Reg. No.										

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

DEPARTMENT OF MECHATRONICS

VI SEMESTER B.TECH. MECHATRONICS

END SEMESTER EXAMINATION, MAY 2023

SUBJECT: ENERGY AND HEAT TRANSFER [MTE 3252]

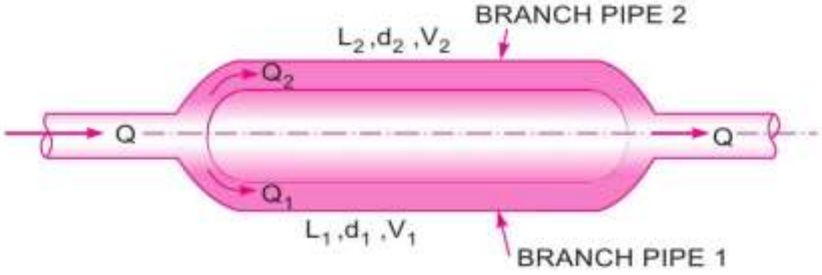
Time: 3 hours **Max. Marks: 50**

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed and justified.

Q. No	PROBLEM STATEMENT	M	CO	PO	LO	BL
1A.	Two Carnot engines A and B are connected in series between two thermal reservoirs maintained at 1000 K and 100 K respectively. Engine A receives 1680 kJ of heat from the high-temperature reservoir and rejects heat to the Carnot engine B. Engine B takes in heat rejected by engine A and rejects heat to the low-temperature reservoir. If engines A and B have equal thermal efficiencies, Determine (a) The heat rejected by engine B (b) The temperature at which heat is rejected by engine, A	**4**	**1**	**1,3**	**1,2**	**3**
1B.	Two ends of a copper rod (k = 380 W/(m-K)), 15 mm diameter and 300 mm long are connected to two walls, each maintained at 300°C. Air is blown across the rod with a heat transfer coefficient of 20 W/(m^2K). Air temperature is 40°C. Determine: (i) midpoint temperature of the rod (ii) net heat transfer to atmosphere.	**3**	**3**	**1,3**	**1,2**	**3**
1C.	The aluminium square fins (0.5 mm×0.5mm) of 10 mm length are provided on a surface of semiconductor electronic device to carry 1W of energy generated by electronic device. The temperature at the surface of the device should not exceed 80°C when surrounding temperature is 40°C. Taking the following data, Calculate the number of fins required to carry out above duty. Neglect the heat loss from the end of fins k (aluminium) = 200 W/m°C; h = 15 W/m^2°C.	**3**	**3**	**1,3**	**1,2**	**3**
2A.	A 0.8 m high, 1.5 m wide double pane window consists of two 4 mm thick layers of glass (*k* = 78 W/mK) and is separated by a 10 mm wide stagnant air space (*k* = 0.026 W/mK). The room is at 20°C and the outside air is at 10°C. The heat transfer coefficients are h_i = 10 and h_o = 40 W/m^2K. Determine (i) The rate of heat transfer through the window, (ii) the inside surface temperature	**4**	**2**	**1,3**	**1,2**	**3**
2B.	Water (C_p = 4.187 kJ/kg K) is heated at the rate of 1.4 kg/s from 40°C to 70°C by an oil (C_p = 1.9 kJ/kg K) entering at 110°C and leaving at 60°C in a counter flow heat exchanger. If U_o = 350 W/m^2 K, determine the surface area required.	**3**	**3**	**1,3**	**1,2**	**3**

2C.	In a parallel flow double-pipe heat exchanger water flows through the inner pipe and is heated from 20°C to 70°C. Oil flowing through the annulus is cooled from 200°C to 100°C. It is desired to cool the oil to a lower exit temperature by increasing the length of the heat exchanger. Determine the minimum temperature to which the oil may be cooled.	**3**	**3**	**1,3**	**1,2**	**3**
3A.	A 4 kg/s product stream from a distillation column is to be cooled by a 3 kg/s water stream in a counter-flow heat exchanger. The hot and cold stream inlet temperatures are 400K and 300K respectively, and the area of the exchanger is 30 m^2. If the overall heat transfer coefficient is estimated to be 820 W/m^2K, determine the product stream outlet temperature, if its specific heat is 2500 J/kg-K and the coolant outlet temperature using NTU Method.	**4**	**3**	**1,3**	**1,2**	**3**
3B.	In a pipe of 300 mm diameter and 800 m length an oil of specific gravity 0·8 is flowing at the rate of 0·45 m^3/s. Compute (i) Head lost due to friction, and (ii) Power required to maintain the flow. Take kinematic viscosity of oil as 0.3 stoke.	**3**	**6**	**1,3**	**1,2**	**3**
3C.	In a pipe of diameter 350 mm and length 75 m water is flowing at a velocity of 2.8 m/s. Compute the head lost due to friction using Darcy-Weisbach formula. Assume kinematic viscosity of water as 0.012 stoke.	**3**	**6**	**1,3**	**1,2**	**3**
4A.	Derive an expression for the velocity distribution for viscous flow through a circular pipe. Also sketch the velocity distribution and shear stress distribution across a section of the pipe.	**5**	**5**	**1,3**	**1,2**	**4**
4B.	Prove that the total head loss when pipes are connected in series sum of head loss in individual pipes.	**3**	**6**	**1,3**	**1,2**	**5**
4C.	Oil of absolute viscosity 1.5 poise and density 848.3 kg/m^3 flows through a 30 cm I.D. pipe. If the head loss in 3000 m length of pipe is 20 m, assuming a laminar flow, determine. **(i)** the velocity, **(ii)** Reynolds number.	**2**	**6**	**1,3**	**1,2**	**3**
5A.	An oil of viscosity 9 poise and specific gravity 0.9 is flowing through a horizontal pipe of 60 mm diameter. If the pressure drop in 100 m length of the pipe is 1800 kN/m^2, Determine: (i) The rate of flow of oil. (ii) The centerline velocity. (iii) The total frictional drag over 100 m length. (vi) The velocity gradient at the pipe wall. (v) The velocity and shear stress at 8 mm from the wall.	**5**	**5**	**1,3**	**1,2**	**3**
5B.	A main pipe divides into two parallel pipes which again forms one pipe as shown in Figure Q5B. The length and diameter for the first parallel pipe are 2000 m and 1.0 m respectively, while the length and diameter of 2nd parallel pipe are 2000 m and 0.8 m. Determine the rate of flow in each parallel pipe, if total flow in the main is 3.0 m^3/s. The co-efficient of friction for each parallel pipe is same and equal to 0.005.	**3**	**6**	**1,3**	**1,2**	**3**

	 **Figure Q5B**					
5C.	Compare between the hydraulic gradient line (H.G.L.) and energy gradient line (E.G.L.) for a flow of fluid in the pipe.	**2**	**5**	**1**	**1**	**5**