Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent institution of MAHE, Manipal)

III SEMESTER B.TECH. (MECHATRONICS ENGINEERING)

END SEMESTER EXAMINATIONS, DEC 2018

SUBJECT: ENGINEERING THERMODYNAMICS AND HEAT TRANSFER

[MTE 2103]

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Data not provided may be suitably assumed

1A. The working fluid, in a steady flow process flows at a rate of 220 kg/min. The fluid rejects 100 kJ/s passing through the system. The conditions of the fluid at inlet and outlet are given as: C_1 = 320 m/s, p_1 = 6.0 bar, u_1 = 2000 kJ/kg, v_1 = 0.36 m^3/kg and C_2 = 140m/s, p_2 = 1.2 bar, u_2 = 1400 kJ/kg, v_2 = 1.3 m^3/kg. The suffix 1 indicates the condition at inlet and 2 indicates at outlet of the system. Determine the power capacity of the system in MW. The change in potential energy may be neglected. **03**

1B. 1 kg of gaseous CO_2 contained in a closed system undergoes a reversible process at constant pressure. During this process 42 kJ of internal energy is decreased. Determine the Heat supplied/rejected and work done during the process. Take c_p = 840 J/kg°C and c_v = 600 J/kg°C. **04**

1C. 1 kg of ethane (perfect) gas is compressed from 1.1 bar, 27°C according to a law $pV^{1.3}$ = constant, until the pressure is 6.6 bar. Calculate **03**

a. Gas constant
b. Adiabatic index and
c. Heat flow to or from the cylinder walls.

2A. An ice plant working on a reversed Carnot cycle refrigerator produces 15 tonnes of ice per day. The ice is formed from water at 0°C and the formed ice is maintained at 0°C. **04**

The heat is rejected to the atmosphere at 25°C. The refrigerator is used to run the ice plant is coupled to a Carnot engine which absorbs heat from a source which is maintained at 220°C by burning liquid fuel of 44500 kJ/kg calorific value and rejects the heat to the atmosphere. Determine :

(i) Power developed by the engine

(ii) Fuel consumed per hour.

Take enthalpy of fusion of ice = 334.5 kJ/kg.

2B. Refrigerant 134a is the working fluid in an ideal vapor-compression refrigeration cycle that communicates thermally with a cold region at 0 ºC and a warm region at 26 ºC. Saturated vapor enters the compressor at 0 ºC and saturated liquid leaves the condenser at 26 ºC. The mass flow rate of the refrigerant is 0.08 kg/s. Determine (a) the compressor power, in kW, (b) the refrigeration capacity, in tons, (c) the coefficient of performance. **06**

3A An iron cube at a temperature of 400°C is dropped into an insulated bath containing 10 kg water at 25°C. The water finally reaches a temperature of 50°C at steady state. Given that the specific heat of water is equal to 4186 J/kg K. Calculate the entropy changes for the iron cube and the water. Is the process reversible? If so why? Specific heat of water, c_{pw} = 4186 J/kg K **04**

3B Aluminium square fins (0.5 mm X 0.5 mm) of 10 mm length are provided on the surface of an electronic semiconductor device to dissipate 1W of energy. The device surface temperature is 80°C while the surrounding temperature is 40°C. Calculate the number of fins required to dissipate the heat. Assume a fin with insulated tip. $k_{aluminium}$ =200 W/m°C and h=15 W/m^2 °C. **04**

3C Consider a sealed 20-cm-high electronic box (Fig 3C) whose base dimensions are 40 cm x 40 cm placed in a vacuum chamber. The emissivity of the outer surface of the box is 0.95. If the electronic components in the box dissipate a total of 100 W of power and the outer surface temperature of the box is not to exceed 55°C, determine the temperature at which the surrounding surfaces must be kept if this box is to be cooled by radiation alone. Assume the heat transfer from the bottom surface of the box to the stand to be negligible. **02**

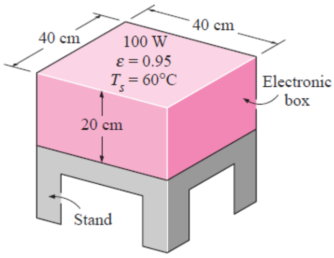

Fig 3C

4A. Steam at T_1 = 320°C flows in a cast iron pipe (k =80 W/m °C) whose inner and outer diameters are $D1$ = 5 cm and $D2$ =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_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. **05**

4B. A cold storage room has walls made of 220 mm of brick on the outside, 90 mm of plastic foam, and 16 mm of wood on the inside. The outside and inside air temperatures are 25°C and -3°C respectively. If the inside and outside heat transfer coefficients are 30 W/m°C and 11 W/m°C respectively and the thermal conductivities of brick foam and wood are 0.99, 0.022 and 0.17 W/m°C respectively, determine the rate of heat removal by refrigeration if the total wall area is 85 m^2. Also calculate the temperature at the inside surface of the brick. **05**

5A A counter-flow double-pipe heat exchanger 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. **04**

5B Consider a large plane wall of thickness L =0.4 m, thermal conductivity k =2.3 W/m °C, and surface area A = 20 m^2. The left side of the wall is maintained at a constant temperature of 80°C while the right side loses heat by convection to the surrounding air at 15°C with a heat transfer coefficient of 24 W/m^2 °C. Assuming constant thermal conductivity and no heat generation in the wall, (a) express the differential equation and **04**

the boundary conditions for steady one-dimensional heat conduction through the wall, (b) obtain a relation for the variation of temperature in the wall by solving the differential equation, and (c) evaluate the rate of heat transfer through the wall.

5C Explain the advantages and disadvantages of positioning fan at the inlet and at the outlet of an electronic enclosure. **02**