NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

Bachelor of Engineering Honours Degree Industrial and Manufacturing Engineering

2nd Semester Main Examination

COURSE : **INDUSTRIAL INSTRUMENTATION AND CONTROL II**

CODE : **TIE 3214**

DATE : **MAY 2014**

DURATION : **3 HOURS**

INSTRUCTIONS AND INFORMATION FOR CANDIDATE

1. Answer any FIVE **(5)** questions.
2. Each question carries 20 marks.
3. This paper contains SEVEN**(7)** questions.
4. There are six **(6)** printed pages.

ADDITIONAL MATERIAL

a. Semi Log graph papers
b. Normal Graph papers
c. Laplace Tables

QUESTION 1

(a) What is the difference between a feedback and a feed forward control loop? [2]

(b) A torsional spring of stiffness *K*, a mass of moment of inertia *I* and a fluid damper with damping coefficient *C* are connected together as shown in Figure Q1 below. If the angular displacement of the free end of the spring is $\Theta_i\,(t)$ and the angular displacement of the mass and damper is $\Theta_o(t)$. Find the differential equation relating $\Theta_i\,(t)$ and $\Theta_o(t\,)$ given that

I=2.5Kgm^2

C = 12.5Nms/rad

K= 250Nm/rad [7]

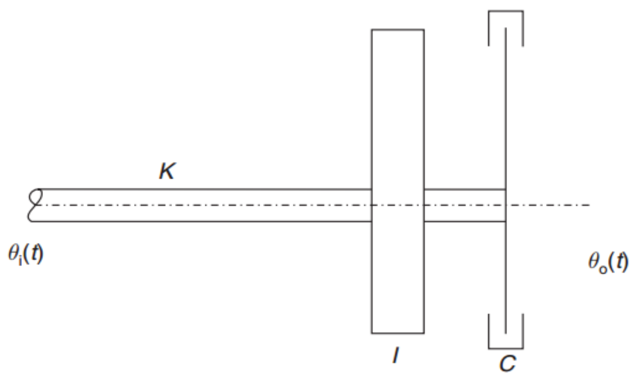

Figure Qu 1

(c) Derive the standard form of transfer function for a first-order system

$$a\frac{dx_o}{d_t} + bx_o = cx_i(t)$$

using the constants K as steady-state gain constant and T as the time constant in seconds [5]

(d) Why do controllers need tuning? [2]

(e) Explain why the Proportional Integral plus Derivative (PID) controller is preferred to the Proportional controller. [4]

QUESTION 2

(a) With the aid of a clearly labelled diagram explain a transient error and a steady state error. [5]

(b) Given the control system in Figure Q2.1 with two inputs R(s) and G(s). Use the superposition principle to find the overall transfer function for the control system. [8]

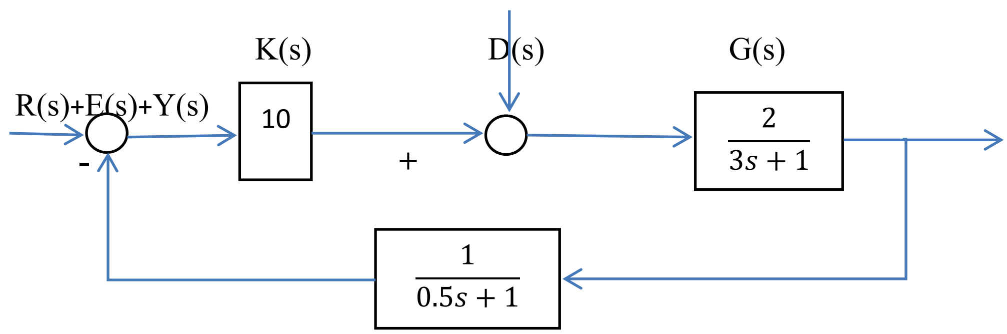

Figure 2.1

(c) Using standard block diagram reduction techniques,derive the overall transfer function for the system represented by the block diagram in Figure Q2.2 given that $g_1(s) = \frac{1}{s+1}$, $g_2(s) = \frac{3}{s+5}$,$h_1(s) = 1$ and $h_2(s) = \frac{3}{s}$. [7]

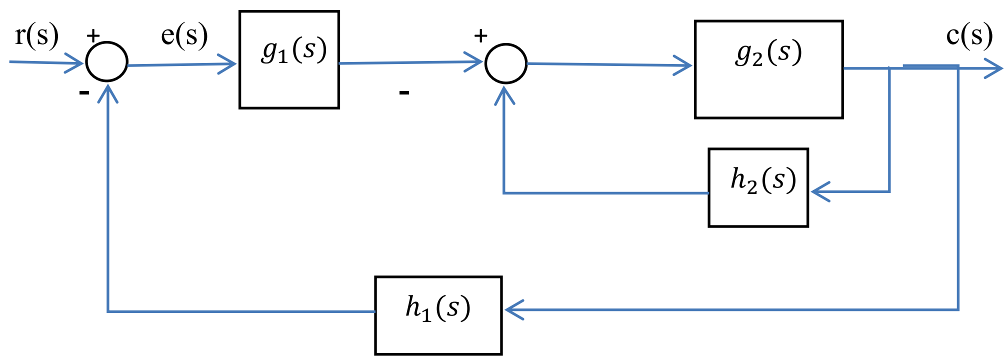

Figure 2.2

QUESTION 3

(a) Create a bode plot for the plant /controller having the transfer function:

$$G(s) = \frac{10}{(1+s)(1+0.6s)(1+0.1s)} \qquad [10]$$

(b) On the plot clearly show:

(i) The gain crossover frequency. [1]

(ii) The gain margin. [1]

(iii) The phase cross-over frequency. [1]

(iv) The phase margin. [1]

(c) Determine the stability of the system. . [2]

(d) Write the Matlab command to plot the Bode diagram of the system. [4]

QUESTION 4

(a) State the following theorems

(i) Initial Value Theorem . [2]

(ii) Final value theorem. [2]

(b) Use the Initial and final value theorems to determine the initial and final values of the corresponding casual time signals.

i. $H(s) = \frac{s-2}{s(s+2)}$ [3]

ii. $V(s) = \frac{s^3+10}{s^3(s+1)}$ [3]

Use the Routh array to test the stability of the system having the characteristic equation

$F(s) = s^5 + 2s^4 + 2s^3 + 2s^2 + s + 1$ [10]

QUESTION 5

A system has an open-loop transfer function of

$$G_o(s) = \frac{K}{s(s+6)}.$$

(c) What is the gain when there is

(i) critical damping? [5]

(ii) a damping ratio of 0.6? [5]

(d) Draw the root locus diagram for the system [10]

QUESTION 6

(a) With the aid of diagrams, explain what you understand by the term,'transfer function' of a system. [3]

(b) For what type of systems are transfer function techniques applicable? [2]

(c) Evaluate the following transfer functions

(i) $\dfrac{Y(s)}{U(s)}$ [4] and

(ii) $\dfrac{Z(s)}{U(s)}$ for the block diagram shown in Fig Q6.1 below. [4]

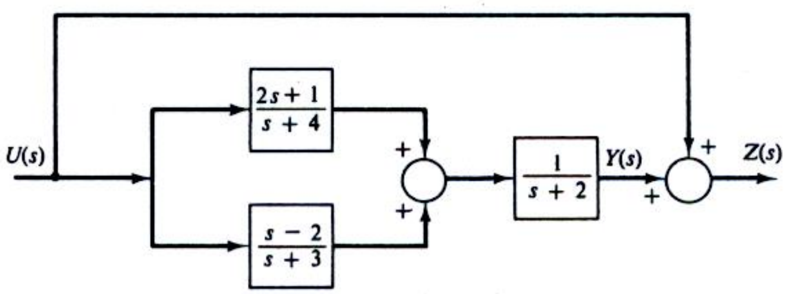

Figure Q6.1

(d) Figure Q6.2 below shows a passive electrical network. Determine the differential equation relating $v_1(t)$ and $v_2(t)$. [7]

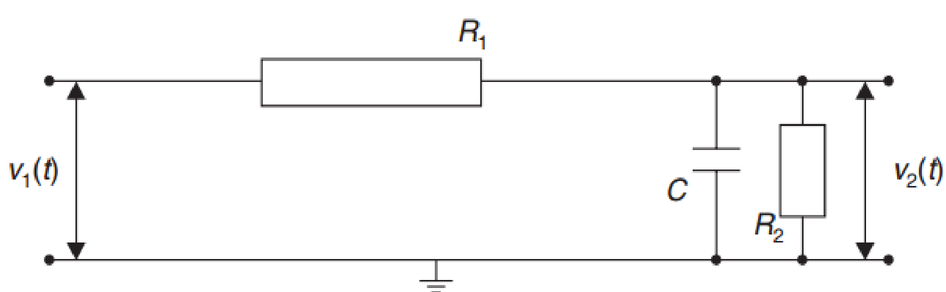

Figure Q6.2

QUESTION 7

(a) Draw the Nyquist diagram for the system whose transfer function G(s) is given as

$$G(s) = \frac{1}{s(s+4)(s+6)} \qquad [10]$$

(b) On the diagram show clearly

i. The gain margin [4]

ii. The phase margin [4]

(c) From the diagram investigate the stability of the system [2]

END OF EXAMINATION