 center of fins iv)The fin efficiency v) The fin effectiveness

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

b. An insulated steam pipe having outside diameter of 30 mm is to be covered with two layers of insulation, each having a thickness of 20 mm. The thermal conductivity of one material 3 times that of the other. Assuming that the inner and outer surface temperatures of composite insulation are fixed, how much heat transfer will be increased when the better insulation material is next to the pipe than when it is at the outer layer? 12

UNIT - III

5 a. What is lumped system analysis? When it is applicable? What is the physical significance of Biot Number? 6

b. An iron sphere [k = 60 W/m.K, ρ = 7850 kg/m^3, C_p = 0.46 kJ/kg.K and $\alpha = 1.6 \times 10^{-5}$ m^2/s] of diameter 5 cm is initially at a uniform temperature 225°C. Suddenly the surface of the sphere is exposed to an ambient at 25°C with a heat transfer coefficient 500 W/m^2.K. 14

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i) Calculate the center temperature 2 minutes after the start of cooling

ii) Calculate the center temperature at a depth 1.0 cm from the surface 2 minutes after the start of cooling

iii) Calculate the energy removed from the sphere during this time period

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

b. Air at 20°C and at atmospheric pressure flows over a flat plate at a velocity of 3 m/s. The plate is 0.3 m long and at 60°C. The properties of air at the bulk mean temperature of 40°C are [k = 0.02756 W/m.K, C_p = 1005 J/kg.K, ρ =1.128 kg/m^3, V = 19.96 x 10^{-6} m^2/s and P_r = 0.699]. Calculate; 12

i) Velocity and thermal boundary layer thickness at 0.2 m from m from the leading edge

ii) Local and average friction coefficient iii) Average heat transfer coefficient

iv) Rate of heat transfer by convection v) Total drag force on the plate per unit width

UNIT - IV

7 a. Define the following dimensionless numbers. Also give their physical significance; 9

i) Reynolds ii) Prandtl number iii) Nusselt number

b. A horizontal pipe 0.3 m in diameter is maintained at a temperature of 245°C in a room where the ambient air is at 15°C. Calculate the free convection heat loss per meter length of the pipe. Take the properties of air at the bulk mean temperature of 130°C as [k = 34.14 x 10^{-3} W/m.K, v = 26.63 x 10^{-6} m^2/s and P_r = 0.685]. 11

8 a. Briefly explain the classification of heat exchangers by flow arrangement. 8

b. A two-shell pass, four tube pass heat exchanger has water on the shell side and brine on the tube side. Water is cooled from 180°C to 6°C with brine entering at -1°C and leaving at 3°C. The overall heat transfer at coefficient is 600 W/m^2.K. Calculate the heat transfer area required for a design heat load of 24 kW. 12

UNIT - V

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

b. Define intensity of radiation and solid angle. 4

c. Show that the emissive power of a block body is π - times the intensity of emitted radiation. 6

10 a. State i) Kirchhoff's law ii) Planck's law iii) Steffan-Botzmann law 10

b. Two large parallel plates are at 700°C and 500°C. Determine the rate of heat exchange per unit area, when; 10

i) The surface are black

ii) The hot surface has an emissivity of 0.9 and the cold surface has an emissivity of 0.6

iii) A large plate of emissivity 0.1 is inserted between them. Also find the percentage of reduction in heat transfer because of introduction of the large plate.

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