

MANIPAL INSTITUTE OF TECHNOLOGY MANIPAL

A Constituent Institution of Manipal University

III SEMESTER B.TECH. (MECHATRONICS ENGINEERING) END SEMESTER EXAMINATIONS, DEC 2017

SUBJECT: ENGINEERING THERMODYNAMICS AND HEAT TRANSFER

[MTE 2103]

REVISED CREDIT SYSTEM

Time: 3 Hours

MAX. MARKS: 50

Instructions to Candidates:

- ✤ Answer ALL the questions.
- 1A Calculate the thermal efficiency of the heat engine working on a Carnot cycle 05 between the temperature limits of 300 °C and 30 °C. To improve the thermal efficiency by 10%, what must be the new source temperature when the sink temperature is held at 30 °C.
- **1B** Prove that, for a Carnot engine, the efficiency can be given as **05** $\eta = \frac{T_2}{T_1}$, where T₁ is the source temperature and T₂ is the sink temperature.
- 2A Air at temperature 15°C passes through a heat exchanger at a velocity of 30 m/s
 05 where its temperature is raised by 800 °C. It then enters a turbine with a same velocity of 30 m/s and expands until the temperature falls to 650 °C. On leaving the turbine, the air is taken at a velocity of 60 m/s to a nozzle where it expands until the temperature has fallen to 500 °C. If the air flow rate is 2 kg/s, calculate
 - a. Rate of heat transfer to the air in the heat exchanger
 - b. Power output from turbine assuming no heat loss
 - c. Velocity at exit from the nozzle assuming no heat loss Take Cp= 1.005 kJ/kgK

2B Derive the equation for work done in an isothermal process**03**

2C Air expands inside a piston cylinder arrangement. Initial volume and pressures 02 are 0.2 m³ and 20 bar. An external force is applied to keep 750 kg piston in position which is open to the atmosphere of 100 kPa. When the external force is removed, the piston occupies 0.5 m³. Gas in the cylinder is kept at same temperature. Calculate the total amount of work done by the gas.

- **3B** Consider a large plane wall of thickness L = 0.2 m, thermal conductivity k = 1.2 **05** W/m · °C, and surface area $A = 15 \text{ m}^2$. The two sides of the wall are maintained at constant temperatures of $T_1 = 120^{\circ}$ C and $T_2 = 50^{\circ}$ C, respectively, as shown in Figure 1. Determine (a) the variation of temperature within the wall. (b) the value of temperature at x = 0.1 m and (c) the rate of heat conduction through the wall under steady conditions.
- **3C** In the given Figure Q3C, derive the individual resistances and the total **03** resistance posed by the composite wall.



Figure Q3C

- 4A What is critical radius of insulation? State the formula for sphere and cylinder 03 and explain with a graph to show heat transfer variation with the radius.
- **4B** A 3-mm-diameter and 5-m-long electric wire is tightly wrapped with a 2-mm thick plastic cover whose thermal conductivity is $k = 0.15 \text{ W/m} \cdot ^{\circ}\text{C}$. 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 $h = 12 \text{ W/m}^2 \cdot ^{\circ}\text{C}$, determine the temperature at the interface of the wire and the plastic cover in steady operation. Also determine whether doubling the thickness of the plastic cover will increase or decrease this interface temperature.
- 4C Draw the graph for Variation of fluid temperatures in a parallel flow heat 03 exchanger when one of the fluids condenses and in the separate graph when one of the fluids boils. A counter-flow double-pipe heat exchanger is to heat water from 20°C to 80°C. The heating is to be accomplished by geothermal water available at 160°C which get down to a temperature of 125 °C at the exit of heat exchanger. Calculate ΔT_{LMTD} for the heat exchanger.

Page 2 of 3

- 5A What are the different types of Fans used in electronic cooling systems and 05 What are the advantages and disadvantages of placing the cooling fan at the inlet or at the exit of an electronic box?
- 5B When do Heat frames are used in electronic cooling of circuit boards. Explain in detail and support your answer with schematic diagram of Conduction cooling of a printed circuit board with a heat frame.