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10ME63

Sixth Semester B.E. Degree Examination, July/August 2022
Heat and Mass Transfer

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer any FIVE full questions, selecting atleast TWO questions from each part.***
2. ***Use of Data Handbook is permitted.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

PART – A

1 a. Derive three dimensional Heat Conduction equation in Cartesian Co-ordinates. **(10 Marks)**

b. A composite wall is made up of three layers of thickness 25cm , 12cm and 14cm of material A, B and C respectively. The thermal conductivities of A and B are 1.8 W/m K and 9.8 W/m K respectively. The outside surface is exposed to air at 20°C with convection coefficient of 15W/m^2 K and the inside is exposed to gases to 1200°C with convection coefficient of 48W/m^2 K. The inside surface temperature is 1115°C. Determine the unknown Thermal conductivity of layer made up of material C. **(10 Marks)**

2 a. Define Fin efficiency and Fin effectiveness with respect to a Fin with insulated tip. **(05 Marks)**

b. What is Critical thickness of insulation for a small diameter wire or pipe? Explain its physical significance. **(05 Marks)**

c. A wire of 6mm diameter of a temperature of 62°C is to be insulated by a material having K = 0.175 W/m K. Convection heat transfer coefficient = 8.8W/m^2 K. The ambient temperature = 24°C. For maximum heat loss, what is the minimum thickness of insulation and heat loss per meter length? Also find percentage increase in heat dissipation. **(10 Marks)**

3 a. Obtain an expression for instantaneous heat transfer and total heat transfer for lumped heat analysis treatment in heat conduction problems. **(10 Marks)**

b. A 12cm diameter long bar initially at a uniform temperature of 40°C is placed in a medium at 650°C with a convection coefficient of 22W/m^2 K. Calculate the time required for the bar to reach 255°C. Take K = 20W/m K, ρ = 580 kg/m^3 and C_p = 1050 J/kg K. **(10 Marks)**

4 a. With reference to fluid flow over a flat plate, discuss the concepts of velocity boundary layer and thermal boundary layer, with necessary sketches. **(10 Marks)**

b. A vertical plate 0.5m high and 1m wide is maintained at a uniform temperature of 124°C. It is exposed to ambient air at 30°C. Calculate the heat transfer rate from the plat. **(10 Marks)**

PART – B

5 a. With the help of dimensional analysis , derive expression for the Reynolds number , Prandtl number and Nusselt number. **(10 Marks)**

b. Water at 50°C enters 1.5cm diameter and 3m long tube with a velocity of 1.5cm/s. The tube wall is maintained at 100°C. Calculate the heat transfer coefficient and total amount of heat transferred , if the water exit temperature is 70°C. **(10 Marks)**

6 a. Obtain the LMTD for a parallel flow heat exchanger. (10 Marks)

b. Engine oil is to be cooled from 80°C to 50°C by using a single pass counter flow, concentric tube heat exchanger with cooling water available at 20°C. Water flows inside pipe of diameter 25mm at a rate of 0.08kg/s and oil flows through the annulus at a rate of 0.06 kg/s. The heat transfer coefficient for the water side and the oil side are 1000W/m^2 K and 80W/m^2 K respectively. Neglecting the tube wall resistance, calculate the length of the tube required. Take $C_{p\ water}$ = 418 J/kg K and $C_{p\ oil}$ = 2090 J/kg K. (10 Marks)

7 a. Derive Nusselts theory of Laminar film condensation for condensation over a vertical flat plate. (10 Marks)

b. Explain the different regimes of pool boiling with the help of neat sketches. (10 Marks)

8 a. Define the following :

i) Black body.
ii) Kirchoif's law.
iii) Stefan – Boltzman law.
iv) Wien's displacement law.
v) Irradiation. (10 Marks)

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b. Two large parallel plates are at 1200K and 900K. Determine the heat exchange per unit area when i) The surface are black.

ii) The hot surface has an emissivity 0.8 and cold one 0.5.

iii) A shield of emissivity 0.03 is introduced between the plates having emissivities 0.8 and 0.5. Also find the percentage reduction in heat transfer due to the shield. (10 Marks)

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