THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
DIPLOMA IN TECHNOLOGY – LEVEL 4
FINAL EXAMINATION – ACADEMIC YEAR 2010/2011
MEX4243 - CONTROL SYSTEMS ENGINEERING/
ECX4242 - CONTROL SYSTEMS

Date: March 27, 2011 **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 roll, pitch and yaw of an Aircraft which needs to be stabilized by controlling the roll of the plane.

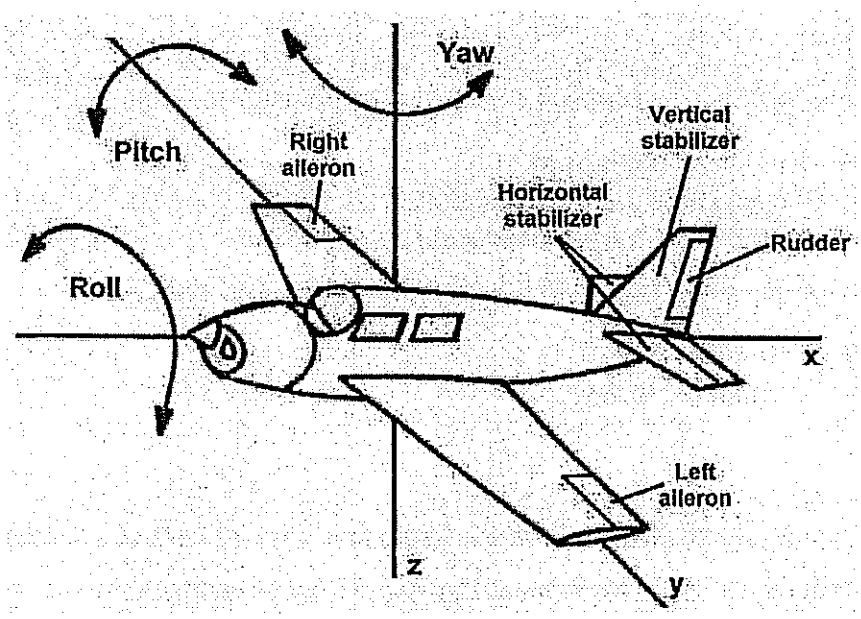

Figure Q1

(a) What is the system output? What type of transducer is used for measuring it? [3]

(b) What is the controller of this system? [2]

(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 entity on the block diagram. [3]

(e) Describe the control system that you have drawn in (c). [4]

(f) What are the external disturbances for this kind of control system? [2]

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.

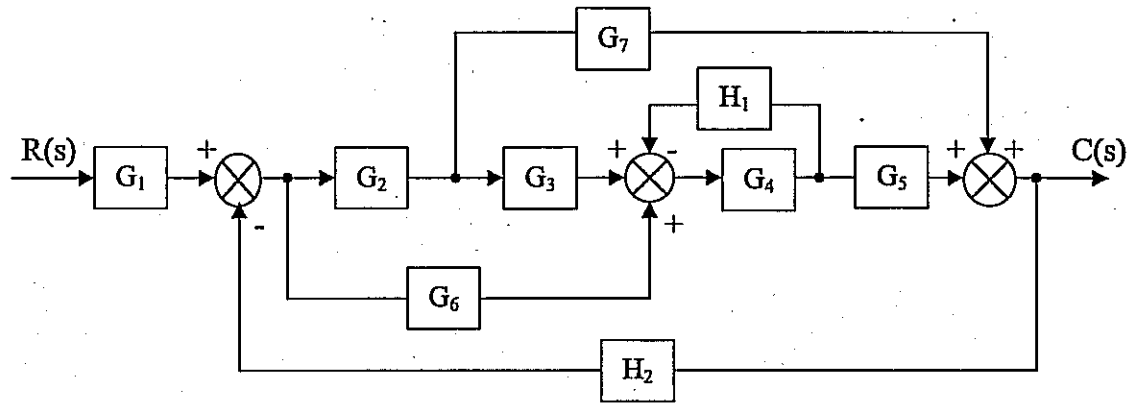

Figure Q2

(a) Draw the signal flow graph for the system given in figure Q2. [5]

(b) Apply the Mason's gain formula to find the transfer function C(s)/R(s). Show all the steps clearly. [15]

Question 03

A unity feedback system has a feed forward transfer function, $\frac{5000}{s(s+75)}$.

(a) For a unit step input, find
   i) the expected percent overshoot.
   ii) the settling time of the system. [14]

(b) If $u(t)$ is a unit step function, find the steady state error for

   i) an input of $5u(t)$.
   ii) an input of $5t.u(t)$. [6]

Question 04

(a) Explain the difference between Order and Type of control systems. [4]

(b) Explain briefly, what is meant by Sensitivity of control systems? [4]

(c) Figure Q4 shows the block diagram of a control system. K_1 and K_2 are constants.

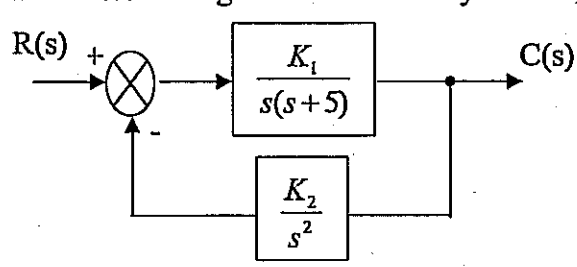

Figure Q4

i) Find the Order and Type of the above system. [4]

ii) Find the Sensitivity of the system separately with respect to K_1 and K_2. [8]

SECTION B

Question 05

(a) What is bandwidth? [2]

(b) Why negative feedback is invariably preferred in a closed loop system? [2]

(c) What are the main advantages of Bode plot? [2]

(d) What are the advantages of Nichols chart? [2]

(e) What are the two types of compensation? [2]

(f) What are the three types of compensators? [3]

(g) What is the effect of PI controller on the system performance? [2]

(h) Why derivative controller is not used in control systems? [2]

(i) What is the significance of integral controller and derivative controller in a PID controller? [3]

Question 06

(a) The characteristic equation of a servo system is given by:

$$a_0 s^4 + a_1 s^3 + a_2 s^2 + a_3 s + a_4 = 0$$

Determine the conditions which must be satisfied by the coefficients of the characteristic equation for the system to be stable. [6]

(b) A unity negative feedback control system has an open-loop transfer function

$$G(s) = \frac{K(s+1)(s+2)}{(s+0.1)(s-1)}$$

Using Routh stability criterion, determine the range of valves of K for which the closed loop system has 0, 1 and 2 poles in the right-half plane. [14]

Question 07

(a) Define the following terms: [2]

i) Complementary Root Loci (CRL)

ii) Root Contours (RC)

(b) A feedback control system has a open loop transfer function: [18]

$$G(s) = \frac{K}{s(s+3)(s^2+4s+7.84)}$$

i) Find the breakaway point on the real axis and the gain for this point.

ii) Find the gain to provide two complex roots nearest the $j\omega$ axis with a damping ratio of 0.707.

iii) Are the two roots of part ii) dominant?

iv) Determine the settling time (2% criterion) of the given system when the gain of part ii) is used.

Question 08

(a) Define the following terms: [4]

i) Gain margin
ii) Phase margin
iii) Gain crossover point
iv) Phase crossover point

(b) A servomechanism has an open-loop transfer function of

$$G(s)=\frac{10}{s(1+0.5s)(1+0.1s)}$$

Draw the Asymptotic Bode plot and determine the phase and gain margins. A network having the transfer function $\frac{(1+0.23s)}{(1+0.023s)}$ is now introduced in tandem. Determine the new gain and phase margins. Comment upon the improvement in system caused by the network. [16]

- End.