MECHANICAL ENGINEERING DEPARTMENT
MOTILAL NEHRU NATIONAL INSTITUTE OF TECHNOLOGY ALLAHABAD

End Semester Examination (2016)

B. Tech. IV Semester (Mechanical & Production)

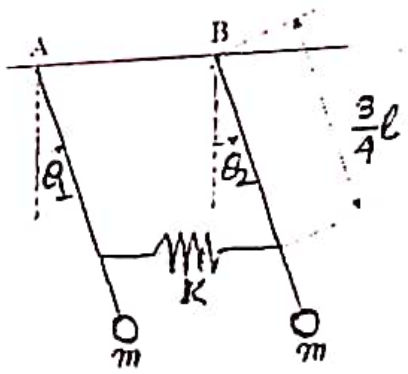
Automatic Control (ME-1401)

Time: 3 Hours **Max. Marks: 60**

NOTE: Attempt any six questions. Assume additional data suitably, if required.

1. (a) Indicate the suitability of state-space method with respect to the transfer-function method. 2

(b) Obtain the state space representation for the double pendulum system shown in figure. Assume the displacement angles of the pendulums are small enough to ensure that the spring is always horizontal. The pendulum rods are taken to be massless and of length l. The outputs of interest are angle of rotations of both pendulums from initial positions. 8



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2. (a) What do you understand by transfer function of a control system? In a system with two inputs and two outputs, how will you define the transfer function(s)? 2

(b) Find the state transition matrix for the linear time-invariant system

$$\dot{X}(t) = AX(t) + BU(t),\ A = \begin{bmatrix} -1 & 1 \\ 0 & -2 \end{bmatrix},\ B = \begin{bmatrix} 0 \\ 1 \end{bmatrix},\ X(0) = \begin{Bmatrix} -1 \\ 0 \end{Bmatrix}$$

Also determine the states $X(t)$ for $t \geq 0$ when the input to the system is unit step input. 8

(10)

3. The open-loop transfer function of a feedback system with unity feed-back is G(s). Sketch the root locus of the characteristic equation for positive value of K if

a. $G(s)=K(s+1)/(s^2+2s+2)$ 3

b. $G(s)=(s+1)/s(s+K)$ 5

c. Also indicate the range of K for which the systems (a) and (b) above are stable. 2

(10)

4. (a) What is Derivative Control? What is the effect of Proportional-Derivative control on the time-response characteristics of the feed-back control system? 2

(b) The open loop transfer function of the uncompensated system is given by $G(s)=K/\{s(s+1)(s+4)\}$. The system is now required to be compensated to meet the following specifications: Damping Ratio=0.5; Undamped natural Frequency =2, Error constant $K_v>5$. Design a lead compensator. Check the design for the required characteristics. 8

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5. (a) The open loop transfer function of a plant for unity feedback system $G_{p(s)}=K/\{s(1+.1s)(1+.2s)\}$. The performance specifications are as follows: $K_v=100$/sec, Phase margin>30°. Design a suitable phase-lag compensator using Frequency response Characteristics. 5

(b) Using Nyquist stability criteria, check the stability of the unity feed-back system with open loop transfer function $G(s)=K(s-1)/\{s(s+1)\}$. Also find out the value of K for which the close loop system will be stable. 5

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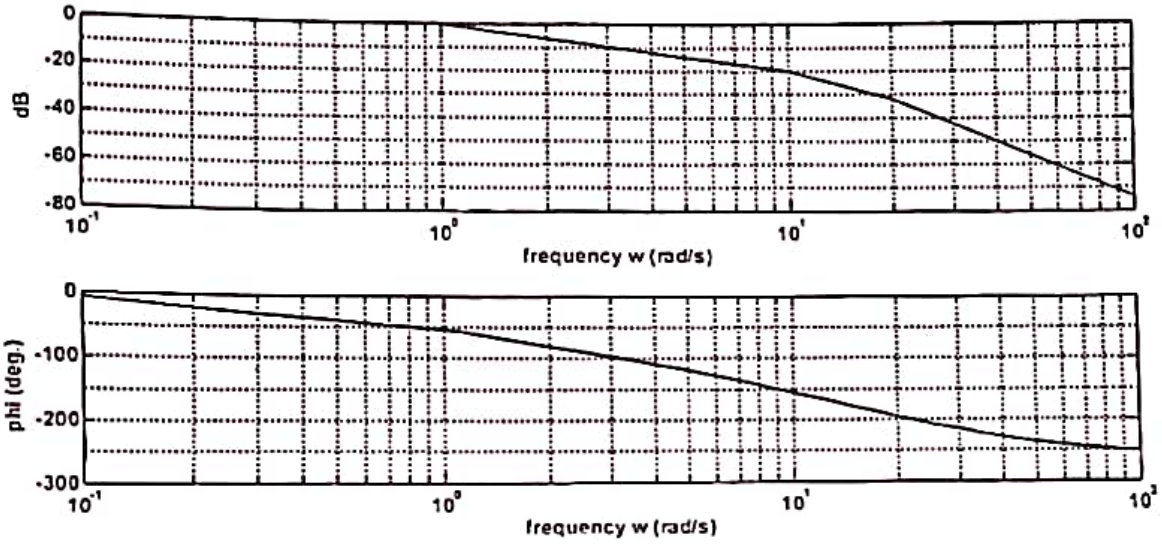
(f) The asymptotic Bode plot is shown in figure below. The gain plot is asymptotic whereas the phase plot is the actual plot. Find out the open loop transfer function of the system. 4 10

(g) For the open loop transfer function $G(s) = \dfrac{400s^2}{(s+5)(s+20)(s+100)}$, sketch the bode magnitude and phase plots. Sketch the plots for each term and then sketch the total plots. Show the slopes of each section and of the total plot. 6



Explain any five of the followings in the context of control-systems.: 2 x 5 10

(a) Effect of Time delay on system response.
(b) Free response and forced-response components of a system output.
(c) Response of second order system for step input for different values of damping coefficients.
(d) Root Sensitivity.
(e) Comparison of Frequency domain analysis with time-domain analysis.
(f) Steady-state error and error constants.
(g) Standard test signals for frequency domain analysis
(h) Bandwidth and its importance in compensator design.