THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
DIPLOMA IN TECHNOLOGY – LEVEL 4
FINAL EXAMINATION – ACADEMIC YEAR 2011/2012
MEX4243 - CONTROL SYSTEMS ENGINEERING/
ECX4242 - CONTROL SYSTEMS

Date: March 18, 2012 **Time: 1400 - 1700 hrs**

Important:

1. This question paper consists of **eight** questions.
2. Write the answers for the **Section A** and **Section B** in **separate answer books**.
3. Answer **Q1, which is compulsory,** and FOUR other questions selecting at least ONE from SECTION A and TWO from SECTION B.
4. Present important but relevant facts and information briefly. Any missing information can be sensibly and reasonably assumed provided that you state them clearly. Wherever necessary, use neatly drawn sketches to explain answers.

SECTION A

Question 01

Figure Q1 shows the industrial process temperature control system which is required to control the temperature (θ) in the tank.

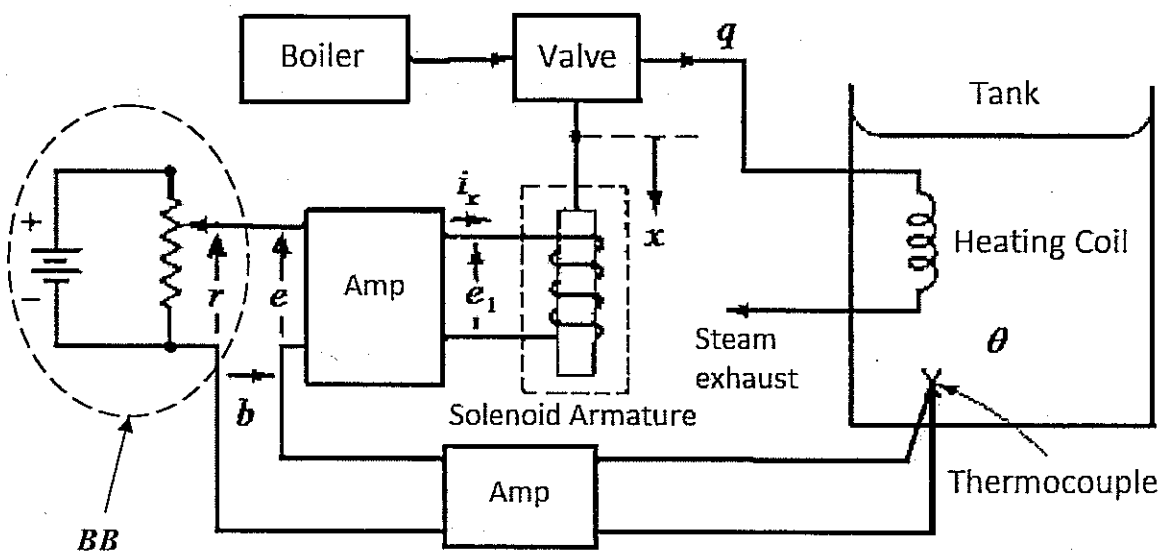


Figure Q1

(a) What is the block that is marked as ***BB***? What is the purpose of it? [2]

(b) What is the main purpose of Solenoid Armature? [3]

(c) Draw a complete functional block diagram for the closed loop system that includes the transducer, the controller, the plant and other entities. [6]

(d) Identify each output signal for each block (in given terms) on the diagram. [3]

(e) Describe the operation of the control system that you have drawn in (c). [6]

Question 02

Figure Q2 shows the block diagram of a control system, where R(s) is the reference signal and C(s) is the output. Find the transfer function C(s)/ R(s) of the system by

(a) Simplifying the block diagram. Show all the steps clearly. [12]

(b) Applying the Mason's gain formula. Show all the steps clearly. [8]

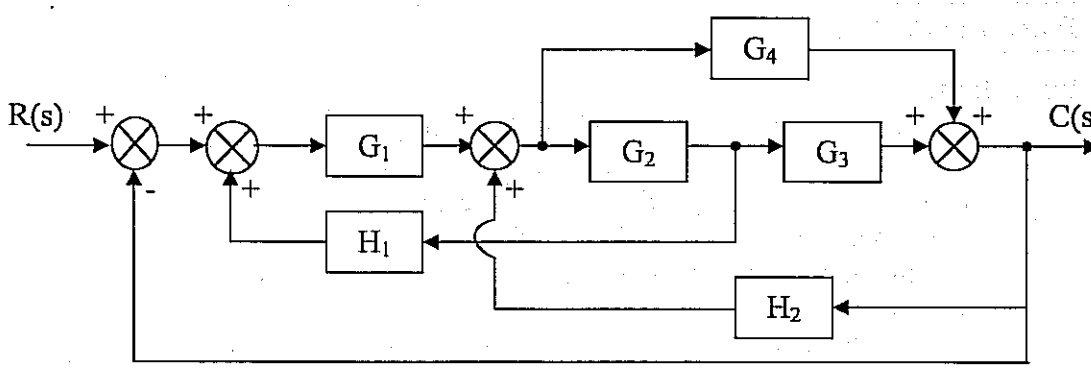


Figure Q2

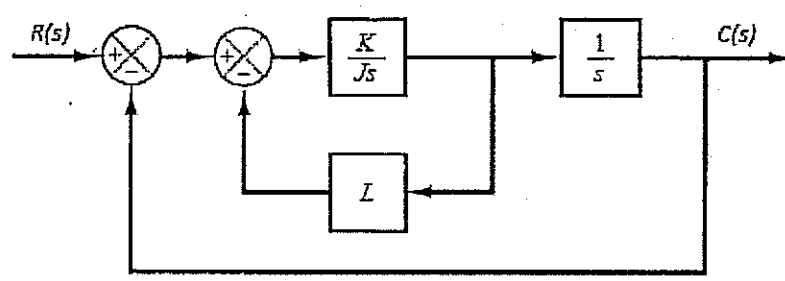
Question 03

(a) Briefly explain (marks will not given for sketches and equations) following for a 2nd order control system: [8]

i) Peak time
ii) Maximum overshoot
iii) Rise time
iv) Delay time

(b) Figure Q3 shows the block diagram of a control system and the response of the system output when a unit-step input is applied. Assume that $J = 1$ kgm^2. Find: [12]

i) Damping ratio
ii) Natural frequency
iii) Values of K and L



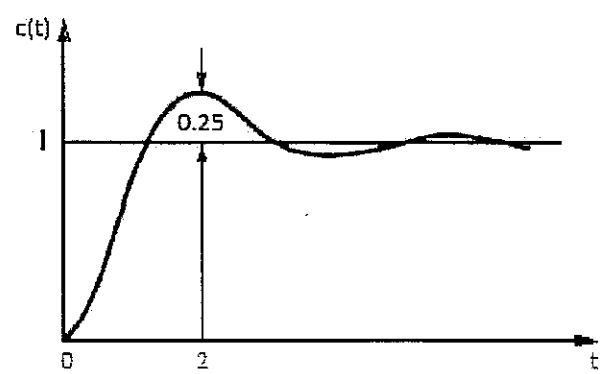


Figure Q3

Question 04

(a) For the Figure Q4(a) find the position, velocity & acceleration error constants. [8]

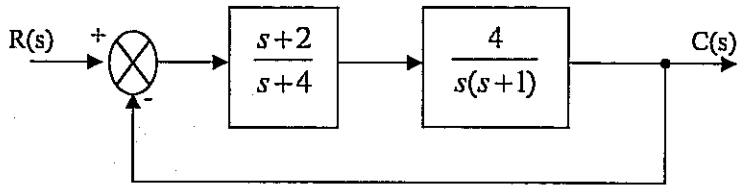


Figure Q4(a)

(b) Figure Q4(b) shows the block diagrams of two systems: I & II. Find the sensitivities of the two systems with respect to parameter K_1 for nominal values $K_1 = K_2 = 100$ and compare them. [12]

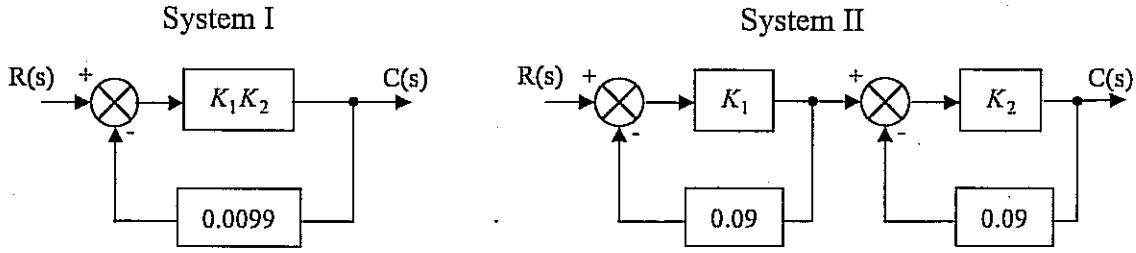


Figure Q4(b)

SECTION B

Question 05

A system is given by the input-output differential equation.

$$\frac{d^3y}{dt^3} + 6\frac{d^2y}{dt^2} + 11\frac{dy}{dt} + 6y = 2\frac{du}{dt} + 6u$$

where, u = input, y = output.

(a) Using Routh-Hurwitz criterion (and without solving the characteristic equation), determine how many poles of the system are on the left half plane. Is the system stable? [4]

(b) For a unit step input, determine the steady state value of the response, by using the differential equation and explaining your rationale. Next, verify your answer using Final Value Theorem. [8]

(c) Suppose that all the poles of the given system are moved to the right by 1 (and the system zeros are not changed).Using Routh-Hurwitz criterion (and without actually solving the characteristic equation) determine the stability of the new system (with moved poles).[6]

Question 06

The loop transfer function of a feedback control system is given by

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

(a) Sketch the root locus of the closed- loop system by first determining the:
- (i) location and the angles of the asymptotes;[4]
- (ii) break points;[2]
- (iii) points at which the root locus intersects with the imaginary axis, and the corresponding gain value.[2]

(b) Fully justifying your answer, state whether the system is stable for K=10.[4]

(c) Suppose that a zero at -3 is introduced to the control loop so that

$$GH = \frac{K(s+3)}{s(s+1)(s+2)}$$

Sketch the root locus of the new system and state whether the system is stable for K=10.[8]

Question 07

(a) Determine the resonant frequency , resonance peak and bandwidth for the system whose transfer function is given by

$$\frac{C(s)}{R(s)} = \frac{5}{s^2+2s+5}$$ [8]

(b) Sketch the asymptotic bode plot for a unity feedback system characterized by loop transfer function

$$G(s) = \frac{K(1+0.5s)(1+0.025s)}{s^3(1+0.002s)(1+0.005s)}$$

Show that the system is continuously stable. Find the range of values for which the system is stable.[12]

Question 08

An automatic steering system is being designed for a ship, to make it follow a compass course. It will be used in the open sea, where there are no obstructions. The ship will be subjected to the effects of the wind, which will tend to deflect it steadily from its course, and to the effect of waves, which will subject it to sudden forces that will cause the ship to move sharply away from its course.

Discuss how control systems of the following types will respond:

(a) proportional [5]
(b) proportional plus integral (P+I) [5]
(c) proportional plus integral plus derivative (P+I+D) [5]

Show with a graph what an ideal response from a P+I+D system would look like.[5]

- End-