

KATHMANDU UNIVERSITY
End Semester Examination
July/August, 2024

Marks Scored:

Level : B.E.
Year : III

Course : MEEG 306
Semester : II

Exam Roll No. : Time: 30 mins.

F. M. : 20

Registration No.:

Date

16 AUG 2024

Data, steam tables & formula sheets are permitted during **SUBJECTIVE EXAMINATION ONLY.**

SECTION "A"

[20 Q. \times 1 = 20 marks]

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

1. Fin length that causes efficiency to drop below ____ percent usually cannot be justified economically.
 40 50 60 70
2. Which of these statements is false about Heat Transfer?
 It deals with the determination of rates of energy transferred between a system to its surroundings.
 It deals with systems that exhibit thermal equilibrium.
 Its basic requirement involves the presence of a temperature difference.
 It is higher in a system with a higher thermal gradient.
3. The value of conductivities of gases such as air vary by a factor of 10^4 from those of ____
 Pure metals Nonmetallic Solids
 Liquids Nonmetallic Crystals
4. Which of these materials has the higher Thermal diffusivity?
 Wood Concrete Mercury Copper
5. The amount of heat released when a unit amount of fuel at room temperature is completely burnt, and the combustion products are cooled to room temperature without recovering the heat of vaporization is known as ____
 Low heating value High heating value
 Combustion index Fire point
6. Conduction in gases occurs due to the domination of phenomenon related to ____
 electromagnetic waves motion of electrons
 mixing of gas layers elastic impact of molecules
7. A wire of radius R is insulated to an outer radius R_o whose conductivity is X and Y is the heat transfer coefficient of the outer surface of the insulated wire, then the maximum heat transfer from the outer surface occurs when the value of R_o becomes equal to ____
 Y/X $2X/Y$ X/Y $(XY)^{1/2}$
8. In transient heat conduction, two significant dimensionless parameters are ____
 Reynolds & Biot Numbers Biot & Fourier Numbers
 Biot & Prandtl Numbers Reynolds & Prandtl Numbers

9. In the conduction equation $Q = \frac{KA(T_1 - T_2)}{L}$, the term $\frac{L}{KA}$ is known as thermal _____
 gradient coefficient resistance conductivity
10. Studies show, the error involved in 1-D fin analysis is negligible (<1%) when $\frac{(h \times \delta)}{k}$ is ____
 ± 0.2 equal to 0.2 less than 0.2 greater than 0.2
11. The conduction shape factor of a wall with one side at 5°C and the other side at 25°C with conductivity 5 W/m.K having a head loss of 50 W is _____
 0.25 0.5 1 2
12. Heat is lost from a steam pipe of 10 cm diameter to ambient air at 30°C. If the Nusselt number is 25 and $K(\text{air}) = 0.03 \text{ W/m.K}$, then the heat transfer coefficient (W/m².K) on the surface of the pipe is _____
 7.5 16.25 25.5 30.2
13. A steam condenser transfers 250 kW of thermal energy at a condensing temperature of 65°C. The cooling water enters the condenser at 20°C with a flow rate of 7500 kg/hr. If the overall heat transfer coefficient for the condenser surface is 1250 W/m²K, what surface area is required to handle this load?
 7.08 m² 5.08 m² 4.08 m² 1.08 m²
14. Typically, the dropwise condensation occurs on a _____ surface.
 smooth coated glazed oily
15. Correction factor, F in heat exchanger typically is used for designing _____ type heat exchanger.
 Parallel Flow Counter Flow Cross Flow Phase Change
16. The radiation correction term for a typical thermometer reading with emissivity 0.5, surrounding surface temperature 10°C, thermometer reading 8°C, and the convective coefficient for the thermometric fluid 10 W/m²K is approximately _____
 $9 \times 10^6 \sigma$ $8 \times 10^7 \sigma$ $7 \times 10^6 \sigma$ $6 \times 10^6 \sigma$
17. A crossflow type air heater has an area of 50 cm². The overall heat transfer coefficient is 100 W/m²K and the heat capacity of both hot and cold streams is 1000 W/m K. The value of NTU is _____
 500 125 25 5
18. In a counter-flow heat exchanger the hot fluid is cooled from 110°C to 80°C and the cold fluid is heated from 30°C to 60°C. The LMTD of the heat exchanger is _____
 100°C 50°C 25°C 20°C
19. The emissive power is multiplied by a factor of _____ to obtain the intensity of normal radiation for a unit surface area.
 2π π $\pi/2$ $1/\pi$
20. The radiosity of the perfect black body is _____
 infinite 1
 equal to emissive power equal to radiation intensity

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SECTION "B"

[5 Q. × 11 = 55 marks]

Attempt ALL questions. Assume any missing values (if and only if needed). Students are permitted to use data books and formula sets during subjective examination ONLY.

1.

- a. The large furnace wall represented in **Figure A-1** consists of a 250 mm thick composite bricklayer with $k = 0.65 \text{ W/m.K}$, lined on the inside with a 300 mm thick layer of magnesite bricks with $k = 11.5 \text{ W/m.K}$. The inner side of the furnace is exposed to hot gases at 1400°C with a convective heat transfer coefficient of $17.5 \text{ W/m}^2\text{K}$, and a radiative heat transfer coefficient of $23.2 \text{ W/m}^2\text{K}$. The temperature of surrounding air is 30°C with a convective heat transfer coefficient of $7.5 \text{ W/m}^2\text{K}$ and radiation heat transfer coefficient of $11.5 \text{ W/m}^2\text{K}$. Calculate

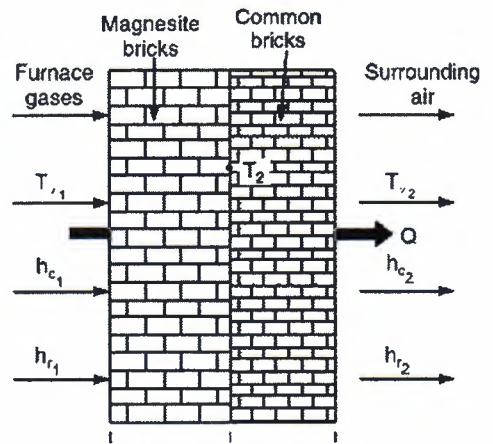


Figure A-1

- i. The rate of heat transfer through the wall per unit area, and [3]
 - ii. The maximum temperature to which the common brick is subjected. [3]
- b. Consider steady-state conditions for one-dimensional conduction in a plane wall (**Figure A-2**) having a thermal conductivity $k = 50 \text{ W/m.K}$ and a thickness $L = 0.25 \text{ m}$, with no internal heat generation.

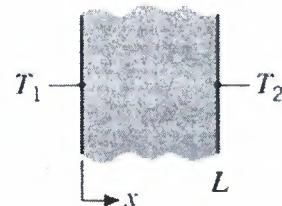


Figure A-2

Determine the heat flux and the unknown quantity for each case and sketch the temperature distribution, indicating the direction of the heat flux. [5]

Case	$T_1(^{\circ}\text{C})$	$T_2(^{\circ}\text{C})$	$dT/dx \text{ (K/m)}$
1	50	-20	
2	-30	-10	
3	70		160
4		40	-80
5		30	200

P.T.O.

2.

- a. Pure copper fins @100°C with a rectangular cross-section as shown in **Figure B-3** 1 mm thick, 10 mm long, are attached to a plane wall maintained at a temperature of 230°C. The fins dissipate heat by convection into an ambient at 30°C with a heat transfer coefficient of 40 W/m². K. Fins are spaced at 8 mm. Assume negligible heat loss from the fin tip. Calculate fin efficiency, area-weighted fin efficiency, the total heat transfer rate per m² of the plane wall surface, and the heat transfer rate from the plane wall if no fins were attached. [6]

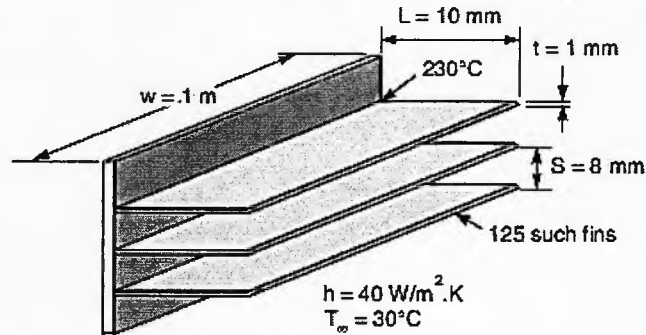


Figure B-3

- b. A horizontal steel shaft, 30 mm in diameter and 600 mm long, has its first bearing located 100 mm from the end connected to the impeller of a centrifugal pump. If the impeller is immersed in a hot liquid metal at 500°C, work out the temperature at the bearings under the conditions:
- The shaft is very long [2]
 - The heat flow through the end of the shaft is negligible, and [1]
 - The heat is transferred to the surroundings from the end. [2]

The temperature and convection coefficient associated with the fluid adjoining the shaft are 35°C and 68 kJ/m²hr⁰C. For steel shaft, thermal conductivity $k = 72 \text{ kJ/m}\cdot\text{hr}^0\text{C}$.

3.

- a. Calculate all view factors for conical geometry as shown in **Figure E-9**. [6]

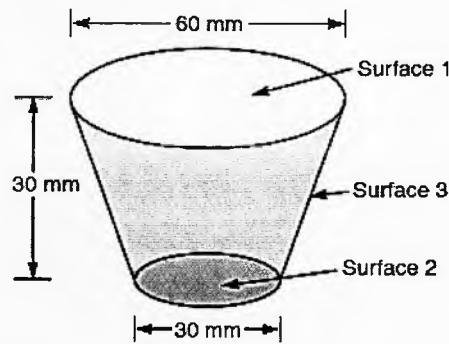


Figure E-9

- b. Determine the net radiant heat exchange per m² area for two infinite parallel plates held at temperatures of 800 K and 500 K respectively. Take emissivity as 0.6 for the hot plate and 0.4 for the cold plate. What should be the emissivity of a polished aluminum shield placed between them if heat flow is to be reduced to 40 percent of its original value? Calculate the equilibrium temperature of the shield and all salient view factors. [5]

4.

- a. A 2.5 kW plate heater of size 10 cm × 20 cm is held vertically with a 20 cm side in a water bath at 40°C. Assuming the property of water remains constant and the heat transfer takes place by convection only, find the steady state temperature attained by the heater. Use relation $Nu = 0.13 (Gr.Pr)^{1/3}$

The properties of water are

[5]

Temp (°C)	C_p , J/kg.K	K_f , W/m.K	ν , m ² /s	Pr	B, K ⁻¹
60	4179	0.659	0.478×10^{-6}	2.98	5.11×10^{-4}
70	4187	0.668	0.415×10^{-6}	2.55	5.7×10^{-4}
80	4195	0.675	0.365×10^{-6}	2.21	6.32×10^{-4}

- b. The local atmospheric pressure of Location X at elevation 1610 m, is 0.823 atm. Air at this pressure and 20°C flow with a velocity of 8 m/s over a 1.5 m x 6 m flat plate whose temperature is 140°C (Figure C-6). Determine the rate of heat transfer from the plate if the air flows parallel to the

i. 6-m-long side and

[3]

ii. The 1.5-m side.

[3]

{Hint: Adjusted kinematic viscosity, $\nu_x = \nu_{@ \text{atmospheric}} / P_{\text{in atmosphere}}$ }

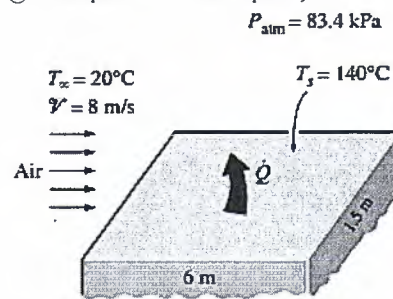


Figure C-6

5.

- a. Hot gases enter a finned-tube, cross-flow heat exchanger as shown in Figure D-7 at 300°C and leave at 100°C, which are used to heat the water at a flow rate of 1 kg/s from 35°C to 125°C. The exhaust gas-specific heat is approximately 1000 J/kg. K and the overall heat transfer coefficient based on the gas side surface is 100 W/m²K. Calculate

i. Mass flow rate.

[1]

ii. Actual heat transfer rate in the exchanger.

[2]

iii. Maximum theoretically possible heat transfer rate in the exchanger.

[1]

iv. Effectiveness of the heat exchanger.

[1]

v. The required gas side area using the NTU method.

[2]

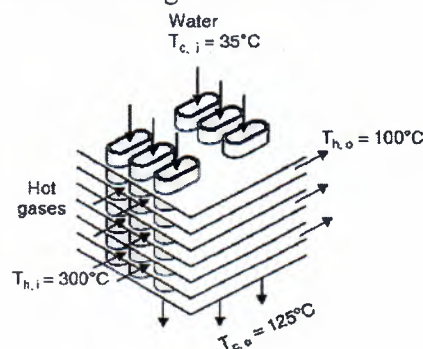


Figure D-7

- b. Calculate the nucleate boiling heat transfer coefficient for water boiling on the tube, whose wall temperature is maintained at 20°C , above the saturation temperature. Assume water to be at 20 bars. Also calculate the heat transfer coefficient, when

i. Temperature is reduced by 10°C at 20 bars. [2]

ii. Pressure is reduced by 10 bar at 20°C temperature difference. [2]

Comment on the result.

Use correlation:

$$h_A = 5.56 \times (\Delta T)^3 \text{ W/m}^2 \cdot \text{K}$$

$$\text{And } h_p = h_A \left\{ \frac{p}{p_0} \right\}^{0.4} \text{ W/m}^2 \cdot \text{K}$$

suffix, A corresponds to atmospheric pressure; p corresponds to fluid pressure. Assume atmospheric pressure to be 100kPa.