Reg. No.										

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

I SEMESTER M.TECH (TSES) END SEMESTER EXAMINATIONS, NOVEMBER 2018

SUBJECT: DESIGN OF THERMAL SYSTEMS [MME 5141]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- Use of Thermodynamic data hand book permitted

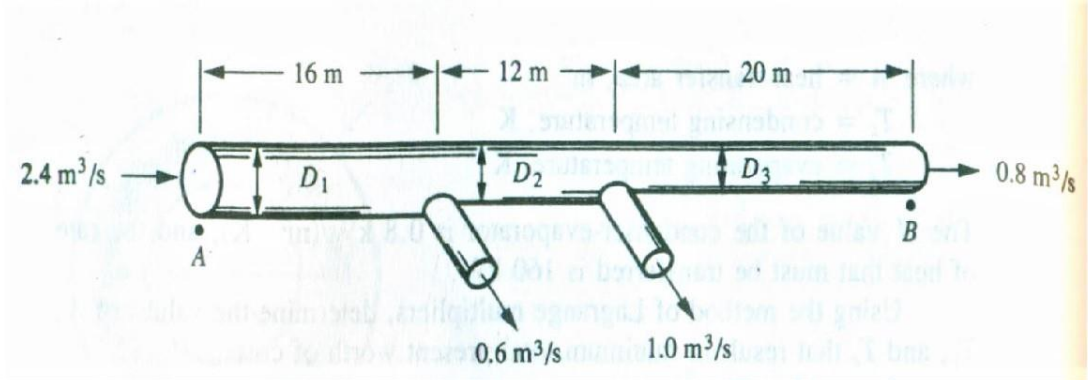
1A. Explain the different types of models used in design and optimization of thermal systems **03**

1B. Explain the terms (a) Payback period (b) Rate of return (c)Life cycle saving method (d)future worth factor **02**

1C. Using the method of Lagrange multiplier for constrained optimization determine the diameters of the circular duct in the duct system shown in Figure 1 so that static pressure drop between points A and B is minimum.

Quantity of sheet metal available is 60 m^2

Use friction factor of 0.2 and density of air as 1.2 kg/m^3



05

Figure 1

2A. Derive the equation $t_{1,o} = t_{1,i} - (t_{1,i} - t_{2,i})\frac{1-e^D}{\frac{W_1}{W_2}-e^D}$ for a counter flow heat exchanger with usual notations. **04**

2B. Three materials A, B and C of varying thicknesses are available for combining into a building wall. The characteristics and costs of the materials are as shown in the Table. Total thermal resistance of the wall must be 120 or greater and the total load bearing capacity must be 42 or greater. Minimum cost wall is sought. Use the simplex algorithm to determine the optimum thickness of each material.

Material	Thermal resistance, per cm thickness	Load bearing capacity, per cm	Cost per cm in dollars
A	30	7	8
B	20	2	4
C	10	6	3

06

3A. Design a simple steam power plant which is capable of developing 20 MW using burning of waste material for heat input and a local river for heat rejection. It is found that saturated temperature as high as 300°C could be achieved by the heat source and temperature in the river is restricted to 30°C. Consider 80% efficiency for the turbine. Also list the assumptions made. **05**

3B. Variable Z is to be expressed in the form of an equation

$$Z = ax + by + cxy$$

The following data points are available and a least square fit is desired. Determine the values of a, b and c

z	x	y
0.1	1	1
-0.9	1	2
2.0	2	2
-1.8	3	1

05

4A. In an electronic circuitry power source may be considered as a thin square with side dimension as L meters. It is desired to minimize the heat transfer from the surface of the power supply to the local surroundings. Heat transfer coefficient h is given by

$h = (2 + 10L^{0.5})T^{0.25}\,L^{-1}$

where T is the temperature difference. It is seen that strength of the bond that attaches the power supply behaves according to $L \times T = 5.6$. Calculate the minimum heat transfer rate, dimension L and temperature T by using Fibonacci search method. Take the range of temperature 100 - 175°C. Take n =6. **05**

4B. Operating point of a fan and a duct are to be determined. Equations for the two components are

$SP = 80 + 10.73Q^{\frac{9}{5}}$ and $Q = 15 - (73.5 \times 10^{-6})$ where SP = static pressure (pa) and Q is the volume flow rate (m^3/s). Use Newton Raphson's method to determine the operating point starting with the trial value of SP =200 Pa and Q =10 m^3/s. **05**

5A. A cooling pond serving a power plant is equipped with circulating pumps and sprays to enhance the rate of heat rejection from the pond. Pumps are to be operated so that heat rejection is accomplished with minimum pumping energy. On a particular day pond temperature is 28.5°C at 18.00 hours. Pond temperature is to be reduced to 21.5°C by 6.00 AM in the next morning. The rate of decrease of temperature of the pond water is a function of the temperature difference between the pond water and ambient wet bulb temperature as well as intensiveness of the pumping. Pumping energies during a 3-hour period are shown in the table. The ambient wet bulb temperatures at the beginning of 3-hour period are (18.00 25°C; 21.00, 23°C; 24.00, 21.5°C; 3.00, 20°C); Use dynamic programing to determine the pond water temperature at each 3 hour interval that results in minimum pumping energy.

Temperature difference at the at the start of 3.00 hr period	Drop in pond water temperature in 3 hour period in °C					
1.5	0	2	16	54	×	×
2		1	12	45	×	×
2.5		0	8	36	96	×
3			4	27	80	166
3.5			0	18	64	139
4				9	48	111
4.5				0	32	83
5					16	55
5.5					0	27
6						0

05

5B. Heat lost by a thermal system is given as hL^2T, where h is the heat transfer coefficient, L is the characteristic dimension and T is the temperature difference from the ambient. h is given by

$$h = 3\left(\frac{T^{\frac{1}{3}}}{L^{\frac{3}{2}}}\right) + 8.7\left(\frac{T^{\frac{1}{3}}}{L^{\frac{1}{2}}}\right).$$ It is given that temperature must not exceed $7.4L^{-\frac{3}{4}}$ .Using geometrical programing with constrained approach solve to determine the values of L, T and heat lost. **05**