



10. In general, surface tension of liquid-vapor interface for water ..... with increase in temperature.  
 decreases       increases       remains constant       is unrelated
11. A flow characterized by no free surface for vapor to escape and thus leading to both liquid vapor forced to flow together is known as .....flow boiling.  
 bubble       mist       internal       external
12. The error in using the arithmetic mean temperature difference is less than 1 percent, when  $\Delta T_1$  differs from  $\Delta T_2$  by no more than ..... percent.  
 60       50       40       30
13. For a rotating shaft at 10 rps and 10 N force, radius is given as 0.1 m, the shaft work equals .....  
 1 J       6.28 J       49 J       62.8 J
14. A designer chooses the values of fluid flow rates and specific heats in such a manner that the heat capacities of the two fluids are equal. A hot fluid enters the counter flow heat exchanger at  $100^\circ\text{C}$  and leaves at  $60^\circ\text{C}$ . A cold fluid enters the heat exchanger at  $40^\circ\text{C}$ . The mean temperature difference between the two fluids is  
  $20^\circ\text{C}$         $40^\circ\text{C}$         $60^\circ\text{C}$         $66.7^\circ\text{C}$
15. The value of the wavelength corresponding to maximum emissive power is given by..... law.  
 Kirchoff's       Stefan's       Wein's       Planck's
16. The quantity that describes the magnitude of radiation emitted in a specified direction in space is .....  
 radiation Intensity       radiosity  
 solid Angle       emissivity
17. In a typical laboratory base shell and tube heat exchanger the flow parameters are measured by .....  
 pressure Gauge       venturi meter       rotameter       orifice meter
18. The average Nusselt number in a laminar natural convection from a vertical wall at  $180^\circ\text{C}$  when surrounding air temperature is  $20^\circ\text{C}$  is found to be 48. If the wall temperature falls to  $30^\circ\text{C}$  then the average Nusselt number will be .....  
 4       8       12       24
19. The ratio of mechanical energy increase of working fluid to that of mechanical energy input in a system is called ..... efficiency.  
 mechanical       turbine       pump       rotor
20. A composite slab has two layers of different materials with thermal conductivities  $k_1$  and  $k_2$ . If each layer has the same thickness, then the equivalent thermal conductivity of the slab will be .....  
  $k_1 \cdot k_2$         $k_1 + k_2$   
  $2 k_1 \cdot k_2 / (k_1 + k_2)$         $k_1 + k_2 / (k_1 \cdot k_2)$

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

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

SECTION "B"

Attempt ALL questions. Use of Data book and steam table is allowed.

**Q. No. 1**

- Assume the condenser of a large power plant to be shell and tube type heat exchanger consisting of a single shell and 30000 tubes, each executing two passes. The tubes are of thin wall constructed with 25 mm in diameter, and steam condenses on their outer surface with an associated convection coefficient of  $11000 \text{ W/m}^2\text{K}$ . The heat transfer rate that must be effected by exchanger is 2000 MW and this is accomplished by cooling water through the tubes at the rate of 30000 kg/s. The water enters at  $20^\circ\text{C}$ , while the steam condenses at  $50^\circ\text{C}$ . What is the temperature of cooling water coming out the condenser? What is the required tube length per pass? [6]
- Oil at a mean specific heat of  $2.5 \text{ kJ/kg} \cdot \text{K}$  is to be cooled from  $110^\circ\text{C}$  to  $30^\circ\text{C}$  in a single pass counter flow heat exchanger. The coolant is water which enters at  $20^\circ\text{C}$  and leaves at  $80^\circ\text{C}$  and the overall heat transfer coefficient for this type of heat exchanger is  $1.5 \text{ kW/m}^2\text{K}$ . If the water flow rate is 1500 kg/hr, determine the quantity of oil that can be cooled per hour and the heat exchanger area. What would be the fluid exit temperatures when the water flow rate is decreased to 1000 kg/hr for the same oil flow rate? [5]

**Q. No. 2**

- The monochromatic emissivity of a diffuse surface at 1600 K varies with wavelength in the following manner:  $\epsilon = 0.4$  for  $0 < \lambda \leq 2$ ;  $\epsilon = 0.8$  for  $2 \leq \lambda \leq 5$ . Sketch this variation and determine the total emissivity and the total emissive power. [3]
- Establish a relation for the shape factor of cavity with respect to itself.: [2+2]

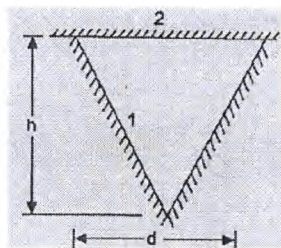


Figure 1: A conical cavity of diameter  $d$  and depth  $h$

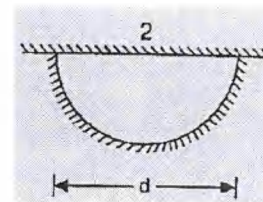


Figure 2: A hemispherical bowl of diameter  $d$

- A flat plate solar collector with no cover has selective absorber surface with  $\epsilon = 0.1$  and  $\alpha_s = 0.95$ . At a particular time of a day, the absorber surface temperature  $T_s$  is  $120^\circ\text{C}$ , when the solar irradiation is  $750 \text{ W/m}^2$ , the effective sky temperature is  $-10^\circ\text{C}$  and ambient air temperature  $T_\infty$  is  $30^\circ\text{C}$ . Assume the natural convection is given by:

$$q = 0.22 (T_s - T_\infty)^{4/3} \text{ W/m}^2\text{K}.$$

Calculate the useful heat removal rate ( $\text{W/m}^2$ ) from the collector for these conditions. What is the corresponding efficiency of the collector? [4]

**Q. No. 3**

- a. The air at a temperature of  $T_\infty$ , flows over a flat plate with a free stream velocity of  $u_\infty$ . The plate is maintained at a constant temperature of  $T_s$ . The velocity  $u$  and temperature  $T$  of air at any location are given by  $\frac{u}{u_\infty} = \sin \frac{\pi y}{2\delta}$  and  $\frac{T - T_s}{T_\infty - T_s} = 2 \left( \frac{y}{\delta_{th}} \right) - \left( \frac{y}{\delta_{th}} \right)^2$  where  $y$  is the distance measured from the plate along its normal, and  $\delta$  and  $\delta_{th}$  are the hydrodynamic and thermal boundary layer thickness, respectively. Find the ratio of heat transfer coefficient to shear stress at the plate surface using following data: [5]

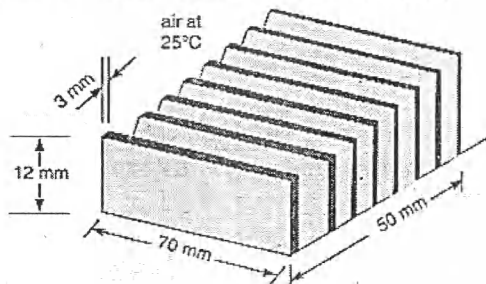
$$u_\infty = 10 \text{ m/s} \quad \mu_{(air)} = 2.5 \times 10^{-5} \text{ kg/ms} \quad \delta/\delta_{th} = Pr^{1/3} \quad T_s = 200^\circ\text{C}$$

$$K_{(air)} = 0.04 \text{ W/m.K} \quad C_p (air) = 1000 \text{ J/kg.K} \quad T_\infty = 50^\circ\text{C}.$$

- b. The insulation boards for air conditioning purposes comprise three layers. A 12 cm thick layer of grass ( $k = 0.022 \text{ W/m.K}$ ) is sandwiched between 3 cm thick layer of plywood ( $k = 0.15 \text{ W/m.K}$ ) on each side. The bonding is achieved with glue which does not offer any resistance to heat flow. If the side surfaces of the board are maintained at  $40^\circ\text{C}$  and  $20^\circ\text{C}$  temperatures, determine the heat flux. How would the heat flux be affected if instead of glue, the three pieces are fastened by four steel bolts ( $k = 40 \text{ W/m.K}$ ) of 1.2 cm diameter at the corners? Draw the resistive circuit diagram for the same. [6]

**Q. No. 4**

- a. Two ends of a fin of the cross-sectional area  $2 \text{ cm}^2$ , perimeter  $2 \text{ cm}$ ,  $100 \text{ cm}$  long are maintained at  $127^\circ\text{C}$  and  $327^\circ\text{C}$ , respectively. It loses heat from the surface due to natural convection to surroundings at  $27^\circ\text{C}$  with heat transfer coefficient of  $5 \text{ W/m}^2\text{K}$ . Thermal conductivity of fin material is  $45 \text{ W/m.K}$ . Find the minimum temperature in the fin and its location. Also calculate the heat conducted from each end. [6]
- b. An aluminum heat sink (Figure 1) for electronics components has a base of length  $50 \text{ mm}$  and width  $70 \text{ mm}$ . The eight aluminum ( $k = 180 \text{ W/m.K}$ ) fins are attached in such a way that their width is  $70 \text{ mm}$ . The fins are  $12 \text{ mm}$  long, and  $3 \text{ mm}$  thick. The fins cooled by air at  $25^\circ\text{C}$  with a convective heat transfer coefficient of  $h = 10 \text{ W/m}^2\text{K}$ . Assuming that the same value of heat transfer coefficient acts on the tip of the fins as along the rest of the external surface, determine: [5]
- The heat flow through the heat sink for a base temperature of  $50^\circ\text{C}$ ,
  - The fin effectiveness, and efficiency,
  - The length of the fin such that the heat flow is 95 % of the heat flow for an infinite long fin,
  - The percentage increase in heat transfer with fins.



**Q. No. 5**

- a. The insulation boards for air conditioning purposes comprise three layers. A 12 cm thick layer of grass ( $k = 0.022 \text{ W/m.K}$ ) is sandwiched between 3 cm thick layer of plywood ( $k = 0.15 \text{ W/m.K}$ ) on each side. The bonding is achieved with glue which does not offer any resistance to heat flow. If the side surfaces of the board are maintained at  $40^\circ\text{C}$  and  $20^\circ\text{C}$  temperatures, determine the heat flux. How would the heat flux be affected if instead of glue, the three pieces are fastened by four steel bolts ( $k = 40 \text{ W/m.K}$ ) of 1.2 cm diameter at the corners? Draw the resistive circuit diagram for the same. [6]
- b. For the configuration shown and conditions specified, determine the temperature  $t_2$  and  $t_3$ . Thermal conductivities conform to the following relation:  $k_1 = k_4 = k_2/2 = k_3/3 = k$ . [5]

