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TME505

(Following Paper ID and Roll No. to be filled in your Answer Book)

PAPER ID : 4078

Roll No.

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B.Tech.

(SEM. V) ODD SEMESTER THEORY EXAMINATION

2010-11

HEAT & MASS TRANSFER*Time : 3 Hours**Total Marks : 100*

Note : (1) Attempt all questions. Marks are indicated against each question/part.

(2) Use the data and relations provided in the question paper.

(3) Assume missing data suitably, if any.

1. Answer any **four** parts of the following : **(5×4=20)**

(a) Derive an expression for critical radius of insulation for cylinder.

(b) Derive an expression for thermal resistance for spherical wall.

(c) What do you understand by contact resistance ?

(d) Derive general heat conduction equation in Cartesian coordinate system.

- (e) A plane wall having a uniform energy generation per unit volume is exposed to a fluid. Assuming one-dimensional heat conduction, derive an expression for temperature distribution within the wall.
- (f) What do you understand by the Heat Electrical analogy? With the help of an example of walls in series explain its importance.

2. Attempt any two parts of the following : (10×2=20)

- (a) Consider two long, very long rods (A and B) of the same diameter but different materials. One end of each rod is attached to a base surface at 100°C, and the rods are exposed to the ambient air at 20°C. By traversing the length of each rod with a thermocouple, it was observed that the temperatures of the rods were equal at the positions $X_A = 0.15$ m (for rod A) and $X_B = 0.075$ m (for rod B), where X is measured from the base surface. If the thermal conductivity of rod A is known to be $k_A = 70$ W/m.K, determine the value of k_B for rod B.
- (b) Derive an expression for time constant of temperature measuring device. Discuss the effect of various parameters on the time constant.
- (c) Derive an expression for heat transfer rate from a fin with insulated tip. Discuss the concept of corrected length of fin.

3. Answer any **two** parts of the following : (10×2=20)

- (a) Explain the significance of various dimensionless numbers to natural convection. Discuss physical mechanism of free convection with the help of neat sketch.
- (b) Air at temperature of 28°C flows with a velocity of 10m/s over a flat plate 0.5m long and 10 m wide. Find the heat transfer rate from the plate, if the plate is maintained at 300°C.

For air take : $\nu = 5.21 \times 10^{-4} \text{ m}^2/\text{s}$;
 $k = 0.0364 \text{ W/m. K}$; $Pr = 0.687$

Use the following expression for local Nusselt Number

$$N_{uL} = 0.332 Re_x^{1/2} Pr^{1/3}$$

- (c) Oil at 150°C flows slowly through a long, thin-walled pipe of 30-mm inner diameter. The pipe is suspended in a room for which the air temperature is 20°C and the convection coefficient at the outer tube surface is 11 W/m². K. Estimate the heat loss per unit length of tube. Assume fully developed flow and negligible thermal resistance of tube wall.

For unused engine oil at 423 K : $k = 0.133 \text{ W/m. K}$

Answer any **two** parts of the following : (10×2=20)

- (a) What do you understand by the self radiation rule, summation rule and reciprocity rule ? Prove any two of them.

What do you understand by the following ?

- (i) Emissive power of a surface
- (ii) Colored Surface
- (iii) Kirchoff's Law.

(c) Consider two large, diffuse gray, parallel surfaces separated by a small distance. If the surface emissivities are 0.8, what emissivity should a thin radiation shield (placed between the surfaces) have to reduce the radiation heat transfer rate between the surfaces to 10% of the original ?

5. Answer any two parts of the following : (10×2=20)

(a) Saturated steam at 373 K condenses in a double pipe heat exchanger with a surface area of 0.5 m² and an overall heat transfer coefficient of 2000 W/m². K. Water enters at 0.5 kg/s and 288 K. Determine the outlet temperature of the water and the rate of steam condensation (Latent heat = 2257 kJ/ kg)

For Double pipe heat exchanger

$$\varepsilon = 1 - \exp(-NTU) \quad ; \quad \text{for } C_{\min}/C_{\max} = 0$$

$$\varepsilon = NTU / (1 + NTU) \quad ; \quad \text{for } C_{\min}/C_{\max} = 1$$

- (b) Derive an expression for molar diffusion rate for steady state equimolar counter diffusion.
- (c) Discuss various modes of Pool boiling with the help of Pool boiling curve. List different regimes of forced convective boiling.