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# MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

*(A constituent unit of MAHE, Manipal)*

**I SEMESTER M. TECH (TSES) END SEMESTER MAKE-UP**

**EXAMINATIONS, DECEMBER 2018**

SUBJECT: DESIGN OF THERMAL SYSTEMS [MME 5141]

**REVISED CREDIT SYSTEM**

Time: 3 Hours MAX.MARKS: 50

**Instructions to Candidates:**

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

**1A.** Explain the different steps involved in the design and optimization procedure of any thermal system **05**

**1B.** 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**

**2A.** 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**

**2B** An experimental study is performed in a plastic screw extruder along with a die to determine the relationship between mass flow rate m and the pressure difference P. The relationship for the die is found to be

$m = 0.5P^{0.5}$ and the screw extruder is $P = 2 + 3.5m^{1.4} - 5m^{2.2}$. Simulate the system using Newton Raphson's method assuming initial guess of m= P= 0.25. **05**

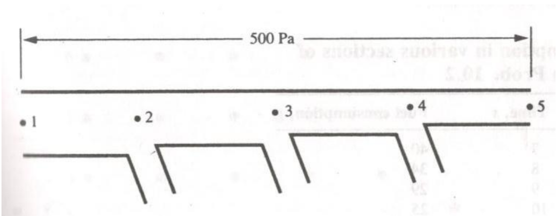
**3A.** Compute the constants in the equation $y = a_0 + a_1 x + a_2 x^2$ to provide a best fit in the sense of least squares for (1, 9.8), (3, 13),(6,9.1) and (8,0.6). Find y when x =7 **05**

**3B.** A power plant system needs machinery for a suitable operation. Two types A and B are available. The applicable costs are given as in the table.

| 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 |
| Annual tax | 1250 | 1370 |

Useful life is 8 years for A and 6 years for B. Rate of interest is 9% compounded quarterly. Using annual cost method, determine which is a better acquisition? **05**

**4A.** Total pressure drop from point 1 to point 5 in the multi branch duct system in the figure is to be 500 Pa. Table below presents the costs for various duct sizes in each of the section as a function of the pressure drop in the section. Use dynamic programming to determine the pressure drop in each section resulting in the minimum total cost of the system.




| Section | Pressure drop (Pa) | Cost (dollars) |
|---|---|---|
| 1-2 | 50 | 256 |
| | 100 | 222 |
| | 150 | 205 |
| | 200 | 193 |
| 2-3 | 50 | 210 |
| | 100 | 180 |
| | 150 | 166 |
| | 200 | 157 |
| 3-4 | 50 | 149 |
| | 100 | 135 |
| | 150 | 125 |
| | 200 | 117 |
| 4-5 | 50 | 106 |
| | 100 | 93 |
| | 150 | 86 |
| | 200 | 81 |

**05**

**4B.** A hydraulic power system must provide 300W of power and cost can be expressed as a function of volume flow rate Q ($m^3$/s)and pressure build up $\Delta P$ as cost $=1200Q^{0.4}\sqrt{10+(\Delta P \times 10^{-4})}$ dollars. Using geometrical programming find the minimum cost, pressure build up and volume flow rate required? **05**

**5A.** A food processing firm is planning construction of a plant that could manufacture a combination of three frozen food products, pot pies,TV dinners and pizzas. The investment cost consists of plant costs and machinery costsand the credit rating of the firm will permit loans of $4.8 million or less for the building construction and$1.6 million or less for the machinery. The building and machinery costs for each of the proposed products are

| Food products | Building cost($) | Machinery cost($) |
|---|---|---|
| Pot pies | $600{,}000x_1$ | $100{,}000x_1$ |
| TV dinners | $500{,}000x_2$ | $400{,}000x_2$ |
| Pizzas | $400{,}000x_3$ | $200{,}000x_3$ |

Where $x_1$, $x_2$ and $x_3$ represent the hourly production rate of pot pies,TV dinners and pizzas respectively in thousands of units. The hourly profit from the manufacture of each of the products in $ is $25x_1$, $30x_2$ and $40x_3$. Use linear programming method and determine the optimal values of $x_1$, $x_2$ $x_3$ and the hourly profit. **05**

**5B.** Fuel consumption F of a vehicle is given in terms of x and y which characterizes 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 1.2 and assume uniform step size of 0.3 in y. **05**