Reg.No.										

MANIPAL INSTITUTE OF TECHNOLOGY

A Constituent Institute of Manipal University, Manipal

I SEMESTER M.TECH (TSES)

END SEMESTER EXAMINATION NOVEMBER 2016

SUBJECT: DESIGN OF THERMAL SYSTEMS (MME 5141)

REVISED CREDIT SYSTEM (24/11/2016)

ANSWER ANY FIVE FULL QUESTIONS

1A) Explain the different types of models for thermal design with examples. (05)

1B) In a system for providing hot water for industrial use heating unit has a power input of 150 kW and a thermal efficiency of $100(0.2+0.07HT^{0.5}-0.08H^2)$in percent where T is the operating temperature in degree centigrade and H is the height of the system. Rate of heat loss to the environment in kW is given by $0.15HT^{1.25}$. Formulate the optimization problem to maximize rate of energy supplied to the industry and obtain the optimum by using geometric programing. Also obtain the temperature and height of the system. (05)

2A) Convective heat transfer from a spherical reactor of diameter D and temperature T_s to a fluid at temperature T_a with a convective heat transfer coefficient h denoting T_s-T_a as θ, h is given by $h = 2 + 0.55\theta^{0.27} D^{-1.2}$. Also a constraint arises from strength considerations and is given by Dθ =75. Wishing to minimize the heat transfer from the sphere set up the objective function in terms of D and θ. Using lagrange method for constrained optimization obtain the values of D, θ , heat transfer rate and lagrange multiplier. (05)

2B) A power plant system needs pump for a suitable operation. Two types A and B are available. The applicable costs are given as

particulars	A (Rs)	B (Rs)
Initial cost	20000	30000
Annual maintenance cost	4000	2000
Refurbishing cost at the end of 4 years	3000	0
Annual saving	500	1000
Salvage value	500	3000

Useful life is 8 years for both A and B. Rate of interest is 9% compounded half yearly. Using life cycle method, determine which is a better acquisition? (05)

3A) Fuel consumption F of a vehicle is given in terms of x and y which characterize the combustion process and drag as $F = 10.5x^{1.5} + 6.2y^{0.7}$ with a constraint from the conservation laws as $x^{1.2}y^2 = 20$. Using hemstitching method solve the above constrained problem and determine the optimum values of x and y. Take initial guess in x as (05)

1.2 and assume uniform step size of 0.3 in y.

3B) Variation of Z on the two independent variables x and y are given by $Z = Cx^a y^b$ where C, a and b are constants. Table shows the variation of Z for different values of x and y. Using best fit method compute the values of C, a and b.

	Y1= 2.3	Y2 =3.5	Y3 =4.9
X1 =0.1	*12*	*25*	*64*
X2 =0.5	*18*	*37*	*93*
X3= 1.3	*23*	*54*	*116*

(05)

4A) Explain with an example how Fibonacci search method is used for optimization of thermal systems? (04)

4B) Figure 1 shows 4 heat Exchangers in series are each served by steam at a different temperature and heat water from 50 to 300°C. The sums of the first cost of the heat exchangers and present worth of the life time steam cost (in dollars) are shown in the table below. Use dynamic programing to determine the outlet temperature from each of the heat exchanger that results in the minimum present worth of costs.

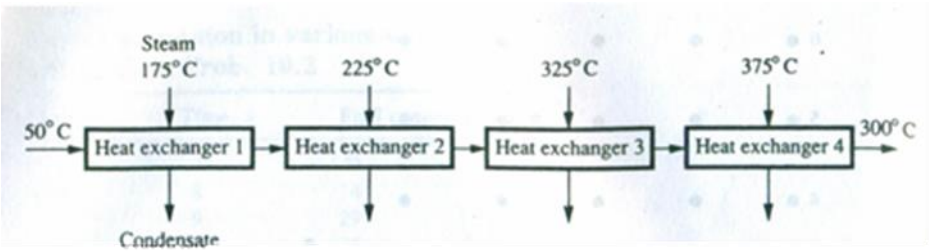

Figure 1

Heat exchanger	Inlet temperature(°C)	Outlet temperature (°C)					
		50	100	150	200	250	300
1	50	0	20.8	58			
2	50	0	23.1	62.6	132.3		
	100		0	36.1	93.6		
	150			0	62.8		
3	50	0	24.8	79.9	129.9	177	308.3
	100		0	41.1	94.3	141.7	266.7
	150			0	51.2	103	223.6
	200				0	57.6	176.4
4	50						372.4
	100						309.3
	150						243.7
	200						173.7
	250						94.4
	300						0

(06)

5A) To ventilate a factory building, 5 kg/s of factory air at a temperature of 27°C is exhausted. And an identical flow rate of outdoor air at a temperature of −12°C is introduced to take its place. To recover some of the heat of the exhaust air, heat exchangers are placed in the exhaust and ventilation air ducts as shown in the figure 2. 2 kg/s of water is pumped between the two heat exchangers.UA values of both the heat exchangers is 6.33 kW/K. what is the temperature of the air entering into the factory? (04)

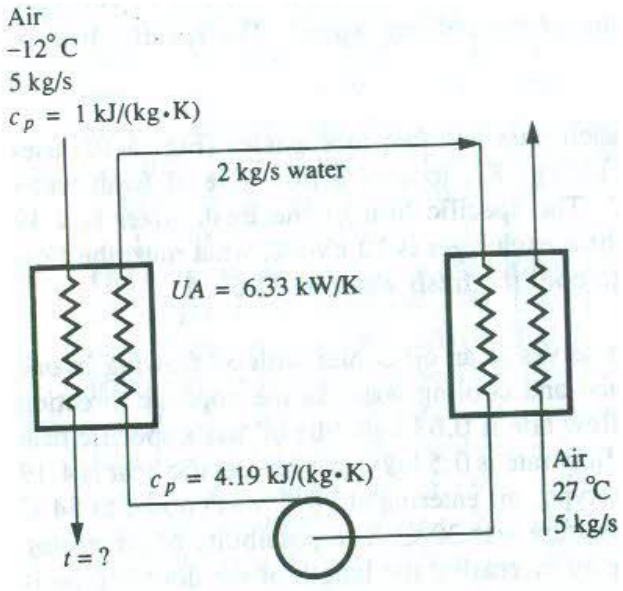

Figure 2

5B) A water pumping system consists of two parallel pumps drawing water from a lower reservoir and delivering it to another which is 40 m above. In addition to overcome the pressure difference due to elevation friction in the pipe is 7.2 w^2 where w is the combined flow rate in kg/s. Pressure flow rate characteristics of the two pumps are

ΔP (kPa) = $810-25w_1-3.75w_1^2$

ΔP (kPa) = $900-65w_2-30w_2^2$ where w_1 and w_2 are the flow rates through pump 1 and 2 respectively. Using newton Raphson's method simulate the system and find the values of w, w_1, w_2 and ΔP (06)

Assume trial values for w=5, w_1 =3, w_2 =1.5 and ΔP =750

6A) Explain the terms payback time and return on investment with examples (02)

6B) Discuss the advantages and disadvantages of successive substitution method over newton raphson's method (02)

6C) 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

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

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. (06)
