KATHMANDU UNIVERSITY
End Semester Examination
June/July, 2023

Marks Scored:

Level : B.E./B.Tech.
Year : III

Course : MEEG 306
Semester : II

Exam Roll No. :

Time: 30 mins.

F. M. : 20

Registration No.:

Date : 17 JUL 2023

SECTION "A"
[20Q. × 1 = 20 marks]

Mark [X] to the most appropriate option.

1. Unit of thermal conductivity is
[ ] J /m ° K [ ] W/m ° K [ ] J/m^2 ° K [ ] W/m^2 ° K

2. Eggs with a mass of 0.15 kg per egg and a specific heat of 3.32 kJ/kg °C are cooled from 32 °C to 10 °C at a rate of 300 eggs per minute. The rate of heat removal from the eggs is
[ ] 11 kW [ ] 80 kW [ ] 25 kW [ ] 55 kW

3. Which of the following is the correct representation of the convection resistance through a wall?
[ ] L/(kA) [ ] 1/(kA) [ ] 1/(hA$_s$) [ ] L/(hA$_s$)

4. In the case of insulating materials with thermal conductivity of 0.04 W/m°C, the contact resistance
[ ] May or may not be significant [ ] Very significant, so cannot be ignored
[ ] Can be ignored [ ] Depends on the base material

5. Heat transfer through a hollow pipe can be modeled as one-dimensional because
[ ] The temperature of the pipe depends on axial direction only
[ ] The temperature of the pipe depends on tangential direction only
[ ] The temperature of the pipe depends on radial direction only
[ ] Hollow pipes cannot be modeled as one-dimensional

6. At the outer radius of the pipe less than the critical radius of insulation
[ ] The rate of heat transfer reaches a maximum value
[ ] The rate of heat transfer decreases with the addition of insulation
[ ] The rate of heat transfer from the cylinder increases with addition of insulation
[ ] There is no effect on the rate of heat transfer after increasing the insulation

7. Which of the following relation can be used for corrected fin length in the case of a cylindrical fin with diameter L?
[ ] L + D/2 [ ] L + D [ ] L + D/4 [ ] L + D/3

8. The 700 m^2 ceiling of a building has a thermal resistance of 0.2 m^{2}K/W. The rate at which heat is lost through the ceiling on a cold winter day when the ambient temperature is -10°C and the interior is at 20°C is
[ ] 150 MW [ ] 105 MW [ ] 118 MW [ ] 87 MW

9. Which of the following equation cannot be used to calculate the friction factor based on the Reynold's number and roughness of the materials?

[ ] Moody Chart [ ] Colebrook Equation
[ ] S E Haaland Relation [ ] Darcy-Weisbach Equation

10. In the case of an internal flow in a circular pipe with diameter 100 mm, the Reynolds number was measured to be 5000. What is the minimum distance from the inlet of the pipe to install a flowmeter, such that the fully developed region of the water flow can be measured?

[ ] 1 m [ ] 5 m [ ] 15 m [ ] 25 m

11. Which of the following statement is **TRUE** for an internal flow with Pr>1?

[ ] Thermal entry length is larger than the hydrodynamic entry length
[ ] Thermal entry length is less than the hydrodynamic entry length
[ ] Thermal entry length and hydrodynamic entry length are equal
[ ] The higher value between thermal entry length and hydrodynamic entry length depends on the property of fluid

12. Water ($\mu = 9.0\times10^{-4}$ kg/m·s, $\rho = 1000$ kg/m^3) enters a 2-cm-diameter, 3-m-long tube whose walls are maintained at 100°C. The water enters this tube with a bulk temperature of 25°C and a volume flow rate of 3 m^3/h. The Reynolds number for this internal flow is

[ ] 59,000 [ ] 105,000 [ ] 178,000 [ ] 236,000

13. Water enters a 2-cm-diameter, 3-m-long tube whose walls are maintained at 100°C with a bulk temperature of 25°C and volume flow rate of 3 m^3/h. Neglecting the entrance effects and assuming turbulent flow, the Nusselt number can be determined from $Nu = 0.023\ Re^{0.8}\ Pr^{0.4}$. The convection heat transfer coefficient in this case is.... (For water, use $k = 0.610$ W/m·°C, Pr = 6.0, $\mu = 9.0\times10^{-4}$ kg/m·s, $\rho = 1000$ kg/m^3)

[ ] 4140 W/m^2·K [ ] 6160 W/m^2·K [ ] 8180 W/m^2·K [ ] 9410 W/m^2·K

14. Condensation is taking place over a tube with length 15 times larger than the diameter. Which of the following orientation of the tube would accelerate the condensation heat transfer?

[ ] Horizontal orientation [ ] Vertical orientation
[ ] -30 degree angle with the flow [ ] 30 degree angle with the flow

15. In a parallel-flow heat exchanger, the NTU is calculated to be 2.5. The lowest possible effectiveness for this heat exchanger is

[ ] 10% [ ] 27% [ ] 41% [ ] 50%

16. A counter-flow heat exchanger is used to cool oil (cp = 2.20 kJ/kg·°C) from 110°C to 85°C at a rate of 0.75 kg/s by cold water (cp = 4.18 kJ/kg·°C) that enters the heat exchanger at 20°C at a rate of 0.6 kg/s. If the overall heat transfer coefficient is 800 W/m2·°C, the heat transfer area of the heat exchanger is ...(in m^2)

[ ] 0.745 [ ] 0.760 [ ] 0.775 [ ] 0.790

17. For the same inlet and exit temperatures of two fluids, the LMTD for counterflow is always

[ ] smaller than LMTD for parallel flow [ ] greater than LMTD for parallel flow
[ ] same as LMTD for parallel flow [ ] unpredictable

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18. The wavelength at which the blackbody emissive power reaches its maximum value at 300 K is

[ ] 5.1 μm [ ] 9.7 μm [ ] 15.5 μm [ ] 38.0 μm

19. Thermal radiation takes place from a body by electromagnetic waves as a result of

[ ] the weight of the body [ ] the magnetic property of the body
[ ] the temperature of the body [ ] does not require any property

20. Solar radiation is incident on a semi-transparent body at a rate of 500 W/m^2. If 150 W/m^2 of this incident radiation is reflected back and 225 W/m^2 is transmitted across the body, the absorptivity of the body is

[ ] 0 [ ] 0.25 [ ] 0.30 [ ] 0.45

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SECTION "B"
[5Q. × 11 = 55 marks]

Attempt *ALL* questions. Assume suitable data if necessary. *Use of a data book, formula sheet and steam table is allowed.*

1. a. Explain the ways of minimizing thermal contact resistances. [2]

   b. Steam with a temperature of 320° C flows inside a steel pipe with the thermal conductivity of 15 W/mK. The inner and outer diameters of the pipe is 5 cm and 5.5 cm, respectively. The pipe is insulated by using a glass wool of 3 cm thickness, and having the thermal conductivity of 0.038 W/mK. Heat is lost to the surrounding with the temperature of 5 °C through both convection and radiation. The combined natural convection and radiation heat transfer coefficient outside of the pipe is 15 W/m^2K, whereas that of the flow is 80 W/m^2K. Determine the rate of heat loss from the steam per unit length of the pipe. Also, determine the temperature drops across the pipe shell and the insulation. [6]

   c. The steady-state temperature distribution in a one-dimensional wall of thermal conductivity k and thickness L is of the form $T = ax^3 + bx^2 + cx + d$. Derive expressions for the heat generation rate per unit volume in the wall and the heat fluxes at the two wall faces (x=0, L). [3]

2. a. Consider two long, slender rods of the same diameter but different materials. One end of each rod is attached to a base surface maintained at 100°C, while the surfaces of the rods are exposed to ambient air at 20°C. By traversing the length of each rod with a thermocouple, it was observed that the temperatures of the rods were equal at the positions x_A = 0.15 m and x_B = 0.075 m, where x is measured from the base surface. If the thermal conductivity of the rod A is known to be k_A = 70 W/m.K, determine the value of k_B for rod B. [5]

   b. Steam in a heating system flows through tubes whose outer diameter is 5 cm and whose walls are maintained at a temperature of 180 °C. Circular aluminum alloy 2024-T6 fins (k = 186 W/m. °C) of outer diameter 6 cm and constant thickness 1 mm are attached to the tube. The space between the fins is 3 mm, and thus there are 250 fins per meter length of the tube. Heat is transferred to the surrounding air at T_∞ = 25 °C, with a heat transfer coefficient of 40 W/m^2. °C. Determine the increase in heat transfer from the tube per meter of its length as a result of adding fins. [6]

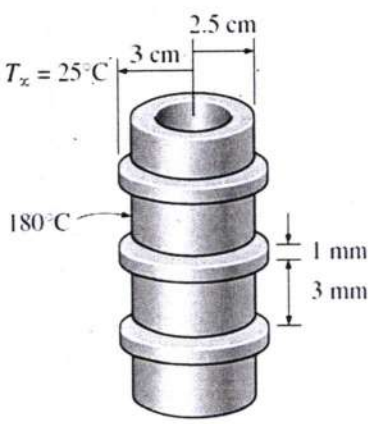

Figure 1

3. a. Provide a mathematical expression for 'Thermally fully developed region' of a flow. [1]

b. A 6-mm diameter electrical transmission line carries an electric current of 50 A and has a resistance of 0.002 ohm per meter length. Determine the surface temperature of the wire during a windy day when the air temperature is 10 °C and the wind is blowing across the transmission line at 40 km/h. [5]

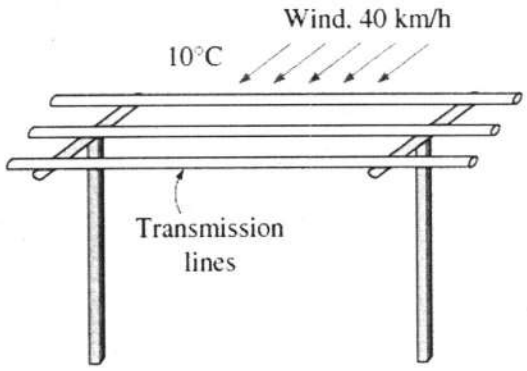

Figure 2

c. During a winter day, the window of a patio door with a height of 1.8 m and width of 1.0 m shows a frost line near its base. The room wall and air temperatures are 15°C. Estimate the heat loss through the window due to free convection and radiation. Assume the window has a uniform temperature of 0°C and emissivity of the glass surface is 0.94. If the room has electric baseboard heating, estimate the corresponding daily cost of the window heat loss for a utility rate of 0.08 $/kW.h. [5]

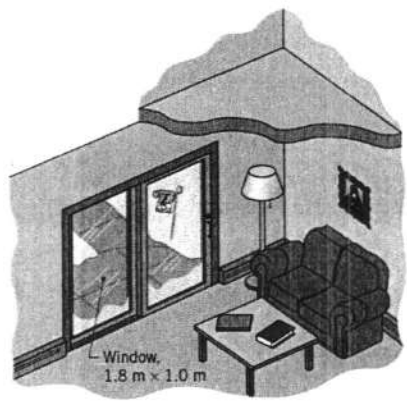

Figure 3

4. a. The bottom of a copper pan, 150 mm in diameter, is maintained at 115°C by the heating element of an electric range. Estimate the power required to boil the water in this pan. Determine the evaporation rate. [5]

b. The condenser of a large power plant is to be remove 500 MW of heat from steam condensing at 30°C (h_{fg} = 2430 kJ/kg). The cooling is to be accomplished by cooling water (C_p = 4180 J/kg °C) from a nearby river, which enters the tubes at 18°C and leaves at 26°C. The tubes of the heat exchanger have an internal diameter of 2 cm, and the overall heat transfer coefficient is 3500 W/m^2°C. Determine the total length of the tubes required in the condenser. [6]

5. a. Explain the process how microwaves are able to warm foods. [2]

b. A 3 mm thick glass window transmits 90% of the radiation between λ = 0.3 and 3 μm and is essentially opaque for radiation at other wavelengths. Determine the rate of radiation transmitted through a 2 m x 2 m glass window from blackbody sources at 1000 K. [5]

c. Calculate all the view factors associated with a cylinder. [4]