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

(An Autonomous Institution affiliated to VTU, Belgaum)

Fifth Semester, B.E. - Automobile Engineering

Semester End Examination; Dec. - 2015

Heat Transfer

Time: 3 hrs *Max. Marks: 100*

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

UNIT - I

1 a. Discuss the mechanism of heat transfer involved along with governing laws and equations with a cold canned drink is left in a room at atmosphere temperature. 8

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

2 a. Write the mathematical expressions for different kinds of boundary conditions for a hollow cylinder. 10

b. A 10 cm diameter copper ball is to be heated from 100º C to an average temperature of 150ºC in 30 minutes. Taking the average density and specific heat of copper in this temperature range to be ρ = 8950 kg/m^3 and C_p = 0.395 kJ/kg ºC, respectively. Determine; 10

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

(ii) The average rage of heat transfer to the ball

(iii) The average heat flux.

UNIT - II

3 a. Derive an expression for the critical radius appropriate for the insulation of a cylinder. 6

b. A dormitory at a large university, built 50 years ago, has exterior walls constructed of L_S = 25 mm-thick sheathing with a thermal conductivity of k_s = 0.1 W/m.K. To reduce heat losses in the winter, the university decides to encapsulate the entire dormitory by applying an L_i = 25 mm thick layer of extruded insulation characterized by k_i = 0.029 W/m.K to the exterior of the original sheathing. The extruded insulation is, in turn, covered with an L_g = 5 mm thick architectural glass with k_g = 1.4 W/m.K. Determine the heat flux through the original and retrofitted walls when the interior and exterior air temperature are T_i = 25ºC and T_0 = 18°C, respectively. The inner and outer convection heat transfer coefficients are h_i = 5 W/m^{2}K and h_o = 25 W/m^{2}K respectively. 14

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

Contd…..2

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 40ºC and the heat transfer coefficient is 23 W/m^2K calculate;

i) The rate of heat transfer by the fins 12

ii) The percentage increase in heat transfer due to fins

iii) The temperature at the centre due to fins

iv) The fin efficiency

v) The fin effectiveness.

UNIT - III

5 a. Derive an expression for lumped system analysis. 6

b. A solid iron rod (k = 60 W/m.K, ρ = 7280 kg/m^3, C_p = 410 J/kg.K and α = 2 x 10^{-5} m^2/s) of 6 cm diameter, initially at temperature 800ºC, is suddenly dropped into an oil bath at 50ºC. The heat transfer coefficient between the fluid and the surface is 400 W/m^2K,

i) Using the transient-temperature charts, determine the centerline temperature 10 min after immersion in the fluid. 14

ii) How long will take the centerline temperature to reach 100ºC

iii) The energy removed from the rod during this period.

6. a. Define the following dimensionless numbers. Also given their physical significance:

i) Prandtl number 6

ii) Nusselt number

b. Air at 20º C and at atmosphere pressure flows over a flat plate at a velocity of 3 m/s. The plate is 0.3 m long and at 60ºC. The properties of air at the bulk mean temperature of 40ºC are [k = 0.02756 W/m.K, C_p = 1005 J/kgK, ρ = 1.128 kg/m^3, ν = 19.96x10^{-6} m^2/s and Pr = 0.699] Calculate;

i) Velocity and thermal boundary layer thickness at 0.2 m from the leading edge 14

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. Using dimensionless analysis, derive a correlation in terms of Nusselt number, Grashoff number and Prandtl for free convection heat transfer. 8

b. A 0.15 m diameter horizontal pipe with outer surface maintained at temperature of 229ºC is exposed to atmospheric air at 25ºC. Calculate the heat transfer rate per meter length of the pipe by free connection. Take the properties of air at the bulk mean temperature of 127ºC as [k = 33.8x10^{-3} W/m.K, ν = 26.41x10^{-6} m^2/s and P_r = 0.699] 12

Contd…..3

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

b. A shell-and-tube exchanger (two shells, four tube passes) is used to cool 1.5 kg/s oil [C_{ph} = 2100 J/kg] from 90º C to 40 ºC with 1 kg/s water [C_{pc} = 4180 J/kg] entering at 19º C. If the overall heat transfer coefficient is 250 W/m^{2}K, Using NTU method determine; 12

i) The outlet temperature of water

ii) The effectiveness of heat exchanger

iii) The heat transfer surface area required.

UNIT - V

9 a. State: 10

i) Wein's displacement law

ii) Kirchhoff's law

iii) Planck's law.

b. Consider two large parallel plates one at 800 K with emissivity 0.9 and other at 300 K with emissivity 0.5. A radiation shield having an equal emissivity on both sides is placed between these two plates. Calculate the emissivity of the radiation shield in order to reduce the radiative heat transfer between the two plates to 10 percent of that without the shield. 10

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

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

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