

KATHMANDU UNIVERSITY
End Semester Examination
January/February 2024

Marks Scored:

Level : B.Tech.
Year : III

08 FEB 2024

Course : MEEG 306
Semester : I

Exam Roll No. :

Time: 30 mins.

F. M. : 20

Registration No.:

Date :

SECTION "A"

[20Q. × 1 = 20 marks]

Choose and mark [X] the most appropriate option from each set of choices.

1. Consider steady one-dimensional heat conduction through a plane wall, a cylindrical shell, and a spherical shell of uniform thickness with constant thermophysical properties and no thermal energy generation. The geometry in which the variation of temperature in the direction of heat transfer will be linear
 Plane wall Cylindrical shell Spherical shell All of them
2. Thermal diffusivity of a substance is
 Inversely proportional to thermal conductivity
 Direct proportional to thermal conductivity
 Direct proportional to the square of thermal conductivity
 Inversely proportional to the square of thermal conductivity
3. A thin wall whose thickness is ($X=1m$) is provided with uniform volumetric heat source. At $X=0$, $T=T_a$ while at $X=1m$, $T=T_b$ such that $T_a > T_b$. What is the temperature gradient at $\left(\frac{dT}{dX}\right)_{X=0.5m}$ at the mid section of the wall?
 Zero $\frac{T_a - T_b}{L}$ $h(T_a - T_b)$ $\frac{T_a - T_b}{L/2}$
4. A 10 mm diameter electrical wire carrying current is covered by an insulation of 3 mm thickness. The thermal conductivity of the insulation material $k = 0.08 \frac{Wm}{K}$ and the heat transfer coefficient of the surrounding medium is $10 \frac{Wm^2}{K}$, Now adding the further insulation of the same material will
 Increase heat loss continuously
 Decrease heat loss continuously
 Increase heat loss to a maximum and then decrease heat loss
 Decrease heat loss to a minimum and then increase heat loss
5. Hydro dynamic boundary layer is thick than the thermal boundary layer, in which of the following cases?
 $Pr = 1$ $Pr < 1$ $Pr > 1$ $Pr \leq 1$
6. For a boiler using saturated water, the logarithmic mean temperature difference (LMTD) for parallel flow is
 Equal to that of counter flow Greater than that for counter flow
 Smaller than that for counter flow None of these

7. The Nusselt number for the flow of water at 25 °C (velocity = 2 m/s) over a hot metallic sphere (d= 5 cm) of 95 °C can be expressed as

$$Nu = 2 + \left[0.4 \times \sqrt{Re} + 0.06 \times Re^{\frac{2}{3}} \right] Pr^{0.4} \left(\frac{\mu}{\mu_w} \right)^{0.25}$$

What will be the value of Nusselt number if the plate is placed in a stagnant pool of water at 45 °C? Where $Pr = 7.86$ (at 45 °C); $\left(\frac{\mu}{\mu_w} \right) = 1.15$ (at 45 °C)

- 2 3.65 3.9 none

8. The product of Grashof number and Prandtl number is called

- Rayleigh number Peclet number
 Lewis number Reynolds number

9. A vertical hot plate is placed in the medium ($Pr > 1$). In the absence of any medium of cooling, it cools naturally. Where do you think the maximum velocity will be?

δ_T = thermal boundary layer thickness

δ = velocity boundary layer thickness

- Between 0 and δ_T At δ_T
 Between 0 and δ At $\delta = 0$

10. In a completely opaque medium, if 50% of the incident monochromatic radiation is absorbed, then which of the following statements are **CORRECT**?

- (A) 50% of the incident radiation is reflected
 (B) 25% of the incident radiation is reflected
 (C) 25% of the incident radiation is transmitted
 (D) No incident radiation is transmitted

- A and D only B and C only A and B only C and D only

11. A composite wall of a furnace has two layers of equal thickness (δ) having thermal conductivities (k) in the ratio of 2:3. What is the ratio of temperature drop across the two layers?

- 2:3 3:2 1:2 $\log_2 : \log_3$

12. For a gray surface, transmissivity and absorptivity are specified as 0.68 and 0.07, respectively, the emissivity of the surface is

- 0.07 0.25 0.68 0.08

13. The convective heat transfer coefficient does not depend on

- Temperature gradient Temperature difference
 Fluid property System geometry

14. Which of the following statement is **CORRECT**?

- For fixed wavelength (λ), the spectral blackbody emissive power, $E_{b\lambda}(T)$, decreases with T
 For fixed wavelength (λ), the spectral blackbody emissive power, $E_{b\lambda}(T)$, remains constant with increase in T
 For fixed wavelength (λ), the spectral blackbody emissive power, $E_{b\lambda}(T)$, increases with T
 None of the above

1000

KATHMANDU UNIVERSITY
End Semester Examination
January/February 2024

Level : B.Tech.
Year : III
Time : 2 hrs. 30 mins.

Course : MEEG 306
Semester : I
F.M. : 55

08 FEB 2024

SECTION "B"

Attempt *ALL* questions. Assume any necessary data. Use of a data book is allowed.

- 1.
- a. A 3-mm-diameter and 5-m-long electric wire is tightly wrapped with a 2-mm thick plastic cover whose thermal conductivity is $k = 0.15 \text{ W/m}\cdot\text{K}$. Electrical measurements indicate that a current of 10 A passes through the wire and there is a voltage drop of 8 V along the wire. If the insulated wire is exposed to a medium at $T = 30^\circ\text{C}$ with a heat transfer coefficient of $h = 12 \text{ W/m}^2\cdot\text{K}$. Determine the temperature at the interface of the wire and the plastic cover in steady operation. Also determine whether doubling the thickness of the plastic cover will increase or decrease this interface temperature. [4]
- b. 15-cm \times 20-cm integrated circuit board is to be cooled by attaching 4-cm long aluminum ($k = 237 \text{ W/m}\cdot\text{K}$) fins on one side of it (Fig.1). Each fin has a 2-mm \times 2-mm square cross-section. The surrounding ambient temperature is 25°C , and the convection heat transfer coefficient on each fin surface is $20 \text{ W/m}^2\cdot\text{K}$. To prevent the circuit board from overheating, the upper surface of the circuit board needs to be at 85°C or cooler. Design a finned surface having the appropriate number of fins, with an overall effectiveness of 3 that can keep the circuit board surface from overheating. [6]

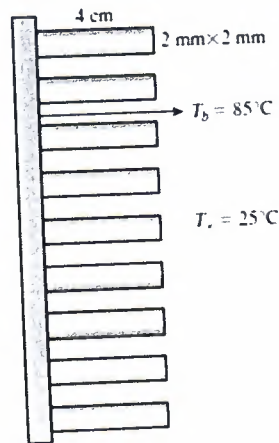


Fig. 1

- 2.
- a. The wall of an industrial furnace is constructed from 0.15-m-thick fireclay brick having a thermal conductivity of $1.7 \text{ W/m}\cdot\text{K}$. Measurements made during steady-state operation reveal temperatures of 1400 and 1150 K at the inner and outer surfaces, respectively. What is the rate of heat loss through a wall that is 0.5 m by 1.2 m on a side? [2]

- b. Consider the base plate of an 800-W household iron with a thickness of $L = 0.6$ cm, base area of $A = 160$ cm², and thermal conductivity of $k = 60$ W/m·K. The inner surface of the base plate is subjected to uniform heat flux generated by the resistance heaters inside. When steady operating conditions are reached, the outer surface temperature of the plate is measured to be 112°C. Disregarding any heat loss through the upper part of the iron, (a) express the differential equation and the boundary conditions for steady one-dimensional heat conduction through the plate, (b) obtain a relation for the variation of temperature in the base plate, and (c) evaluate the inner surface temperature. [6]

3.

- a. The temperature distribution within the laminar thermal boundary layer over a heated isothermal flat plate is given by $\frac{T-T_w}{T_\infty-T_w} = (3/2)(y/\delta_t) - (1/2)(y/\delta_t)^3$ where T_w and T_∞ are the temperature of the plate and free stream velocity respectively, and y is the normal distance measured from the plate. Find the ratio of average to local Nusselt number based on thermal boundary layer thickness δ_t . [4]

- b. Air at 10°C and at a pressure of 100 kPa is flowing over a plate at a velocity of 3 m/s. If the plate is 30 cm wide and at a temperature of 60°C, calculate the following quantities at $x = 0.3$ m. [6]

- i. Boundary layer thickness,
- ii. Local friction coefficient
- iii. Total drag force
- iv. Thermal boundary layer thickness.
- v. Local convective heat transfer coefficient
- vi. The heat transfer from the plate.

- c. Water is to be heated from 15°C to 65°C as it flows through a 3-cm-internal diameter 5-m-long tube (Fig.2). The tube is equipped with an electric resistance heater that provides uniform heating throughout the surface of the tube. The outer surface of the heater is well insulated so that in steady operation, all the heat generated in the heater is transferred to the water in the tube. If the system is to provide hot water at a rate of 10 L/min, determine the power rating of the resistance heater. Also, estimate the inner surface temperature of the tube at the exit. [5]

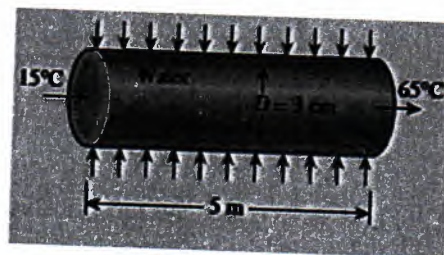


Fig. 2

4. A hot fluid at 200°C enters a heat exchanger at a mass flow rate of 10^4 kg/hr. Its specific heat is 2000 J/kg·K. It is to be cooled by another fluid entering at 25°C with a mass flow rate of 2500 kg/hr., and specific heat 400 J/kg·K. The overall heat transfer coefficient based on an outside area of 20 m² is 250 W/m²·K. Find the exit temperature of the hot fluid when the fluids are in parallel flow. [5]

08 FEB 2024

- 5.
- a. Write two significant differences between boiling and evaporation. [2]
 - b. Draw the pool boiling regime and explain the characteristics of each regime. [3]
- 6.
- a. A thin aluminum sheet with an emissivity of 0.1 on both sides is placed between two very large parallel plates maintained at uniform temperatures $T_1 = 800\text{ K}$ and $T_2 = 500\text{ K}$ and emissivities $\epsilon_1 = 0.2$ and $\epsilon_2 = 0.7$, respectively. Determine the net rate of radiation heat transfer between the two plates per unit surface area of the plates and compare the result to that without the shield. [4]
 - b. Define the law of reciprocity in finding the view factor. For the internal surfaces of the right circular cylinder shown in Fig.3, determine F_{13} and F_{33} . [1+3]

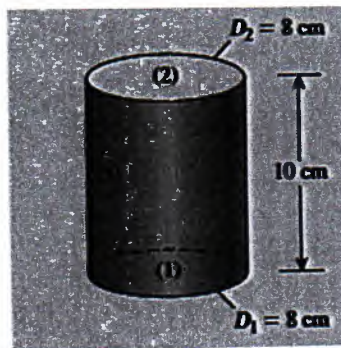


Fig 3

- c. A diffuse surface at 1600 K has the spectral, hemispherical emissivity shown as follows (Fig. 4). Determine the total, hemispherical emissivity and the total emissive power. At what wavelength will the spectral emissive power be a maximum? [4]

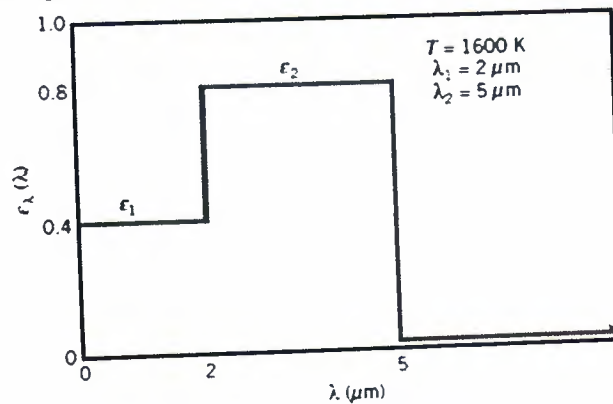


Fig 4

100-101-10