00191

THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
DIPLOMA IN TECHNOLOGY – LEVEL 4
FINAL EXAMINATION – ACADEMIC YEAR 2009/2010
MEX4243 - CONTROL SYSTEMS ENGINEERING/
ECX4242 - CONTROL SYSTEMS

Date : March 28, 2010 **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

Q1 Figure Q1 is a conceptual sketch of a cruise-controlled car.

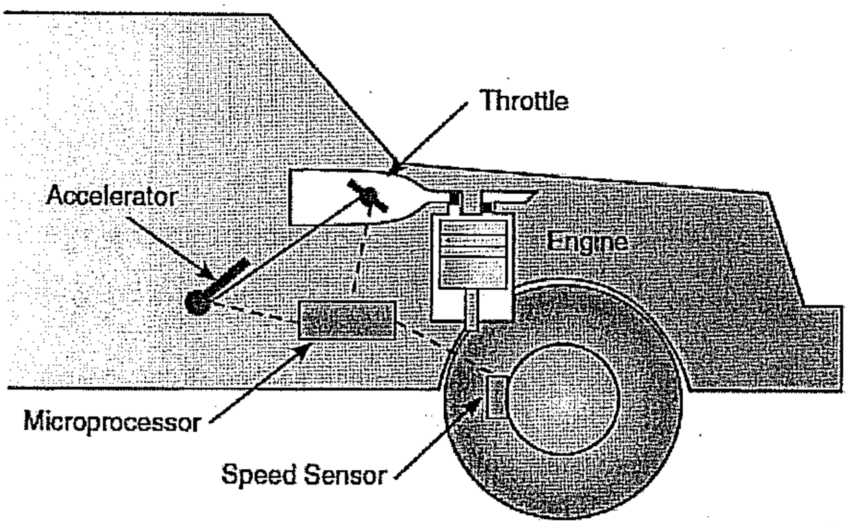

Figure Q1

(a) What is the system output? What type of transducer is used for measuring it? [2]

(b) What is the function of the Throttle as an Actuator? Give a method of throttle actuation for this control system. [3]

(c) What is the function of the Microprocessor? Give another alternative component to use as a Microprocessor. [3]

(d) Give a real situation how the cruise control disconnects from the vehicle. [2]

(e) Describe the complete operation of this control system. [4]

(f) Draw a complete block diagram of this control system. [4]

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

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

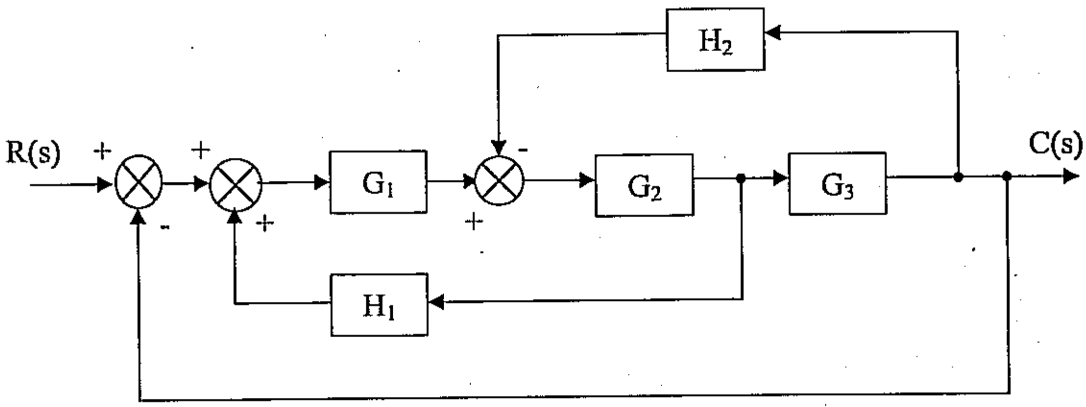

Figure Q2

(a) Derive the transfer function C(s)/ R(s) by simplifying the block diagram. Clearly show the steps. [12]

(b) Draw the Signal Flow Diagram (SFG) for the given system. [2]

(c) Apply the SFG gain formula to find the transfer function C(s)/ R(s). Clearly show the steps. [6]

Q3

(a) Derive an expression for the response of the first order system for unit step input and plot the response. (Hint: $\frac{C(s)}{R(s)} = \frac{a}{(s+a)}$; where a is a constant.) [4]

(b) Draw the response of the under-damped second order system for unit step input and show the Peak time (T_p), Peak overshoot (%OS) and Settling time (T_s) within ± 2 % of the steady state value on your plot. [5]

(c) Write the expressions for above T_p, %OS and T_s. [6]

(d) A control system with unity feedback is shown in figure Q3. Find T_p, %OS and T_s of the system for unit step input. [5]

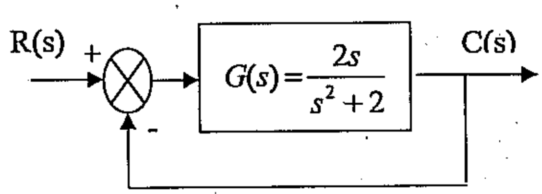

Figure Q3

Q4

(a) Explain what is meant by the Type No. of a control system and discuss its effect on the steady state response of a system to step, ramp and parabolic inputs. [8]

(b) Consider the system shown in Figure Q4 with time constant T, while constants K_1 and K_2 set to arbitrary values. [12]

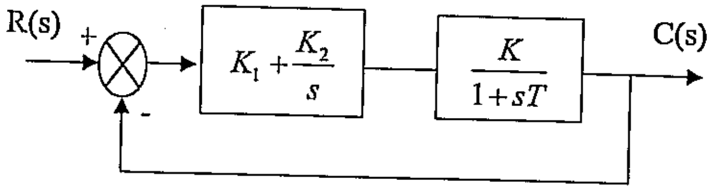

Figure Q4

i) What is the steady-state error for a unit step input, when

a. $K_2 = 0$ b. $K_2 \neq 0$

ii) Determine the steady-state error for a unit ramp input, when

a. $K_2 = 0$ b. $K_2 \neq 0$

iii) Given K_1 = 1.2, K_2 = 8.4, and T = 0.5, what value of K gives an error constant of 6 for a unit ramp input? Find the corresponding steady-state error.

SECTION B

Q5 A unity feedback system has a open loop transfer function

$$G(s) = \frac{K}{S^2(s+2)}$$

(a) By sketching a root locus plot, show the system is unstable for all value of K. [10]

(b) Add a zero at $s = -a(0 \le a \le 2)$ and show that the addition of zero stabilizes the system. [5]

(c) If $a = 1$, sketch the root locus plot, find the value of K which gives the greatest damping ratio for the oscillatory mode. Find also the value of this damping ratio and the corresponding undamped natural frequency. [5]

Q6

(a) Define the following terms. [6]

i) Gain margin

ii) Phase margin

iii) Phase crossover point

(b) Sketch the Bode plot for a unity feedback system, characterized by the open loop transfer function

$$G(s) = \frac{K(1 \div 0.2s)(1 \div 0.5s)}{s^2(1 \div 0.001s)(1 \div 0.005s)}$$

Show that the system is conditionally stable. Find the range of values of K for which the system is stable. [14]

Q7

(a) Write ***Lead Compensation*** transfer function and define each term. [5]

(b) The open loop transfer function of a unity feedback system is

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

It is desired to have the velocity error constant K_v as $12\,\text{sec}^{-1}$ and phase margin as 40^0. Design a lead compensator using ***Bode Plots*** to meet the above specifications. [15]

Q8

(a) Describe and compare the characteristics of

i) Proportional Controller.
ii) Proportional plus Integral Controller.
iii) Proportional plus Integral plus derivative Controller. [6]

(b) The closed loop transfer function of a control system is given by

$$G(s) = \frac{16}{s^2 + 1.6s + 16}$$

Determine the derivative feedback constant K_t and compare the rise time, peak time, maximum overshoot and steady state error for unit ramp input with and without derivative feedback control, if it is desired to have the damping ratio to be 0.8. [14]

- End.