OPTIMAL CONTROL SYSTEMS (SEMESTER - 8)

CS/B.TECH (EE)/SEM-8/EE-801E/09

1. .....
Signature of Invigilator

2. .....
Signature of the Officer-in-Charge

Reg. No. | | | | | | | | | | | | | | |

Roll No. of the Candidate | | | | | | | | | | | | | | |

CS/B.TECH (EE)/SEM-8/EE-801E/09

ENGINEERING & MANAGEMENT EXAMINATIONS, APRIL – 2009

OPTIMAL CONTROL SYSTEMS (SEMESTER - 8)

Time : 3 Hours] [Full Marks : 70

INSTRUCTIONS TO THE CANDIDATES :

1. This Booklet is a Question-cum-Answer Booklet. The Booklet consists of **32 pages**. The questions of this concerned subject commence from Page No. 3.
2. a) In **Group – A**, Questions are of Multiple Choice type. You have to write the correct choice in the box provided **against each question**.
   b) For **Groups – B** & **C** you have to answer the questions in the space provided marked 'Answer Sheet'. Questions of **Group – B** are Short answer type. Questions of **Group – C** are Long answer type. Write on both sides of the paper.
3. **Fill in your Roll No. in the box** provided as in your Admit Card before answering the questions.
4. Read the instructions given inside carefully before answering.
5. You should not forget to write the corresponding question numbers while answering.
6. Do not write your name or put any special mark in the booklet that may disclose your identity, which will render you liable to disqualification. Any candidate found copying will be subject to Disciplinary Action under the relevant rules.
7. **Use of Mobile Phone and Programmable Calculator is totally prohibited in the examination hall.**
8. You should return the booklet to the invigilator at the end of the examination and should not take any page of this booklet with you outside the examination hall, **which will lead to disqualification**.
9. Rough work, if necessary is to be done in this booklet only and cross it through.

No additional sheets are to be used and no loose paper will be provided

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FOR OFFICE USE / EVALUATION ONLY

Marks Obtained

	Group – A										Group – B			Group – C			***Total Marks***	***Examiner's Signature***
Question Number																		
Marks Obtained																		

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Head-Examiner/Co-Ordinator/Scrutineer

8850-E/F (25/04)

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GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

i) Optimal control strategy is applicable for

a) linear continuous time varying application

b) linear discrete time invariant systems

c) continuous or discrete, SISO or MIMO non-linear applications

d) all of these. ☐

ii) In case of optimal design of non-linear and time-varying devices, the performance index will be

a) $J = \int_0^\infty [\, e^2(t) + \lambda\, u^2(t)\,]\ dt$

b) $J = \int_0^\infty [\, e(t) + \lambda\, u(t)\,]\, dt$

c) $J = \int_0^\infty [\, e^2(t)\,]\ dt$

d) $J = \int_0^\infty [\, e(t) + u(t)\,]\, dt.$ ☐

iii) The extremal of the minimum length problem is

a) parabola b) sphere

c) point d) straight line. ☐

iv) For stable matrix, the eigenvalues should have

a) negative real part b) negative imaginary part

c) positive imaginary part d) positive real part. ☐

v) In the case of output regulator problem

a) it is a special case of tracking problem in which $r(t) = 0$

b) it is a special case of state regulator problem in which $r(t) = 0$

c) it is a special case of tracking problem in which $r(t) \neq 0$

d) none of these. ☐

vi) The sufficient condition for objective function J to be minimum in parameter optimization is

a) the Hessian matrix H is symmetric and positive semi-definite

b) the Hessian matrix H is symemtric and positive definite

c) the Hessian matrix H is negative definite

d) the Hessian matrix H is negative semi-definite. ☐

vii) For minimum energy problem, the performance index is

a) $\int_0^{t_f} u(t)\,dt$ b) $\int_0^{t_f} u^2(t)\,dt$

c) $\int_0^{t_f} u^3(t)\,dt$ d) none of these. ☐

viii) Condition for relative maximum and relative minimum of functions are

a) $\Delta f = f(q) - f(q^*) \leq 0$ & $\Delta f = f(q) - f(q^*) \geq 0$

b) $\Delta f = f(q) - f(q^*) \geq 0$ & $\Delta f = f(q) - f(q^*) \leq 0$

c) $\Delta f = f(q^*) - f(q) \geq 0$ & $\Delta f = f(q^*) - f(q) \leq 0$

d) none of these.

ix) The principle of optimality converts

a) N single stage decision process into N stage decision process

b) N stage decision process into N single stage decision process

c) N single stage decision process into $(N + 1)$ stage decision process

d) N single stage decision process into $(N - 1)$ stage decision process.

x) The Steepest Descent Technique is a subclassification of

a) classical optimization b) linear programming

c) non-linear programming d) stochastic programming.

xi) Minimization of function can be solved by Fletcher-Powell method. It requires

a) derivative of the function b) integration of the function

c) square of the function d) root of the function.

xii) If the quadratic form of a matrix A is

$10x_1^2 + 4x_2^2 + x_3^2 + 2x_1 x_2 - 2x_2 x_3 - 4x_1 x_3$,

then the matrix A is

a) positive definite b) positive semi-definite

c) negative definite d) none of these.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. a) What is a state regulator ?

   b) For infinite time state regulator problem, formulate the performance index.

   2 + 3

3. For the system given in figure 1 below, compute the value of K, that minimizes ISE for the unit step input.

   dia

4. Write down the flow-chart for solving an unconstrained optimal problem by Fletcher-Powell method.

5. a) What is the difference between parameter optimization and optimal control problem ?

   b) What are the steps involved in the design of a control system based on parameter otimization ? 2 + 3

6. Consider the model of a dynamic system $\dot{x} = 2x + u$ along with the associated performance index $J = \int_0^\infty (x^2 + ru^2) \, dt$. Find the value of r such that the optimal closed loop system has its pole at -3.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following questions. 3 × 15 = 45

7. Consider the schematic of an armature controlled DC motor given in the figure 2 below, where the system parameters are $R_a = 2\ \Omega$, $L \approx OH$, $K_b = 2$ V/rad/sec and $K_i = 2$ Nm/A and the equivalent moment of inertia referred to the motor shaft is $I_{eq} = 1$ kg-m^2. The friction is assumed to be negligibe.

dia

a) Construct the first order differential equation modeling of the DC motor.

b) Use the Hamilton-Jacobi-Bellman equation to find the optimal state feedback.

7 + 8

8. The regulator shown below contains a plant that is described by

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

and has a performance index $J = \int_0^\infty \left[x^T \begin{bmatrix} 2 & 0 \\ 1 & 0 \end{bmatrix} x + u^2 \right] dt$

dia

Determine :

a) the Riccoti matrix P

b) the state feedback matrix K

c) the closed loop eigenvalues.

9. a) What are the factors on which the dynamic programming solution is based ?

b) Describe the principle which reduces an N variable mulistage decision process into an N signle stage decision process.

c) Develop a general algorithm for the dynamic programming technique. 3 + 8 + 4

10. a) Derive the Euler-Lagrang equation of variational calculus.

b) How can the Steepest Descent Method solve a two-point boundary problem ? Explain with the help of an algorithm. 8 + 7

11. a) Define the following terms :

i) Minimum time

ii) Minimum energy

iii) Minimum fuel problem.

b) What is an output regulator ?

c) Explain the Mayer and Bolza problems of variational calculus. 6 + 3 + 6

END