Exam.Code:0942
Sub. Code: 7061

(30)

1059
B.E. (Mechanical Engineering)
Sixth Semester
MEC-604: Heat Transfer

Time allowed: 3 Hours

Max. Marks: 50

NOTE: *Attempt five questions in all, including Question No. I which is compulsory and selecting two questions from each Part.*

x-x-x

I a What are the *physical mechanisms* associated with heat transfer by *conduction, Convection?* 10
b Physically, what does the Grashof number represent? How does the Grashof number differ from the Reynolds number?
c Define the properties reflectivity and Transmissivity and discuss the different forms of reflection.
d What is the difference between subcooled and saturated boiling?
e Classify heat exchangers according to construction type.

Part-A

II Starting with an energy balance on a ring-shaped volume element, derive the two-dimensional steady heat conduction equation in cylindrical coordinates for $T(r, z)$ for the case of constant thermal conductivity and no heat generation. 10

III a Consider a plane wall of thickness L whose thermal conductivity varies linearly in a specified temperature range as $k(T) = k0(1 + \beta T)$ where $k0$ and β are constants. The wall surface at $x = 0$ is maintained at a constant temperature of $T1$ while the surface at $x = L$ is maintained at $T2$. Assuming steady one-dimensional heat transfer, obtain a relation for the heat transfer rate through the wall and (*b*) the temperature distribution $T(x)$ in the wall. 5

b Consider a 0.8-m-high and 1.5-m-wide glass window with a thickness of 8 mm and a thermal conductivity of $k = 0.78$ W/m · °C. Determine the steady rate of heat transfer through this glass window and the temperature of its inner surface for a day during which the room is maintained at 20°C while the temperature of the outdoors is - 10°C. Take the heat transfer coefficients on the inner and outer surfaces of the window to be $h1 = 10$ W/m2 · °C and $h2 =$ 40 W/m2 · °C, which includes the effects of radiation. 5

IV Obtain a relation for the fin efficiency for a fin of constant cross-sectional area Ac, perimeter p, length L, and thermal conductivity k exposed to convection to a medium at $T\infty$ with a heat transfer coefficient h. Assume the fins are sufficiently long so that the temperature of the fin at the tip is nearly $T\infty$. Take the temperature of the fin at the base to be Tb and neglect heat transfer from the fin tips. Simplify the relation for (*a*) a circular fin of diameter D and (*b*) rectangular fins of thickness t. 10

Part-B

V a Derive analytical relation for the heat transfer coefficient in film condensation on a vertical plate developed by Nusselt. 7
b How are the average friction and heat transfer coefficients determined in flow over a flat plate? 3

VI a Hot oil is to be cooled in a double-tube counter-flow heat exchanger. The 8

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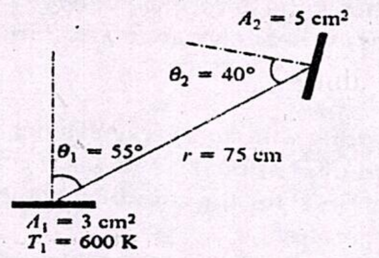
copper inner tubes have a diameter of 2 cm and negligible thickness. The inner diameter of the outer tube (the shell) is 3 cm. Water flows through the tube at a rate of 0.5 kg/s, and the oil through the shell at a rate of 0.8 kg/s. Taking the average temperatures of the water and the oil to be 45°C and 80°C, respectively, determine the overall heat transfer coefficient of this heat exchanger The properties of water at 45°C are $\rho = 990\ kg/m^3$; Pr = 3.91 ; $k = 0.637\ W/m \cdot °C$; $\vartheta = \mu/\rho = 0.602 \times 10^{-6}\ m^2/s$.

b What is boiling? What mechanisms are responsible for the very high heat transfer coefficients in nucleate boiling? 2

VII a Two very long concentric cylinders of diameters $D1 = 0.2$ m and $D2 = 0.5$ m are maintained at uniform temperatures of $T1 = 950$ K and $T2 = 500$ K and have emissivities $\varepsilon_1 = 1$ and $\varepsilon_2 = 0.7$, respectively. Determine the net rate of radiation heat transfer between the two cylinders per unit length of the cylinders. 5

b A small surface of area $A1 = 3$ cm2 emits radiation as a blackbody at $T1 = 600$ K. Part of the radiation emitted by $A1$ strikes another small surface of area $A2 = 5\ cm^2$ oriented as shown in Figure. Determine the solid angle subtended by $A2$ when viewed from $A1$, and the rate at which radiation emitted by $A1$ that strikes $A2$. 5



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