**Seat No.: _____** **Enrolment No._____**

# GUJARAT TECHNOLOGICAL UNIVERSITY

## ME Semester –III Examination Dec. - 2011

**Subject code: 730801** **Date: 05/12/2011**
**Subject Name: Engineering Optimization**
**Time: 10.30 am – 01.00 pm** **Total Marks: 70**

**Instructions:**

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 (a) (i)Define Constrained and Unconstrained optimization problems. 04
(ii) Define objective function and design constraints. 03

(b) The step-cone pulley shown in Fig.1 is to be designed for transmitting a power of at least 0.75 hp.The speed of input shaft is 350 r.p.m. and the output speed requirements are 750,450,250,150 rpm for a fixed centre distance of "a" between the input and output shafts. The tension on the tight side of the belt is to be kept more than twice that on the slack side. The thickness of the belt is "t" and the coefficient of friction between the belt and the pulley is $\mu$.Formulate the problem of finding the width and diameters of the steps for minimum weight. 07

Q.2 (a) Fig.2 shows two frictionless rigid bodies (carts) A and B connected by three linear elastic springs having springs constants $k_1,k_2,k_3$. The springs are at their natural positions when the applied force P is zero. Find the displacements $x_1$ and $x_2$ under the force P by using the principle of minimum potential energy. Take the problem as multivariable optimization with no constraints. 07

(b) A beam of uniform rectangular cross-section is to be cut from a log having a circular cross-section of diameter 2a. The beam has to be used as a cantilever beam (the length is fixed) to carry a concentrated load at the free end. Find the dimensions of the beam that correspond to the maximum tensile (bending) stress carrying capacity. 07

OR

(b) Find the dimensions of a cylindrical tin (with top and bottom) made up of sheet metal to maximize its volume such that the total surface area is equal to $A_o = 24\pi$. Use Lagrange multipliers method. 07

Q.3 (a) Minimize $f(x_1, x_2) = (x_1 - 1)^2 - x_2^2$ 07

subject to

$g_1(x_1, x_2) = x_1^3 - 2x_2 \leq 0$

$g_2(x_1, x_2) = x_1^3 + 2x_2 \leq 0$

Determine whether the constraint qualification and the Kuhn-Tucker conditions are satisfied at the optimum point.

(b) Find the minimum of $f = \lambda^5 - 5\lambda^3 - 20\lambda + 5$ by the Quadratic interpolation method with an initial step size 0.5 and starting value of $\lambda=0$. Take two iterations. 07

OR

Q.3 (a) Minimize the function $f(x) = 0.65 - [0.75/(1+x^2)] - 0.65 \times \tan^{-1}(1/x)$ using the golden section method with n = 6. 07

(b) Explain random search methods for unconstrained minimization problem 07

Q.4 (a) Minimize $f(x_1, x_2) = x_1 - x_2 + 2x_1^2 + 2x_1x_2 + x_2^2$ by using Hooke and Jeeves' pattern search method. Take the starting point $X_1 = \begin{Bmatrix} 0 \\ 0 \end{Bmatrix}$ and $\Delta x_1 = \Delta x_2 = 0.8$ and $\varepsilon = 0.1$ 07

(b) Explain exterior penalty function method of optimization. 07

OR

Q.4 (a) Explain interior penalty function method of optimization. 07

(b) Minimize $f(x_1, x_2) = x_1 - x_2 + 2x_1^2 + 2x_1x_2 + x_2^2$ starting from the point $X_1 = \begin{Bmatrix} 0 \\ 0 \end{Bmatrix}$ using steepest descent method(Gradient search method) Three iterations are required. 07

Q.5 (a) Explain in brief the differences and similarities between genetic algorithms and traditional methods. 07

(b) Solve the problem as stochastic geometric programming problem. 07

Design a helical spring for minimum weight subject to a constraint on the shear stress ($\tau$) induced in the spring under a compressive load P.The data is as under.

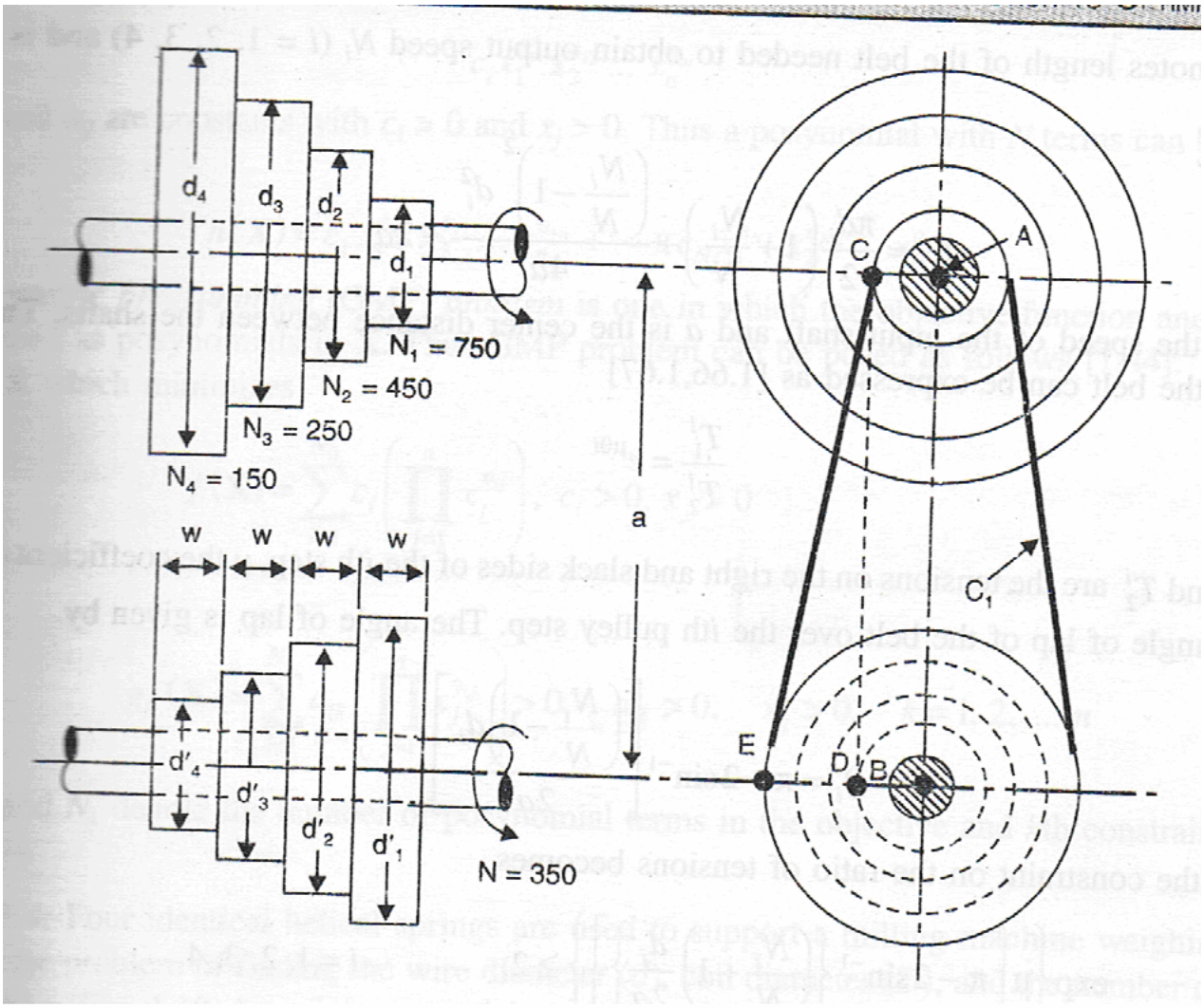
$\tau_{max} = 0.306 \times 10^9$ Pa, $\delta = 0.02$ m, $\rho = 78{,}000$ N/m$^3$, Q = 2

OR

Q.5 (a) Formulate the problem of minimum weight design of a helical spring under axial load as a geometric programming problem. Consider constraints on the shear stress, natural frequency, and buckling of the spring. 07

(b) Stating working principle of genetic algorithms, explain three operators of the same. 07

**Fig.1.** Step-cone pulley



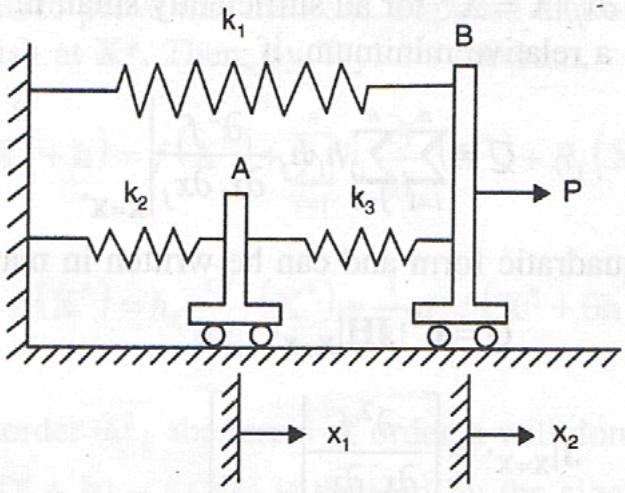




**Fig.2.** Spring-cart system