UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAM
SEMESTER II
SESSION 2012 / 2013

COURSE NAME	:	CONTROL ENGINEERING
COURCE CODE	:	BDA 30703 / BDA 3073
PROGRAMME	:	3 BDD
EXAMINATION DATE	:	JUNE 2013
DURATION	:	3 HOURS
INSTRUCTION :	:	1. PART A (COMPULSORY) : ANSWER **ALL** QUESTIONS 2. PART B (OPTIONAL) : ANSWER **TWO (2)** QUESTIONS ONLY

THIS EXAMINATION PAPER CONTAINS **SEVEN (7)** PAGES

PART A (COMPULSORY): ANSWER ALL THE QUESTIONS

Q1. (a) (i) What is Control System? Explain **THREE (3)** desired output characteristics of a control system.

(4 marks)

(ii) Explain the difference between open-loop and closed loop control

(4 marks)

(b) (i) Define the Transfer Function.

(2 marks)

(ii) Give **ONE (1)** example of Transfer Function using block diagram

(2 marks)

(c) Derive the transfer function for the system shown in **FIGURE Q1** using block diagram reduction technique; with $G_1 = \frac{1}{s}; G_2 = \frac{1}{(2s+3)}; G_3 = \frac{3}{s}; H = 0.5$

(13 marks)

Q2. (a) What mathematical model permits easy interconnection of physical systems ?

(2 marks)

(b) Name **THREE (3)** basic components of rotational systems

(3 marks)

(c) A rotational mechanical system is shown in **FIGURE Q2.** The system is undergoing torsion and consists of a parallel damper and spring attached together in series with other spring. D is the coefficient of viscous damper, K_1 and K_2 are a spring constant, J is moment of inertia and T is external torque. The system rotates with two angular displacements θ_1 and θ_2 as shown. The input and output of the system is external torque T and angular displacement θ_2 respectively.

(i) Draw the free body diagram (FBD) of the system.

(3 marks)

(ii) Write the two equations of motion for the system.

(2 marks)

(iii) Write equations of motion obtained in Q2(c)(ii) in term of s domain using the Laplace transform assuming zero initial conditions.

(2 marks)

(iv) Sketch the block diagram for the system.

(5 marks)

(v) Find the transfer function $G(s) = \theta_2(s)/T(s)$ using the signal flow graph. Let $J = 2\ \text{kgm}^2, D = 2\ \text{Nm/rad}$ and $K_1$and $K_2 = 2\ \text{Nms/rad}$.

(8 marks)

PART B : ANSWER TWO (2) OUT OF THREE QUESTIONS

Q3. A feedback control of DC servomotor mechanism system neglecting the damping factor can be simplified in a block diagram as shown in **FIGURE Q3.**

(a) Obtain all pertinent pints for root locus and draw the root locus

(15 marks)

(b) Find the range of K when the root locus as is varied from 0 to ∞.

(4 marks)

(c) Use a damping ratio, $\zeta = 0.58$ and determine the value of K

(4 marks)

(d) From the locus plotted in Q3(a), find the natural frequency, ω_n and damped natural frequency, ω_d.

(2 marks)

Q4. (a) State **FOUR(4)** steps used in constructing Bode diagram.

(4 marks)

(b) Explain phase and gain stability using Bode diagram.

(3 marks)

(c) Give **TWO (2)** advantages of Bode diagrams over Nyquist plots.

(3 marks)

(d) Consider a system with a unity feedback control system as shown in **FIGURE Q4**.

(i) Create the Bode diagram for the system.

(ii) Show the gain margin, G_m and phase margin, P_m from the Bode diagram and estimates the values.

(iii) Determine the phase and gain crossover frequencies.

(iv) Comment on the stability of the system

(15 marks)

Q5. (a) (i) Explain the function of a controller.

(2 marks)

(ii) Give **TWO (2)** drawbacks of derivative action.

(2 marks)

(b) **FIGURE Q5** shows an ideal derivative compensator or PD controller for the plant. Explain how PD controllers improve the transient response.

(5 marks)

(c) (i) Give the equation for PD controller and elaborate the equation.

(4 marks)

(ii) The open loop transfer function of a control system is given by

$$KG(s)H(s) = \frac{K}{s(s+2)(s+5)}$$

Design the PD controller with the time-domain specifications of dominant poles damping ratio, $\zeta = 0.707$ and dominant poles time constant, $\tau = 0.5$ seconds.

(13 marks)

END OF QUESTIONS

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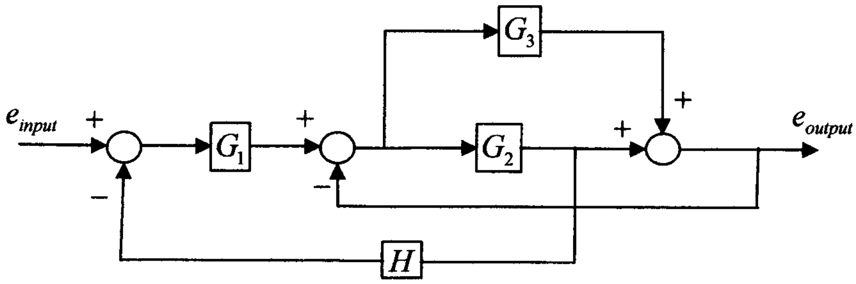

FIGURE Q1

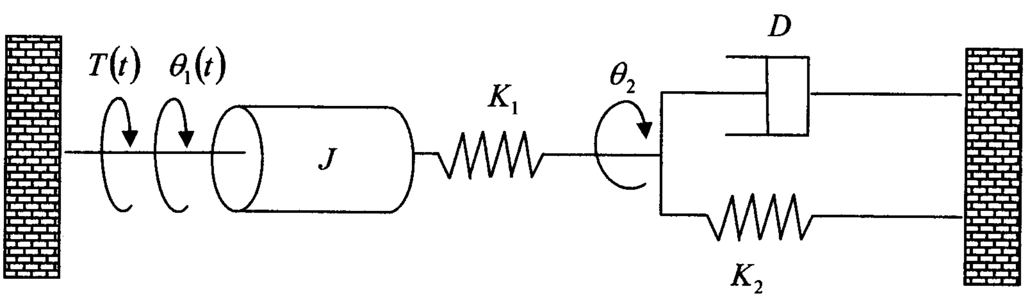

FIGURE Q2

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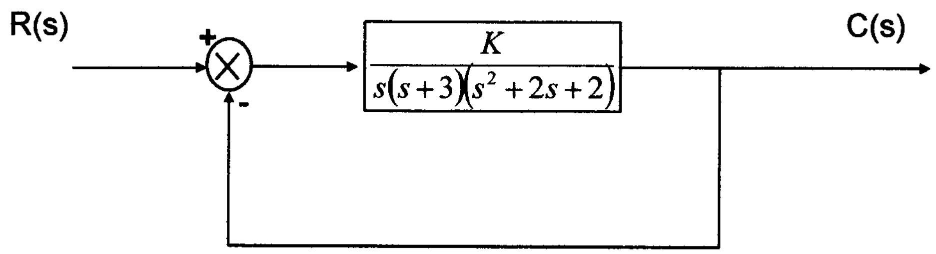

FIGURE Q3

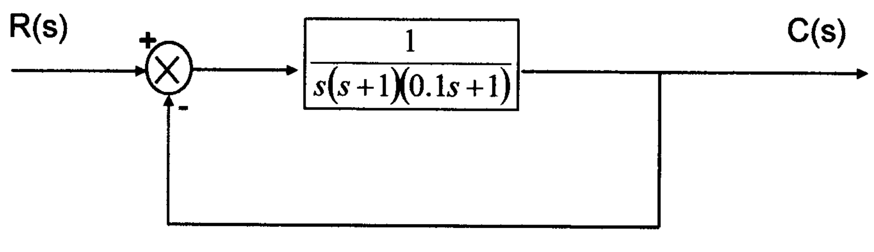

FIGURE Q4

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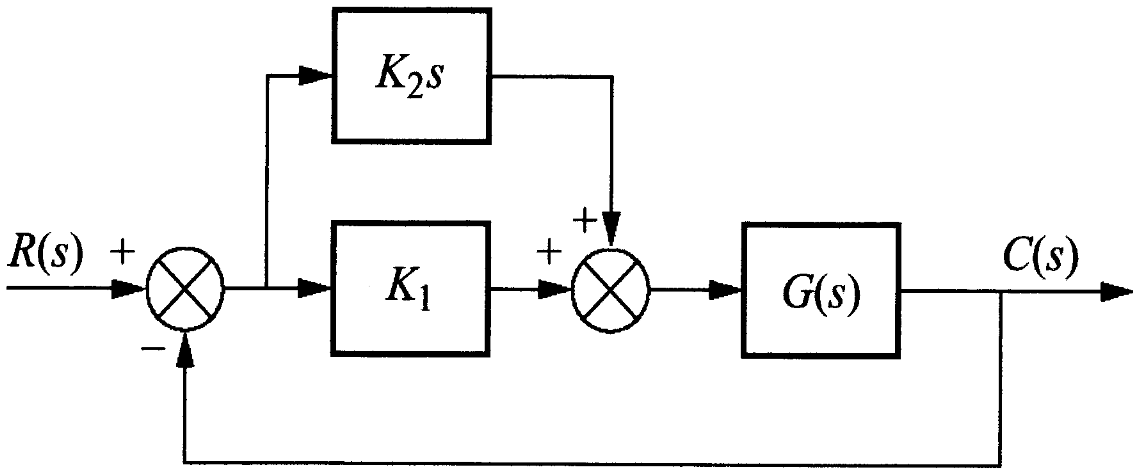

FIGURE Q5

Mason's Rule : The transfer function, $C(s)/R(s)$, of a system represented by a signal – flow graph is

$$G(s)=\frac{C(s)}{R(s)}=\frac{\sum_k T_k\Delta_k}{\Delta}$$

where :

k = number of forward paths

T_k = the kth forward - path gain

$\Delta = 1 - \sum$ loop gains $+ \sum$ nontouching - loop gains taken two at a time $- \sum$ nontouching - loop gains taken three at a time $+ \sum$ nontouching - loop gains taken four at a time $- \ldots$

$\Delta_k = \Delta - \sum$ loop gain terms in Δ that touch the kth forward path. In other words, Δ_k is formed by eliminating from Δ those loop gains that touch the kth forward path.

Root Locus :

$$K=\frac{1}{|G(s)H(s)|}=\frac{\prod \text{pole lengths}}{\prod \text{zero lengths}} \qquad \theta=\sum \text{finite zero angles}-\sum \text{finite pole angles}$$

$$\sigma_a=\frac{\sum \text{finite poles}-\sum \text{finite zeros}}{\#\text{finite poles - }\#\text{finite zeros}} \qquad \theta_a=\frac{(2k+1)\pi}{\#\text{finite poles - }\#\text{finite zeros}}$$