

JK LAKSHMIPAT UNIVERSITY, JAIPUR

INSTITUTE OF ENGINEERING AND TECHNOLOGY

End Term Examination (Regular/ Backlog), April-May 2018

B. Tech in Mechanical Engineering, Semester IV

Roll No.....

ME408: Heat Transfer

Time: 3 hours

Max. Marks: 100

Instructions to students:

1. Do not write anything other than your roll number on question paper.
2. Assume suitable data wherever required and mention it clearly.
3. Writing appropriate units, nomenclature, and drawing neat sketches/schematics/ flow chart wherever, required are an integral part of the answer.

- Q.1A Objective type multiple choice questions (10 questions @ 1 mark) 10
- i. A Plane wall is 25 cm thick with an area of 1 m^2 , and has a thermal conductivity of 0.5 W/mK . If a temperature difference of 60°C is imposed across it, what is the heat flow?
(a) 120 W (b) 140 W (c) 160 W (d) 180 W
 - ii. A composite wall having three layers of thickness 0.3m, 0.2m and 0.1m and of thermal conductivities 0.6, 0.4 and 0.1 W/mK , respectively, is having surface area 1 m^2 . If the inner and outer temperatures of the composite wall are 1840K and 340K, respectively, what is the rate of heat transfer?
(a) 150 W (b) 1500 W (c) 75W (d) 750W
 - iii. Which one of the following expresses the thermal diffusivity of a substance in terms of thermal conductivity (k), mass density (ρ) and specific heat (c_p)?
(a) $k^2/\rho c_p$ (b) $1/k\rho c_p$ (c) $k/\rho c_p$ (d) $\rho c_p/k^2$
 - iv. Calculate the prandlt number for engine oil at 60°C with $\mu = 8.36 \times 10^{-2} \text{ kg/ms}$, $C_p = 2035 \frac{\text{J}}{\text{kg K}}$, $k = 0.141 \frac{\text{W}}{\text{mK}}$.
(a) 1150 (b) 1007 (c) 1207 (d) 1250
 - v. In pool boiling, the highest heat transfer coefficient occurs in
(a) Subcooled boiling zone (b) nucleate boiling zone
(c) Partial film boiling zone (d) film boiling zone
 - vi. Nucleation or bubble formation in nucleate boiling requires liquid to be
(a) superheated (b) saturated (c) subcooled (d) in the boiling regime
 - vii. Two spheres A and B of same material have radii 1m and 4m and temperature 4000K and 2000K respectively, which one of the following statement is correct?
The energy radiated by sphere A is
(a) greater than that of sphere B
(b) less than that of sphere B
(c) equal to that of sphere B
(d) equal to double that of sphere B

- viii. An outer wall of a furnace is at T_w kelvins and it faces an environment at T_e , the wall's average convective heat transfer coefficient h is $4 \text{ W/m}^2 \text{ K}$. for radiative heat transfer the walls emissivity is equals 0.8. The ratio of net heat loss by radiation to heat loss by convection from the wall is closet to

(a) $5\sigma \frac{T_w^4 - T_e^4}{T_w - T_e}$ (b) $2.5\sigma \frac{T_w^4 - T_e^4}{T_w - T_e}$ (c) $0.5\sigma \frac{T_w^4 - T_e^4}{T_w - T_e}$ (d) $0.2\sigma \frac{T_w^4 - T_e^4}{T_w - T_e}$

- ix. In a counter flow heat exchanger,

For the hot fluid

Heat capacity = 2 kJ/kg K ; mass flow rate = 5 kg/sec ; Inlet temperature = 150°C ; Outlet temperature = 100°C ;

For the cold fluid

Heat capacity = 4 kJ/kg K ; mass flow rate = 10 kg/sec ; Inlet temperature = 20°C ;

Neglecting heat transfer to the surrounding, find outlet temperature of the cold fluid in $^\circ\text{C}$.

(a) 7.5 (b) 32.5 (c) 45.5 (d) 70

- x. In a condenser water enters at 30°C and flows at the rate 1500 kg/hr . The condensing steam is at a temperature of 120°C and cooling water leaves the condenser at 80°C . Specific heat of water is 4.187 kJ/kg K . If the overall heat transfer coefficient is $2000 \text{ W/m}^2\text{K}$, then the heat transfer area is

(a) 0.707 m^2 (b) 7.07 m^2 (c) 70.7 m^2 (d) 141.4 m^2

Q.2 Short answer type questions (4 questions @ 2.5 marks) 10

- The surface of a blackbody is at 500 K temperature. Obtain the total emissive power, the wavelength of the maximum monochromatic emissive power.
- Differentiate between film condensation and dropwise condensation.
- A bulb of diameter 10 cm (d) is heated internally with an electric heater of 100 W (Q). The bulb dissipates the heat to the atmosphere by convection. The convection heat transfer coefficient between the air and the bulb (h) is $65 \text{ W/m}^2\text{C}$. If the atmosphere is at 35°C (T_a), determine the bulb surface temperature (T_s).
- Define Stefan-boltzmann law and emissivity.

Q.3A Write the significance of the following: 05

- Reynolds number
- Nusselt number
- Prandtl number
- Rayleigh number

Q.3B Derive the expression for temperature distribution, under one dimensional steady state heat conduction for the Composite plane wall consisting of three layers. 05

Q.4A Derive expression for temperature distribution and heat dissipation in a straight fin of rectangular profile for fin insulated at the tip. 05

Q.4B Derive an expression for rate of heat transfer by considering a case of fluid flowing in a tube with constant surface temperature. 05

Q.5A What is boiling? Differentiate between pool boiling and forced boiling? Explain pool boiling curve with neat sketch. 05

- Q.5B Water at 20°C with a flowrate of 0.015 kg/s enters a 2.5 cm ID tube which is maintained at a uniform temperature of 90°C. Assuming hydrodynamically and thermally fully developed flow determine the heat transfer coefficient and the tube length required to heat the water to 70°C. 05
[water properties at 45°C are:

$$\rho = 992.3 \text{ kg/m}^3; C_p = 4180 \text{ J/kg K}; k = 0.638 \text{ W/mK}; \nu = 0.613 \times 10^{-6} \text{ m}^2/\text{s}$$
The average Nusselt number for the tube $Nu = 3.657$
- Q.6A In a concentric counter flow heat exchanger, water flows through the inner tube at 25°C and leaves at 42°C. The engine oil enters at 100°C and flows in the annular flow passage. The exit temperature of the engine oil is 50°C. Mass flow rate of water and the engine oil are 1.5 kg/s and 1 kg/s, respectively. The specific heat of water and oil are 4.178 J/Kg K and 2130 J/kgK, respectively. Calculate the effectiveness of the heat exchanger. 05
- Q.6B (i) Explain the mechanism of natural convection. 05
(ii) A cylindrical body of 300 mm diameter and 1.6 m height is maintained at a constant temperature of 36.5°C. The surrounding temperature is 13.5°C. Calculate heat loss by free convection from the body per hour if $\rho = 1.025 \frac{\text{kg}}{\text{m}^3}$; $C_p = 0.96 \text{ KJ/Kg}^\circ\text{C}$; $\nu = 15.06 \times 10^{-6}$; $k = 0.0892 \text{ KJ/mh}^\circ\text{C}$; $\beta = \frac{1}{928} \text{ K}^{-1}$. Assume $Nu = 0.12(Gr.Pr)^{1/3}$ (the symbols have their usual meaning)
- OR
- Q.6B (i) Explain the mechanism of natural convection. 02 +
(ii) A room is heated by initiating fire at the fireplace. The exfiltration of room air through a chimney is reduced by the use of a glass door fire screen of height 0.8m and width of 1.1m. If the ambient air temperature is 25°C and the surface temperature attained by the glass is 175°C, calculate the free convection heat transfer rate from the fire place to the room. For this room following correlation given by Churchill and Chu is valid: 03 = 05

$$Nu = \left[0.825 + \frac{0.387 (Gr.Pr)^{1/6}}{[1 + (0.492/Pr)^{9/16}]^{8/27}} \right]^2$$
The thermo-physical properties of air at 100°C are:
 $k = 3.208 \times 10^{-2} \text{ W/m}^2\text{C}$, $\nu = 23.13 \times 10^{-6} \text{ m}^2/\text{s}$, $Pr = 0.688$
- Q.7A A steam pipe ($k = 45 \text{ W/m}^\circ\text{C}$) having 70 mm inside diameter and 85 mm outside diameter is lagged with two insulation layers; the layer in contact with the pipe is 35 mm asbestos ($k=0.15 \text{ W/m}^\circ\text{C}$) and it is covered with 25 mm thick magnesia insulation ($k=0.075 \text{ W/m}^\circ\text{C}$). The heat transfer coefficients for the inside and outside surfaces are 220 W/m²°C and 6.5 W/m²°C respectively. If the temperature of steam is 350 °C and the ambient temperature is 30 °C, calculate: 10
(i) the steady loss of heat for 50 m length of the pipe;
(ii) the overall heat transfer coefficients based on inside and outside surfaces of the lagged steam main.

- Q.8A Write the importance of heat exchangers in the industry. How they are classified? Derive an expression for log mean temperature difference (LMTD) for parallel flow in double pipe heat exchanger. 10
- Q.9A (a) Define intensity of radiation and prove that the intensity of normal radiation is $1/\pi$ times the total emissive power. 07 + 03 = 10
 (b) A black body of 0.2 m^2 area has an effective temperature of 800 K . Calculate
 (i) The total rate of energy emission
 (ii) The intensity of the normal radiation
 (iii) The wavelength of maximum monochromatic emissive power.
- Q.9B (i) What do you understand by efficiency of the fin? 2.5 +
 (ii) A steel rod ($k = 32 \text{ W/m } ^\circ\text{C}$), 12 mm in diameter and 60 mm long, with an insulated end, is to be used as a spine. It is exposed to surroundings with a temperature of 60°C and a heat transfer coefficient of $55 \text{ W/m}^2 \text{ } ^\circ\text{C}$. The temperature at the base of fin is 95°C . Determine: 7.5 = 10
 (a) The Fin Efficiency
 (b) The temperature at the edge of the spine;
 (c) The heat dissipation
- OR
- Q.9B A vertical flat plate in the form of fin is 600 m in height and is exposed to steam at atmospheric pressure. If the surface of the plate is maintained at 60°C , calculate the following: 10
 (a) The film thickness at the trailing edge of the film
 (b) The overall heat transfer coefficient
 (c) The heat transfer rate
 (d) The condensate mass flow rate
 Assume laminar flow conditions and unit width of the plate.
 { Given data:
 The properties of vapour at atmospheric pressure are:
 $t_{sat} = 100^\circ\text{C}$, $h_{fg} = 2257 \text{ kJ/kg}$; $\rho_v = 0.596 \text{ kg/m}^3$.
 The properties of saturated vapour at the mean film temperature $t_f = \frac{100 + 60}{2} = 80^\circ\text{C}$ are:
 $\rho_l = 971.8 \text{ kg/m}^3$, $k = 67.413 \times 10^{-2} \text{ W/m}^\circ\text{C}$, $\mu = 355.3 \times 10^{-6} \text{ Ns/m}^2$ or kg/ms }

***** GOOD LUCK *****