M.E. (EE) 2nd semester Final, Examination , 2012
Subject : Optimal Control Systems- I
EE 1002

Full Marks: 100 **Time: 3 Hrs**

i) Answer any four questions
ii) Questions are of equal value
iii) Credit will be given to brief and to the point answers

1. a) In Calculus of Variations derive the necessary conditions obeyed by a function $y(x)$ in order to attain an extremum for the functional, $J=\int_a^b F\{x;y(x);y'(x)\}dx$, symbols having their usual significance. What are the assumptions made?

b) When is a matrix positive definite? Test whether the matrix $A=\begin{bmatrix} 2 & -1 \\ -1 & 2 \end{bmatrix}$ is positive definite or not.

[19+6]

2. a) Find the optimum current and velocity profiles of a separately excited d. c. motor, used for excavation loads, in a way such that the armature losses are kept constant while the total angle traversed in a given time is maximized. Assume initial and final velocities to be zero.

b) What is a convex optimization problem? What is a "feasible set"?

[19+6]

3. a) Derive an expression of the optimal control input in the Linear Quadratic Regulator control in terms of the adjoint variable.

b) Check whether the following functions are convex or not:

i) X^{-1} for $X \in \Re_{++}$, and ii) e^{aX} on $\Re$, for any $a \in \Re, X \in \Re$.

[15+10]

4.a) Determine the optimal curves $y(x)$ and $z(x)$ for the performance index:

$$J=\int_0^{\frac{\pi}{2}}\{\dot{y}^2(x)+\dot{z}^2(x)+2y(x)z(x)\}dx \text{ subject to } y(0)=0; z(0)=0; y(\frac{\pi}{2})=-1; z(\frac{\pi}{2})=1.$$

b) With an example show that the problem of 'regulating' any arbitrary state to a desired nonzero state may be cast as a problem of bringing the nonzero states to zero.

[20+5]

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5. a) Write the dynamic equations of the closed loop system under Linear Quadratic Regulator control.

b) Examine the extremums of the functional:

$$J=\int_0^2 (xy' + y'^2)dx \text{, subject to } y(0)=0; y(2)=1.$$

[5+20]

6. a) Briefly explain the significance of the Sensitivity function in a SISO feedback loop.

b) Using Conjugate Gradient Method, find the minimum of the function:

$f(x_1,x_2)=4x_1^{\,2}+3x_2^{\,2}-4x_1x_2+x_1$, from the starting point $\begin{bmatrix}0\\0\end{bmatrix}$.

[8+17]

7. a) State the properties of the Linear Time Invariant LQR control.
b) Classify 'Uncertainty', giving examples.

c) What is an 'LMI'? When is it 'feasible'?

[12+7+6]