Due Date: ______________________________

ADDIS ABABA UNIVERSITY
AAiT
School of Mechanical and Industrial Engineering

Heat transfer: Assignment 1 **Instructor: Dawit M.**

1. An electric current is passed through a wire 1mm in diameter and 10cm long. The wire is submerged in liquid water at atmospheric pressure, and the current is increased until the water boils. For this situation h= 5000W/m^2. ^{0}C, and the temperature will be 100^{0}C. How much electric power must be supplied to the wire to maintain the wire surface at 114^{0}C?

2. A 3-m-high and 5-m-wide wall consists of long 16-cm x 22-cm cross section horizontal bricks (k = 0.72 W/m · °C) separated by 3-cm-thick plaster layers (k = 0.22 W/m · °C). There are also 2-cm-thick plaster layers on each side of the brick and a 3-cm-thick rigid foam (k =0.026 W/m · °C) on the inner side of the wall, as shown in Fig. 2. The indoor and the outdoor temperatures are 20°C and -10°C, and the convection heat transfer coefficients on the inner and the outer sides are h_1 = 10 W/m2 · °C and h_2 = 25 W/m2 · °C, respectively. Assuming one-dimensional heat transfer and disregarding radiation, determine the rate of heat transfer through the wall.

3. Steam at $T\infty_1$ = 320°C flows in a cast iron pipe (k = 80 W/m · °C) whose inner and outer diameters are D_1 = 5 cm and D_2 = 5.5 cm, respectively. The pipe is covered with 3-cm-thick glass wool insulation with k = 0.05 W/m · °C. Heat is lost to the surroundings at $T\infty_2$ = 5°C by natural convection and radiation, with a combined heat transfer coefficient of h_2 =18 W/m^2 · °C. Taking the heat transfer coefficient inside the pipe to be h_1 = 60 W/m^2 · °C, 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.

4. Consider a 5-m-high, 8-m-long, and 0.22-m-thick wall whose representative cross section is as given in the figure. The thermal conductivities of various materials used, in W/m · °C, are k_A = k_F = 2, k_B = 8, k_C = 20, k_D = 15, and k_E = 35. The left and right surfaces of the wall are maintained at uniform temperatures of 300°C and 100°C, respectively. Assuming heat transfer through the wall to be one-dimensional, determine (*a*) the rate of heat transfer through the wall; (*b*) the temperature at the point where the sections *B*, *D*, and *E* meet; and (*c*) the temperature drop across the section *F*. Disregard any contact resistances at the interfaces.

5. A 3-mm-diameter and 5-m-long electric wire is tightly wrapped with a 2-mm thick plastic cover whose thermal conductivity is k = 0.15 W/m · °C. Electrical measurements indicate that a current of 10 A passes through the wire and there is a voltage drop of 8V along the wire. If the insulated wire is exposed to a medium at T = 30°C with a heat transfer coefficient of h = 12 W/m^2 · °C, determine the temperature at the interface of the wire and the plastic cover in steady operation. Also determine whether doubling the thickness of the plastic cover will increase or decrease this interface temperature.

6. A 60-W power transistor is to be cooled by attaching it to one of the commercially available heat sinks shown in Table 3–4. Select a heat sink that will allow the case temperature of the transistor not to exceed 90°C in the ambient air at 30°C.

7. 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/m2 · °C. Determine the increase in heat transfer from the tube per meter of its length as a result of adding fins.

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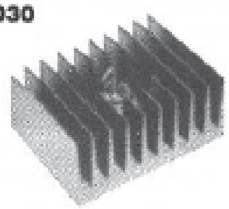
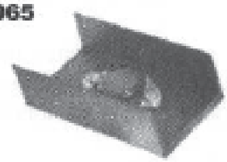
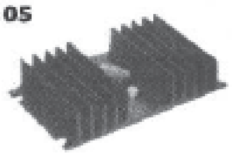
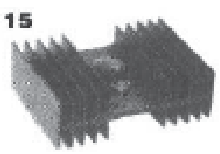
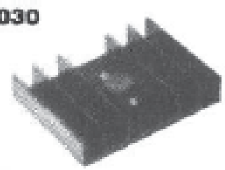
8. A hot surface at 100°C is to be cooled by attaching 3-cm-long, 0.25-cm-diameter aluminum pin fins (k = 237 W/m · °C) to it, with a center-to-center distance of 0.6 cm. The temperature of the surrounding medium is 30°C, and the heat transfer coefficient on the surfaces is 35 W/m^2 · °C. Determine the rate of heat transfer from the surface for a 1-m x 1-m section of the plate. Also determine the overall Effectiveness of the fins.

TABLE 3–4

Combined natural convection and radiation thermal resistance of various heat sinks used in the cooling of electronic devices between the heat sink and the surroundings. All fins are made of aluminum 6063T-5, are black anodized, and are 76 mm (3 in.) long (courtesy of Vemaline Products, Inc.).

HS 5030		R = 0.9°C/W (vertical) R = 1.2°C/W (horizontal) Dimensions: 76 mm × 105 mm × 44 mm Surface area: 677 cm^2
HS 6065		R = 5°C/W Dimensions: 76 mm × 38 mm × 24 mm Surface area: 387 cm^2
HS 6071		R = 1.4°C/W (vertical) R = 1.8°C/W (horizontal) Dimensions: 76 mm × 92 mm × 26 mm Surface area: 968 cm^2
HS 6105		R = 1.8°C/W (vertical) R = 2.1°C/W (horizontal) Dimensions: 76 mm × 127 mm × 91 mm Surface area: 677 cm^2
HS 6115		R = 1.1°C/W (vertical) R = 1.3°C/W (horizontal) Dimensions: 76 mm × 102 mm × 25 mm Surface area: 929 cm^2
HS 7030		R = 2.9°C/W (vertical) R = 3.1°C/W (horizontal) Dimensions: 76 mm × 97 mm × 19 mm Surface area: 290 cm^2

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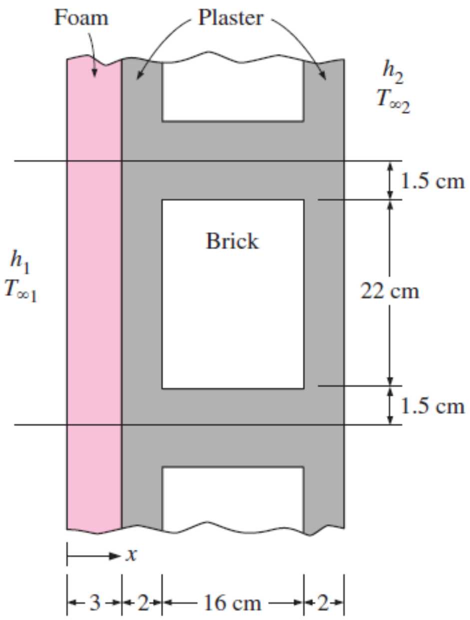

Fig.2 (Question 2)

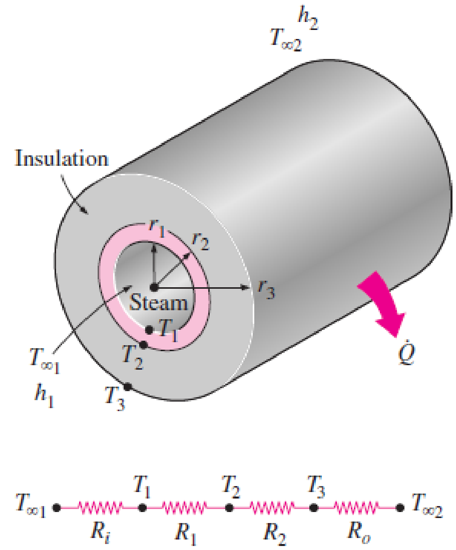

Fig.3 (Question 3)

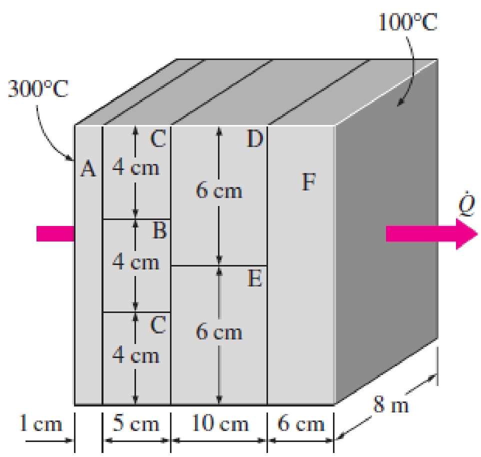

Fig.4 (Question 4)

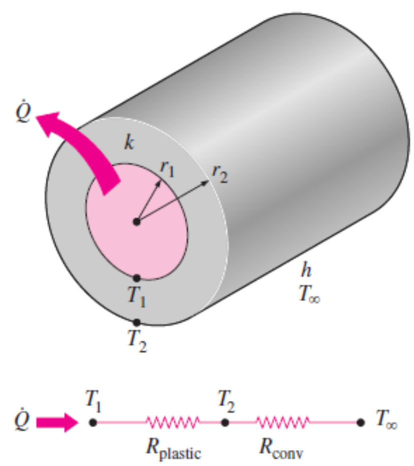

Fig.5 (Question 5)

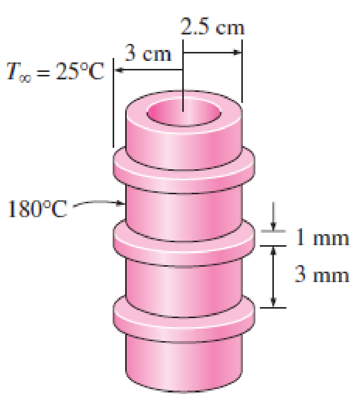

Fig.7 (Question 7)

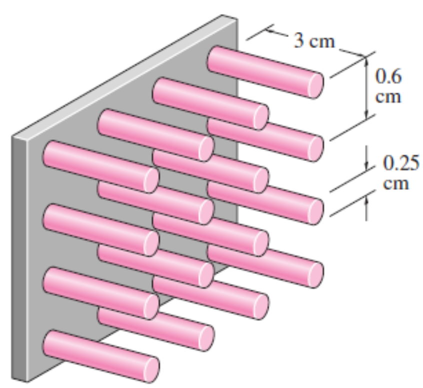

Fig.8 (Question 8)