

9. An increase in convective coefficient over a fin
 increases effectiveness decreases effectiveness
 does not influence effectiveness influences fin efficiency only
10. Heat correction factor is needed in _____ heat exchanger
 multi pass flow counter flow parallel flow cross flow
11. Natural convection heat flow depends on all of the followings, except
 density coefficient of viscosity
 gravitational force velocity
12. For laminar conditions, the thickness of thermal boundary layer increases with its distance from the leading edge in proportion to
 x $x^{1/2}$ $x^{1/3}$ $x^{-1/2}$

SECTION "B"

[8Q. \times 1 = 8 marks]

Fill in the blank space(s).

13. Effectiveness of a heat exchanger is defined as the ratio of _____
to _____
14. The simplifications to the momentum equations for flat plate boundary layer is called _____
15. The ratio of Nusselt number and the product of Reynold's number and Prandtl number is _____
16. According to Stefan-Boltzmann law, the total radiation from a black body per second per unit area is directly proportional to the _____
17. A composite slab has two layers of different material with thermal conductivity k_1 and k_2 . If each layer has the same thickness, the equivalent thermal conductivity of the slab would be _____
18. Thermal radiation is defined as the portion of the electromagnetic spectrum that extends from about _____ to _____ μm .
19. Insulated boundary condition is given by the expression _____
20. Heat is lost at a rate of 275 W per m^2 area of a 15-cm thick wall with a thermal conductivity of $k = 1.1 \text{ W/m}\cdot\text{K}$. The temperature drop across the wall is _____

KATHMANDU UNIVERISTY
End Semester Examination
May/June, 2022

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

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

SECTION "C"

Attempt *ANY FIVE* questions. Use of your own data sheet (or book) is allowed. Assume suitable data if missing.

1.
 - i. Explain the significance of heat diffusion equation. Why do we need boundary conditions? Describe several types of boundary conditions relevant to solving heat diffusion equation. [5.5]
 - ii. A 2-mm-diameter and 10-m-long electric wire is tightly wrapped with a 1-mm-thick plastic cover whose thermal conductivity is $k = 0.15 \text{ W/m} \cdot ^\circ\text{C}$. 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 $T_\infty = 30^\circ\text{C}$ with a heat transfer coefficient of $h = 24 \text{ W/m}^2 \cdot ^\circ\text{C}$, determine the temperature at the interface of the wire and the plastic cover in steady operation. Also discuss if doubling the thickness of the plastic cover will make it less prone to melting. [5.5]
2.
 - i. Explain the difference between fin effectiveness and fin efficiency. What are several aspects needed to be considered while designing the fins. Describe how proper length of a fin is determined. [5.5]
 - ii. Steam in a heating system flows through tubes whose outer diameter is 3 cm and whose wall are maintained at a temperature of 120°C . Circular aluminum fins [$k = 180 \text{ W/mK}$] of outer diameter 6-cm and constant thickness $t = 2 \text{ mm}$ are attached to the tube, as shown in Figure 1. The space between the fins is 3-mm and thus there are 200 fins per meter length of the tube. Heat is transferred to the surrounding air at a temperature of 25°C with a combined heat transfer coefficient of $h = 60 \text{ W/(m}^2 \text{ K)}$. Determine the increase in heat transfer rate from the tube per meter of its length as a result of adding fins. Also, calculate fin effectiveness. [5.5]
3.
 - i. What are the advantages of non-dimensionalizing the convection equations? [1.5]
 - ii. What do you understand by Prandtl number? Explain its meaning when Prandtl number is equal to 1, very smaller than and larger than 1. [2.5]

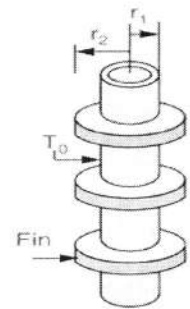


Figure 1

- iii. During a plant visit, it was noticed that a 12-m-long section of a 10-cm-diameter steam pipe is completely exposed to the ambient air. The temperature measurements indicate that the average temperature of the outer surface of the steam pipe is 75°C when the ambient temperature is 5°C . There are also light winds in the area at 10 km/h. The emissivity of the outer surface of the pipe is 0.8, and the average temperature of the surfaces surrounding the pipe, including the sky, is estimated to be 0°C . Determine the amount of heat lost from the steam during a 10-h-long work day. Steam is supplied by a gas-fired steam generator that has an efficiency of 80 percent, and the plant pays $\$0.54/\text{therm}$ of natural gas (1 therm = 105,500 kJ). If the pipe is insulated and 90 percent of the heat loss is saved, determine the amount of money this facility will save a year as a result of insulating the steam pipes. Assume the plant operates every day of the year for 10 h. State your assumptions. [7]
4. i. Sketch the velocity profile of natural convection on a flat plate heated on one side and insulated on the other side. Consider horizontal, vertical and inclined cases. Which orientation is suited the best for cooling the plate? [3]
- ii. A condenser is employed in a steam power plant to handle 35,000kg/h of dry and saturated steam at 50°C . The cooling water enters the condenser at 15°C and leaves at 25°C . The tubes are 22.5mm inside diameter and 25mm outside diameter. The water flows through the tubes at an average velocity of 2m/sec. The heat transfer coefficient on the steam side is $5000\text{W}/(\text{m}^2\text{K})$. Calculate: [8]
- mass flow rate of water,
 - heat transfer surface area
 - number of tubes required for water flow
 - number of tube passes in the condenser if the length of each tube per pass should not be more than 2.5m. Ignore the thermal resistance of wall material. Assume that the condensate coming out the condenser is saturated water i.e steam loose only its latent heat.
5. i. What is the difference between the red colour that we see of a steel bar heated in a furnace to about 800°C and that we see of a red painted steel bar at room temperature? What law describes the red colours visible to our eyes when a metal object is heated? Describe the law. [1+1+2]
- ii. Consider a 1.2-m-high and 2-m-wide glass window with a thickness of 6 mm, thermal conductivity $k = 0.78\text{ W}/\text{m} \cdot ^{\circ}\text{C}$, and emissivity $\varepsilon = 0.9$. The room and the walls that face the window are maintained at 25°C , and the average temperature of the inner surface of the window is measured to be 5°C . If the temperature of the outdoors is -5°C , determine [7]
- the convection heat transfer coefficient on the inner surface of the window,
 - the rate of total heat transfer through the window, and
 - the combined natural convection and radiation heat transfer coefficient on the outer surface of the window. Is it reasonable to neglect the thermal resistance of the glass in this case?

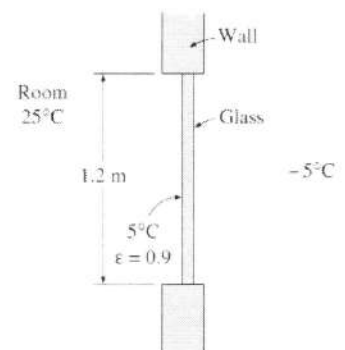


Figure 2

6. i. Draw a typical velocity and temperature profiles for natural convection flow over a hot vertical plate at temperature T_s inserted in a fluid at temperature T_∞ . Which is the most effective way to cool a hot plate – keeping the hot surface. [3]
- ii. What are the common causes of fouling in a heat exchanger? How is the thermal resistance due to fouling in a heat exchanger accounted for? [3]
- iii. The sun can be treated as a blackbody at an effective surface temperature of 5780 K. Determine the fraction of radiation emitted within infrared ($\lambda = 0.76\text{--}100\ \mu\text{m}$), visible light ($\lambda = 0.40\text{--}0.76\ \mu\text{m}$) and ultraviolet light ($\lambda = 0.01\text{--}0.40\ \mu\text{m}$) spectrum for the sun. [5]

