INDIAN INSTITUTE OF INFORMATION TECHNOLOGY GUWAHATI

B.TECH., 5^{th} SEMESTER, ECE, END SEMESTER EXAMINATION, 22^{rd} NOVEMBER 2018
DEPT. OF ELECTRONICS & COMMUNICATION ENGINEERING
SUBJECT: CONTROL SYSTEMS (EC 380)

Time: 3 $hours$ Maximum Marks : 80

1) $2.5 \times 6 = 15$
   a) Explain the different types of mathematical model of dynamic systems with an example.
   b) The impulse response of a second order system to a step input is obtained as $e(t) = 1.66exp^{-5t}sin(8.66025t + 60^o)$. What is the step response of the system?
   c) The characteristic equation of a closed-loop control system is given as $s^2 + 4s + 16 = 0$. Determine the peak overshoot and the peak overshoot frequency of the system.
   d) Write down the transfer function of a non-minimum phase system whose magnitude plot is shown in Fig. 1.
   e) State the advantages of the Bode stability criterion over that of Routh's criterion.
   f) Explain the different properties of state-space model.

2) Write a short note on the application of control systems for the future of humanity. (5)

3) Determine the range of K for stable and under-damped step response of a unity feedback system whose open-loop transfer function is $G(s) = \frac{K}{s(s+1)(s+2)}$. (5)

4) Draw the Bode plots for a system with loop transfer function $G(s)H(s) = \frac{1000(s+1)}{s(s+20)(s+50)}$ and determine the gain margin, phase margin. Comments on the stability of the closed-loop system. (10)

5) Write state-space equations of the systems given in Fig. $2(a)$ and $2(b)$. (5)

6) The state space representation of a system is given below:

$$\dot{x} = \begin{bmatrix} -1 & 1 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -2 \end{bmatrix} x + \begin{bmatrix} 0 \\ 4 \\ 3 \end{bmatrix} u, \qquad y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} x$$

   (i) Obtain the transfer function of the system. (ii) Determine controllability and observability of the system. (10)

7) Find out the diagonal canonical form of the following system:

$$\dot{x} = \begin{bmatrix} 0 & 2 \\ 1 & -1 \end{bmatrix} x + \begin{bmatrix} -1 \\ 1 \end{bmatrix} u, \qquad y = \begin{bmatrix} 0 & 1 \end{bmatrix} x$$

(5)

8) Determine the equilibrium points and Lyapunov stability of the following nonlinear system

$$\frac{dx}{dt} = -6x + 2y$$
$$\frac{dy}{dt} = 2x - 6y - 2y^3$$

(10)

9) A unity feedback control system has a plant transfer function $G(s) = \frac{K}{s(s+2)}$. Design a lag compensator to attain a steady-state error to a ramp $r(t) = At$ of less than $0.01A$ and a phase margin of 45^0. (5)

10) A unity feedback control system has the plant transfer function $G(s) = \frac{1}{s(s+2)}$. Design a PD controller of the form $G_c(s) = k_p + k_d s$ so that the system has a velocity error 2% and peak overshoot 20% to a unit step input. (5)

11) Consider the system represented in state variable form

$$\dot{x} = \begin{bmatrix} 1 & 5 \\ -5 & 10 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u, \qquad y = \begin{bmatrix} 0 & -2 \end{bmatrix} x$$

Verify that the system is observable. Then design a full-state observer by placing the observer poles at $s_1 = -1$ and $s_2 = -2$. (5)