Major

MCL 823, Thermal Design

Friday, 06.05.2016, 3-30 p.m. – 5-30 p.m., Room No. LH111

(Open note exam. No books are allowed. Photocopy of slides are not allowed)

Time =2 hours — Maximum Marks = 60

1. Estimate the liquid flow rate and heat transport capability of a simple water heat pipe operating at 100 °C having a (wrapped screen) wick of two layers of 300 mesh/inch against the inside wall. The heat pipe is 30 cm long and has a bore of 15 cm diameter. It is operating at an inclination to the horizontal of 30°, with the evaporator above the condenser.

   Neglect vapour pressure drop. Water properties at 100 °C are: enthalpy of evaporation = 2258 kJ/kg, density = 958 kg/m^3, dynamic viscosity = 0.283 x 10^{-3} Ns/m^2, surface tension = 58.9 x 10^{-3} N/m. Assume wire diameter to be of 0.004 cm. ***(12 marks)***

2. The total pressure drop from point 1 to point 5 in the multi-branch duct system shown in Fig. below is to be 500 Pa. The table shown below presents the costs for various duct sizes in each of the sections as a function of the pressure drop in the section. Use dynamic programming to determine the pressure drop in each section that results in the minimum total cost of the system. ***(15 marks)***

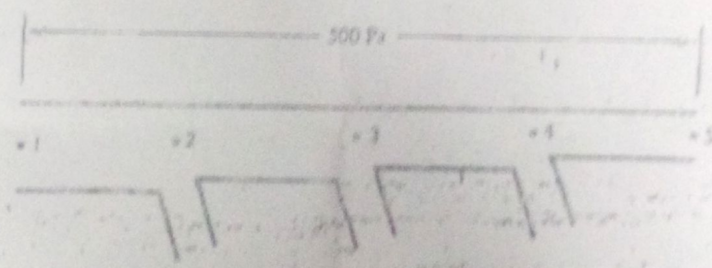

Table 1

Section	Path	Pressure drop, Pa	Cost, Rs
1-2	A	100	2220
	B	150	2050
	C	200	1930
2-3	A	100	1800
	B	150	1660
	C	200	1570
3-4	A	100	1350
	B	150	1250
	C	200	1170
4-5	A	100	930
	B	150	860
	C	200	810

3. The total cost of a rectangular building shell (like a block) and the land it occupies is to be minimized for a building that must have a volume of 14000 m^3. The following cost per square meter apply: land = Rs. 90000, roof = Rs. 14000, floor = Rs. 8000 and wall = Rs. 11000. Set up the problem as one of constrained optimization and determine the minimum cost and optimal dimensions of the building. ***(10 marks)***

4. The heat transfer Q from a spherical reactor of diameter D is given by the equation $Q = h.T.A$, where h is the heat transfer coefficient, T is the temperature difference from the ambient, and A ($=\pi D^2$) the surface area of the sphere. Here, h is given by the expression $h = 2 + 0.5T^{0.2} D^{-1}$. A constraint also arises from material limitations as $DT = 20$. Set up the optimization problem for **minimizing** the total heat transfer Q. Using the hemstitching method, obtain the optimum. Start at the initial point $T = 50$, with step size in T equal to 10. Show only two steps with two consecutive calculations of objective function Q. ***(13 marks)***

5. Find maximum of $(2x^2 + 3/x)$ using genetic algorithm within the range of x between [1, 31].
   - Take the following 4 randomly chosen 5 bit population given as: Initialization: 01110, 11010, 10100, 10101
   - Cross over: Mate the 1st and 3rd individual with crossover point at 3rd place (count from left hand side) and 2nd and 4th individual with crossover point at 4th place.
   - Mutation: You can neglect the mutation operation.

   Show that the after the crossover operation, the average value of the population improves than the average value of the initial population given.

(10 marks)

Table 4.2 Wick Permeability for Several Wick Structures [5]

Structure	K	Data
Circular cylinder (artery or tunnel wick)	$r^2/8$	r = radius of liquid flow passage
Open rectangular grooves	$2\varepsilon\,(r_{h,l})^2/(f_l\,\mathrm{Re}_l)$	ε = wick porosity ω = groove width s = groove pitch δ = groove depth $r_{h,l} = 2\omega\delta/(\omega + 2\delta)$
Circular annular wick	$2\,(r_{h,l})^2/(f_l\,\mathrm{Re}_l)$	$r_{h,l} = r_1 - r_2$
Wrapped screen wick	$\dfrac{d_w^2\varepsilon^3}{122\,(1-\varepsilon)^2}$	d_w = wire diameter in inch $\varepsilon = 1 - (\pi N d_w/4)$ N = mesh number per inch ε = porosity (ratio of pore volume to total volume)