Reg.No.										

MANIPAL INSTITUTE OF TECHNOLOGY

A Constituent Institute of Manipal University, Manipal

I SEMESTER M.TECH (TSES)

END SEMESTER EXAMINATIONS NOVEMBER 2017

SUBJECT: DESIGN OF THERMAL SYSTEMS (MME 5141)

REVISED CREDIT SYSTEM

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.

1A) Explain the different steps involved in design and optimization of thermal systems. (04)

1B) In a condenser water enters at 20°C and steam enters as saturated vapor at 90°C and leaves as the condensate at the same temperature. The surface area of the heat exchanger is 2 m^2 and a total of 250 kW of energy is to be transferred in the heat exchanger. Overall heat transfer coefficient U is given by $U = \frac{m}{0.05+0.2m}$ where m is the mass flow rate in kg/s and U in kW/m^2K. Solve for 'm' by using Newton Raphson's method starting with a trial value of m =0.5 kg/s. (06)

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

2B) A furnace serving a certain steam generating plant is capable of burning coal, oil, and gas simultaneously. Heat release rate of furnace must be 2400 kW, which with 75% combustion efficiency of this furnace requires a combined thermal input rate in the fuel of 3200 kW. Ordinances in certain cities impose a limit on the average sulfur content of the fuel mixture and in the city where this plant is located the limit is 2% or less. The sulfur contents, cost and the heating values of the fuels are shown below. Using the simplex algorithm determine the combination of fuel rates that results in minimum cost and yet meets all the constraints

Fuel	Sulfur content (%)	Cost per Mega gram ($)	Heating Value(kJ/kg)
Coal	3.0	24	35,000
Oil	0.4	36	42,000
Gas	0.2	42	55,000

(06)

3A) 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)

3B) Variation of volume flow rate Q in an open channel depends on down ward slope S and hydraulic radius R as Q =C R^aS^b where C, a and b are constants. Table shows the variation of Q for different values of S and R. Using best fit method compute the values of C, a and b.

	R(m) 0.5	1.0	1.5	2.0
S=0.0015	1.91	3.1	4.11	5.03
S=0.005	3.48	6.66	7.51	9.19
S=0.009	4.67	7.59	10.08	12.33

(05)

4A) 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	50000	80000
Annual maintenance cost	11000	15000
Annual income	26000	36000
Salvage value	10000	20000

Useful life is 5 years for both A and B. Considering a tax rate of 50% and using straight line depreciation method for depreciation, calculate the rate of return for the above cases. (05)

4B) In a two component system cost is given by U =$2x^2$+5y where x and y represent the specifications of two components. These variables are linked by the mass conservation to yield the constraint as G = xy-12. Solve this optimization problem to find the minimum cost using hemstitching method with a constrained approach. Take initial value of x as 2 and step size in y as 0.3. Keep x constant during reaching constraint. (05)

5A) A truck climbs a hill that consists of three sections. The fuel consumption in each section is a function of the time required for the distance in the section to be covered as shown in the table. A total of 25 s is available for the climb of the hill. Use dynamic programing to determine the time allocation to each section that results in minimum total fuel consumption.

Fuel consumption in various sections of hill climb

Section	Time (s)	Fuel consumption(g)
A-B	7	40
	8	34
	9	29
	10	25
B-C	7	61
	8	52
	9	45
	10	38
C-D	7	49
	8	41
	9	35
	10	30

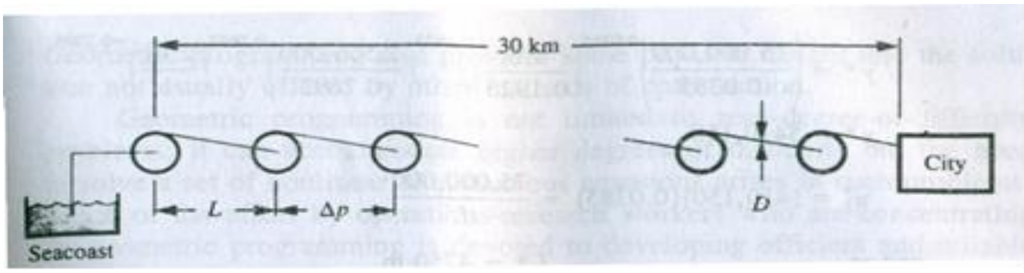
(05)

5B) A water pipeline extends 30 km across a desert from a desalination plant at the sea coast to a city. Pipeline as shown in figure 5B conveys 0.16 m^3/s of water. The first cost of the pipe line are

Cost of each pump = $2500+0.00032\Delta P^{1.2}$ dollars

Cost of 30 km of the pipe = $2{,}560{,}000D^{1.5}$ dollars, ΔP = pressure drop in each pipe section in Pa, D= diameter in m.

Assume a friction factor of 0.02. Use geometric programing on a constrained objective function to select the number of pumps and the pipe diameter that results in the minimum total first cost of the system.



(05)

Figure 5B
