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MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
A Constituent Institution of Manipal University

III SEMESTER B.TECH. (MECHATRONICS ENGINEERING)

END SEMESTER EXAMINATIONS, NOV 2017

SUBJECT: ENGINEERING THERMODYNAMICS AND HEAT TRANSFER

[MTE 2103]

REVISED CREDIT SYSTEM
(18/11/2017)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.

1A. A gas undergoes a thermodynamic cycle consisting of three reversible processes: **04**
Process 1–2: compression with pV = constant, from p_1 = 1 bar, V_1 = 1.6 m^3 to V_2 = 0.2 m^3, $U_2 = U_1 = 0$
Process 2–3: constant pressure to $V_3 = V_1$
Process 3–1: constant volume, $U_1 = U_3 = -3549$ kJ
There are no significant changes in kinetic or potential energy.
Draw the cycle on pV diagram and determine the heat transfer and work for Process 2–3, in kJ.
Is this a power cycle or a refrigeration cycle? Justify your answer with reason

1B. The electronic components of a computer are cooled by air flowing through a fan mounted at the inlet of the electronics enclosure. At steady state, air enters at 20^0 C, 1 atm. For noise control, the velocity of the entering air cannot exceed 1.3 m/s. For temperature control, the temperature of the air at the exit cannot exceed 32^0C. The electronic components and fan receive, respectively, 80 W and 18 W of electric power. Determine the smallest fan inlet diameter, in cm, for which the limits on the entering air velocity and exit air temperature are met. **04**

1C. Why is it wrong to say that the system ***contains*** heat? When you stir a cup of coffee, what happens to the energy transferred to the coffee by work? **02**

2A. Analyze the situations given below with respect to vapor compression cycle and predict their effect on COP. **03**
(a) Effect of decrease in suction pressure of compressor.
(b) Effect of compressing refrigerant vapor in compressor to higher pressure.
(c) Effect of wet vapor entering the compressor.

2B. In a standard vapor compression refrigeration cycle, operating between an evaporator temperature of – 10°C and a condenser temperature of 40°C, the enthalpy of the refrigerant, Freon-12, at the end of compression is 220 kJ/kg. **05**

Show the cycle diagram on T-s plane and Calculate :

(i) The C.O.P. of the cycle.

(ii) The refrigerating capacity and the compressor power assuming a refrigerant flow rate of 1 kg/min.

(iii) Quality of refrigerant at entry of evaporator. You may use the extract of Freon-12 property table given below :

$t(°C)$	$p(MPa)$	$h_f(kJ/kg)$	$h_g(kJ/kg)$
– 10	0.2191	26.85	183.1
40	0.9607	74.53	203.1

2C. In question 2B, calculate the temperature at compressor exit when $c_p = 1.002$ kJ/kg. K. What is the application of Classius's inequality? **02**

3A. A concrete slab of basement is 11 m long, 8 m wide and 0.2 m thick. During winters temperatures are normally 17 ^{o} C and 10 ^{o} C at the top and bottom surfaces. If the concrete has a thermal conductivity k = 1.4 W/m. ^{o} C, **what is the rate of heat loss through the slab?** If the basement is heated by a gas furnace which is 90 % efficient and electricity cost is 5 Rs/MJ, **What is the daily cost of electricity?** **03**

3B. What is the difference between fin effectiveness and fin efficiency in context of their application? Give numerical formulation for both of them. **02**

3C. A 3.3-m-high and 1-m-wide wall consists of a long 18-cm X 30-cm cross section of 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 wall, and a 2-cm-thick rigid foam (k = 0.026 W/m · °C) on the inner side of the wall (refer Fig Q3C.) The indoor and the outdoor temperatures are 22°C and -4°C, and the convection heat transfer coefficients on the inner and the outer sides are $h_1 = 10$ W/m^2 · °C and $h_2 = 20$ W/m^2 · °C, respectively. Assuming one-dimensional heat transfer and disregarding radiation. **(a) Draw resistance network for the system. (b) Determine temperature at foam and wall interface. (c) Total resistance imposed by the composite wall and (d) the rate of heat transfer through the wall.** **05**

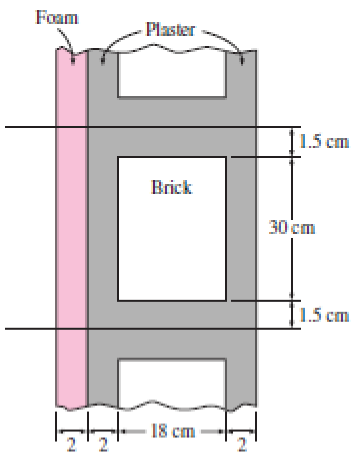

Fig. Q3C

4A. Steam in a heating system flows through tubes as shown in Fig. Q4A, 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 and efficiency of the fin is 95 %. Determine the increase in heat transfer from the tube per meter of its length as a result of adding fins and overall effectiveness of finned tube. **05**

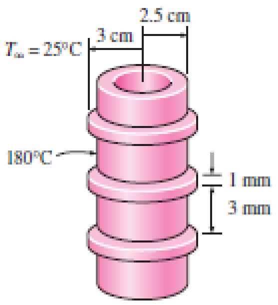

Figure Q4A

4B. A counter-flow double-pipe heat exchanger shown in Fig Q4B is to heat water from 20°C to 80°C at a rate of 1.2 kg/s. The heating is to be accomplished by geothermal water available at 160°C at a mass flow rate of 2 kg/s. The inner tube is thin-walled and has a diameter of 1.5 cm. If the overall heat transfer coefficient of the heat exchanger is 640 W/m^2 · °C, determine the length of the heat exchanger required to achieve the desired heating. **Note :- Take the specific heats of water and geothermal fluid to be 4.18 and 4.31 kJ/kg · °C, respectively.** **03**

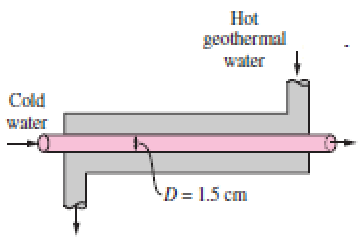

Figure Q 4B.

4C. How the thermal resistance due to fouling in a heat exchanger is accounted for and how do the fluid velocity and temperature affect fouling? **02**

5A. Why is the purpose of lead frame when mounting the chip on the carrier? What should be the desirable properties of PCB? **04**

5B. How do indirect liquid cooling system for electronics operates and support your answer with a schematic diagram of the indirect liquid cooling system. Based on what criteria, type of cooling of electronic system is decided? **06**