# KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

***Department of Mechanical Engineering***

B. Sc. Engineering 4th Year 2nd Term Examination, 2012

ME 4085

(Servomechanism & Control Engineering)

Time: 3 Hours Total Marks: 210

**N.B.**: i) Answer any THREE questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.
iii) Assume reasonable data if missing any.

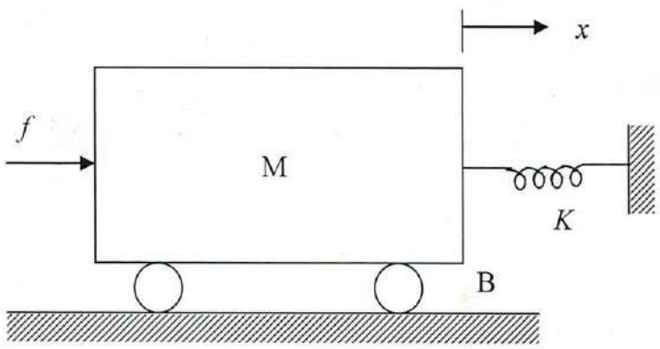
## SECTION-A

1(a) Define control system. Describe the merits and demerits of an open loop control system over closed loop system. What is meant by a modern control system? 10

1(b) Explain the operation of a rotating power amplifier. Draw the schematic diagram of a single-stage rotating amplifier and deduce the input-output relationship. 15

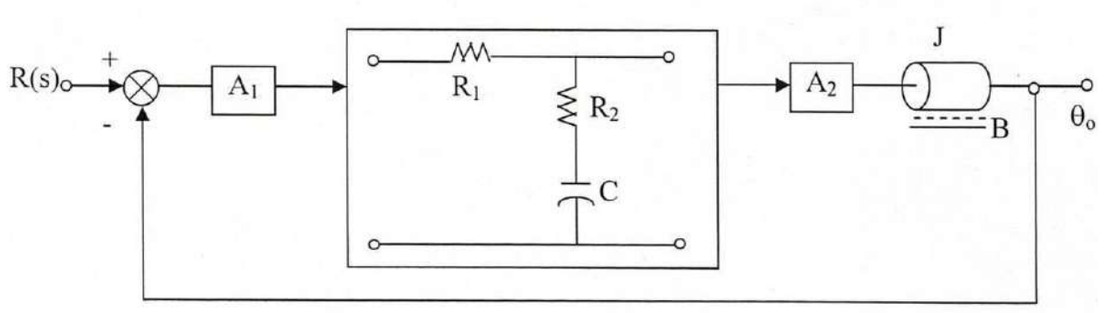
1(c) Draw the schematic diagram and deduce the systems of equation of a dc servomotor with armature control. 10

2(a) For the following system, establish the expression for maximum value of overshoot and time to reach the maximum value of overshoot. 15




2(b) The response of a dc motor is given by the following differential equation: 10
$A_2 \frac{d^2x}{dt^2} + A_1 \frac{dx}{dt} + A_o x = r$, where $x$ is the position and $r$ is input. Find the steady state position of the motor for parabolic input given by the expression, $r = (a_o + a_1 t + a_2 t^2)\, u(t)$.

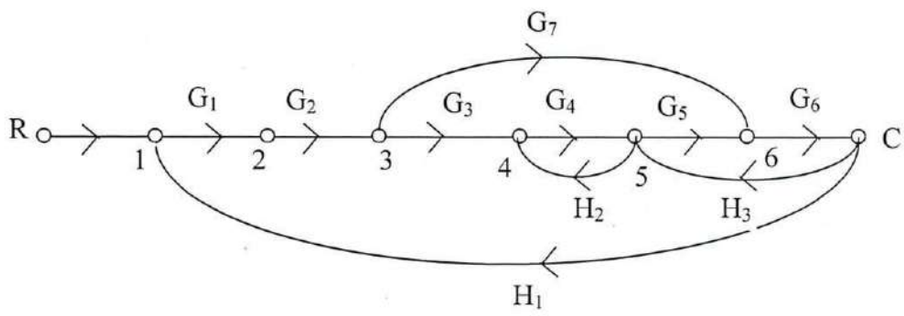
2(c) Deduce the overall transfer function for the following block-diagram of the figure shown below. 10



3(a) Define poles and zero. Explain different location of poles and stability of a closed loop control system. 10

3(b) Draw the block diagram of a position control system and find the overall transfer function from each component of a system. 15

3(c) For the following signal flow graph, find the overall transmittance. 10




4(a) The ratio of output to input is given by 12

$$\frac{X_2(s)}{X_1(s)} = \frac{K(s+2)}{s(s+5)(s^2+2s+5)+K(s+2)}.$$

Determine the range of $K$ for which the system is stable.

4(b) Derive the necessary condition(s) for the coefficients of a third order system to be marginally stable. 06

4(c) Explain different system types. 06

4(d) What is meant by compensating network? Derive the transfer function of a lead compensator using passive element. Also draw the location of poles and zero in s-plane. 11

## SECTION-B

5(a) Briefly explain P, PI and PID controllers. Mention their transfer function and utility in control systems. 14

5(b) Define eigen values of a system. Show that the eigenvalues of a system are invariant. 10

5(c) Define controllability and observability. Show whether the following system is controllable and observable. 11

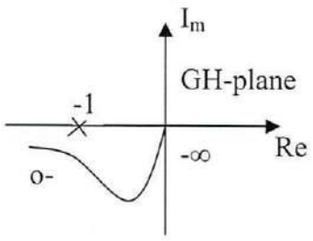
$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}-3 & 1\\ -2 & 1.5\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}1\\ 4\end{bmatrix}u, \qquad y = \begin{bmatrix}0.8 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}$$

6(a) Explain controllable, observable, stabilizable and detectable systems. Consider the system defined by 14

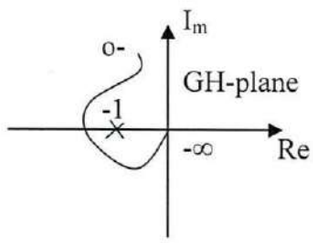
$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}-1 & -2 & -2\\ 0 & -1 & 1\\ 1 & 0 & -1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}2\\ 0\\ 1\end{bmatrix}u, \qquad y=\begin{bmatrix}1 & 1 & 0\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$$

6(b) Describe the operation principle of an on-off controller. What are the limitations of this controller for highly dynamic system? Why differential gap is introduced in on-off controller? 08

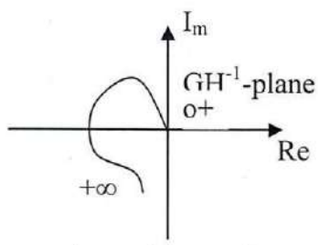
6(c) State Nyquist stability criterion. Complete the following polar plots and comment on the stability of the systems using Nyquist criterion. 13




$$GH=\frac{K}{s^2(Ts+1)}$$




$$GH=\frac{K}{s(T_1s+1)(T_2s+1)}$$

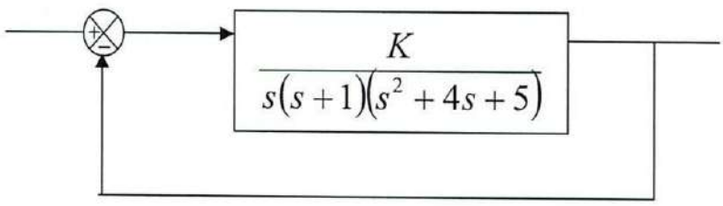



$$[GH]^{-1}=\frac{s(1+T_1s)(1+T_2s)}{K}$$

7(a) Define break-in and break-away points. Explain the effects of adding poles and zeros on the root locus diagram of a system. 10

7(b) Deduce the angle and magnitude conditions for the roots of a system by varying the gain from 0 to ∝. 08

7(c) Sketch the root loci for the system shown in the figure below. 17




8(a) Describe the basic factors that are used in plotting Bode diagrams. 06

8(b) Define gain margin, phase margin, minimum phase system, and non minimum phase system. 08

8(c) Draw the bode diagram of $G(s)=\frac{10(s+3)}{s(s+2)(s^2+s+2)}$. 21

Also determine the gain margin and phase margin.