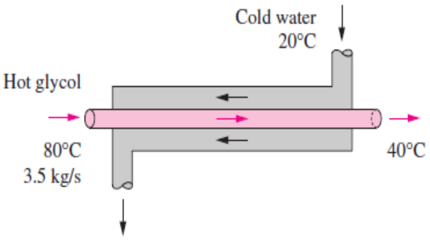
Reg. No.										

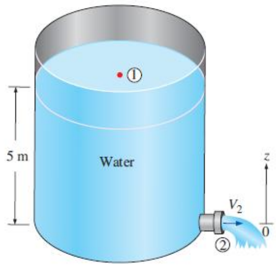
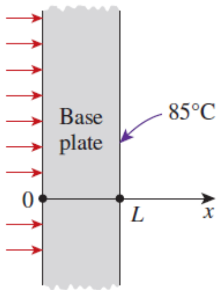
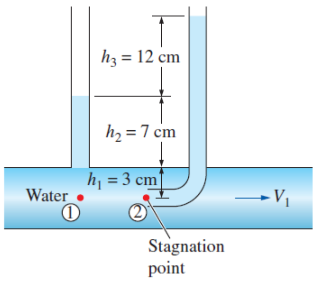
MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

DEPARTMENT OF MECHATRONICS
VI SEMESTER B.TECH. MECHATRONICS
END SEMESTER EXAMINATIONS, MAY 2022
SUBJECT: ENERGY AND HEAT TRANSFRE [MTE 3252]
(Date:)

Time: 3 Hours **MAX. MARKS: 50**

Instructions for the Candidates:
- Answer ALL questions.
- Data did not provide any, may be suitably assumed.
- Formula Book and Steam Tables are allowed.

Q. No		M	CO	PO	LO	BL
1A.	Determine (*a*) the rate of heat transfer, (*b*) the mass flow rate of water, and (*c*) the heat transfer surface area on the inner side of the tube for a double-pipe counter-flow heat exchanger to cool ethylene glycol (*Cp*= 2560 J/kg · °C) flowing at a rate of 3.5 kg/s from 80°C to 40°C by water (*Cp* = 4180 J/kg · °C) that enters at 20°C and leaves at 55°C. The overall heat transfer coefficient based on the inner surface area of the tube is 250 W/m² · °C. Refer Fig. 1A.  ***Fig. 1A***	**05**	**3**	**2**	**2**	**3**
1B.	Calculate the amount of heat transferred through an iron fin of length 50mm, width 100mm and thickness 5mm. Assume k = 210 W/m°. C and h= 42 W/m²°C for the material of the fin and the temperature at the base of the fin as 80°C. Also, determine the temperature of the fin at a distance of 2 mm from the base of the fin, if the atmosphere temperature is 20°C.	**03**	**3**	**2**	**2**	**3**
1C.	A large tank open to the atmosphere is filled with water to a height of 5 m from the outlet tap. A tap near the bottom of the tank is now opened, and water flows out from the smooth and rounded outlet. Determine the maximum water velocity at the outlet. Refer fig. 1C.	**02**	**4**	**2**	**2**	**3**

	 ***Fig. 1C***					
2A.	The base plate of an 800-W household iron with a thickness of $L = 0.6$ cm, base area of $A = 160$ cm^2, and thermal conductivity of $k = 20$ W/m· K. The inner surface of the base plate is subjected to uniform heat flux generated by the resistance heaters inside. When steady operating conditions are reached, the outer surface temperature of the plate is measured to be 85° C. Disregarding any heat loss through the upper part of the iron, (*a*) express the differential equation and the boundary conditions for steady one-dimensional heat conduction through the plate, (*b*) derive a relation for the variation of temperature in the base plate by solving the differential equation, and (*c*) determine the inner surface temperature. Refer fig. 2A.  ***Fig. 2A***	**05**	**2**	**2**	**2**	**3**
2B.	Determine the velocity at the center of the pipe for the mentioned water column heights for a piezometer and a pitot tube tapped into a horizontal water pipe to measure static and stagnation (static 1 dynamic) pressures. Refer fig. 2B.  ***Fig. 2B***	**03**	**4**	**2**	**2**	**3**
2C.	Air enters a nozzle steadily at 2.21 kg/m^3 and 20 m/s and leaves at 0.762 kg/m^3 and 150 m/s. If the inlet area of the nozzle is 60 cm^2, determine (*a*) the mass flow rate through the nozzle, and (*b*) the exit area of the nozzle.	**02**	**4**	**2**	**2**	**3**
3A.	A 30 cm diameter pipe, conveying water, branches into two pipes of diameters 20 cm and 15 cm respectively. If the average velocity in the 30 cm diameter pipe is 2.5 m/s, determine the discharge in this pipe. Also, determine the velocity in 15 cm pipe, if the average velocity in 20 cm pipe is 2m/s.	**05**	**5**	**2**	**2**	**3**

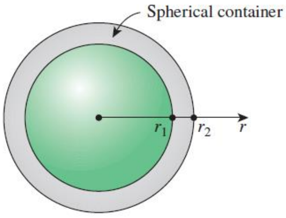
<table>
<tr><td>3B.</td><td>A spherical container has inner radius r_1, outer radius r_2, and thermal conductivity k. Determine the boundary condition on the inner surface of the container for steady one-dimensional conduction for the following cases: (a) specified temperature of 50° C, (b) specified heat flux of 30 W/ m^2 toward the centre, (c) convection to a medium at T_∞ with a heat transfer coefficient of h. Refer fig.3B


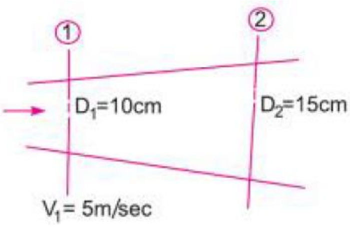
Fig. 3B</td><td>03</td><td>2</td><td>2</td><td>2</td><td>3</td></tr>
<tr><td>3C.</td><td>Determine the velocity at section 2 and discharge through the pipe if diameters of a pipe at the sections 1 and 2 are 10 cm and 15 cm and velocity of water flowing through a pipe at section 1 is 5 m/s respectively. Refer fig.3C.


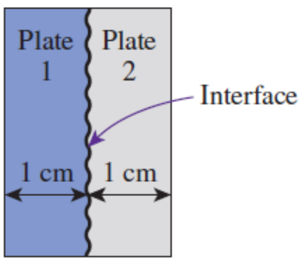
Fig. 3C</td><td>02</td><td>5</td><td>2</td><td>2</td><td>3</td></tr>
<tr><td>4A.</td><td>Determine the rate of heat supply from the 840°C source and rate of heat rejection to the 60°C sink for a heat pump working on the Carnot cycle taking in heat from a reservoir at 5°C and delivers heat to a reservoir at 60°C. The heat pump is driven by a reversible heat engine which takes in heat from a reservoir at 840°C and rejects heat to a reservoir at 60°C. The reversible heat engine also drives a machine that absorbs 30 kW. If the heat pump extracts 17 kJ/s from the 5°C reservoir.</td><td>05</td><td>1</td><td>2</td><td>2</td><td>3</td></tr>
<tr><td>4B.</td><td>The thermal contact conductance at the interface of two 1-cm-thick aluminum plates is measured to be 11,000 W/ m^2 ·K. Calculate the thickness of the aluminum plate whose thermal resistance is equal to the thermal resistance of the interface between the plates. Thermal conductivity = 237 W/m. K. Refer fig. 4B.


Fig. 4B</td><td>03</td><td>2</td><td>2</td><td>2</td><td>3</td></tr>
<tr><td>4C.</td><td>Calculate the dynamic viscosity of the fluid in between a fixed and moving plate, if the moving plate is of 2m x 2m dimension, moves at 40 cm/s and 0.25 mm distant apart from a fixed plate. The force required is 1 N.</td><td>02</td><td>4</td><td>2</td><td>2</td><td>3</td></tr>
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<tr><td>5A.</td><td>Determine the temperature at the interface of the wire and the plastic cover in steady operation for a 2-mm-diameter and 10-m-long electric wire tightly wrapped with a 1-mm-thick plastic cover of thermal conductivity 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 8 V along the wire. The insulated wire is exposed to a medium at T_∞ = 30°C with a heat transfer coefficient of 24 W/m² · °C. Also, determine if doubling the thickness of the plastic cover will increase or decrease the interface temperature. Refer fig. 5A.

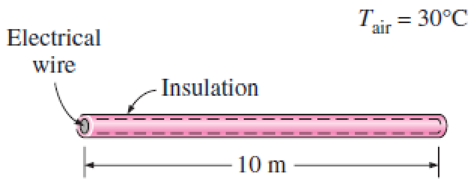

Fig. 5A</td><td>05</td><td>2</td><td>2</td><td>2</td><td>3</td></tr>
<tr><td>5B.</td><td>A 1.4-m-long, 0.2-cm-diameter electrical wire extends across a room that is maintained at 20° C. Heat is generated in the wire because of resistance heating, and the surface temperature of the wire is measured to be 240° C in steady operation. Also, the voltage drop and electric current through the wire are measured to be 110 V and 3 A, respectively. Disregarding any heat transfer by radiation, determine the convection heat transfer coefficient for heat transfer between the outer surface of the wire and the air in the room. Refer fig. 5B.

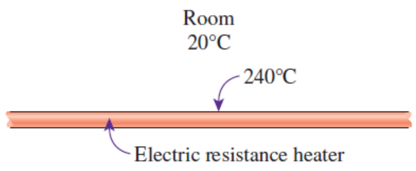

Fig. 5B</td><td>03</td><td>2</td><td>2</td><td>2</td><td>3</td></tr>
<tr><td>5C.</td><td>Two kg of water at 80°C are mixed adiabatically with 3 kg of water at 30°C in a constant pressure process of 1 atmosphere. Calculate the increase in the entropy of the total mass of water due to mixing process. (C_p of water = 4.187 kJ/kg K)</td><td>02</td><td>1</td><td>2</td><td>2</td><td>3</td></tr>
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