NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

Bachelors of Engineering: Honours Degree in Industrial and Manufacturing Engineering
Industrial Instrumentation and Control – TIE 3214

2nd SEMESTER SUPPLIMENTARY EXAMINATIONS – OCTOBER 2009

Time allowed: 3 hours
Instructions: Answer FIVE (5) questions. The marks allocated to each question are given in square brackets against the right hand column.
Semi-log, normal graph papers and Laplace Tables are provided.

Question 1
Figure Q1 below shows a mass, spring damper system.

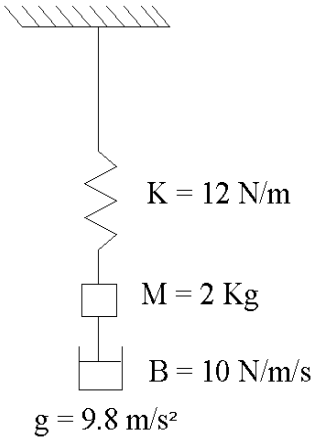

Figure Q1 Mass, spring, damper system

a) Show that the system above can be represented by a second order differential equation of the form

$$M\ddot{p}(t) + Bp(t) + Kp(t) = Mg \qquad [8]$$

b) Transform the differential equation by the term p(t) (Mg is a constant) [4]
c) Find the poles of the transform P(s) and then expand P(s) in partial fractions [4]
d) Find the position p(t) and then determine the equation for the velocity v(t) of the mass by differentiating p(t). [4]

Question 2
Using standard block reduction techniques derive the overall transfer function for the system represented by the block diagram in figure Q2 below. [12]

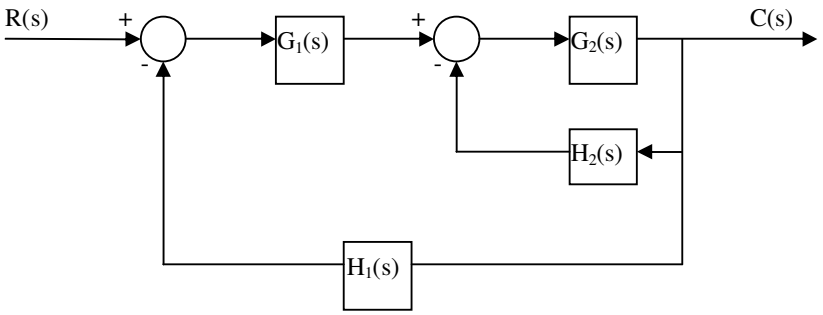

Figure Q2 Block Diagram

b) Given that $G_1(s) = \frac{1}{s+2}$, $G_2(s) = \frac{3}{s+1}$, $H_1(s) = H_2(s) = 1$. Find $\frac{C(s)}{R(s)}$ [5]

c) Define the transfer function of a system [3]

Question 3

The open loop transfer function of a system, G(s), is given as

$$G(s) = \frac{5}{s(0.6s+1)(0.1s+1)}$$

a) Determine

(i) $|G(j\omega)|$ [4]

(ii) ArgG(jω) [4]

b) Give Determine the closed-loop transfer function of the system for the unity feedback. [6]

c) Using the Routh-Hurwitz stability criterion to determine the stability of the system [6]

Question 4

a) State the Nyquist stability criterion. [3]

b) Plot the Nyquist diagram for a system with a transfer function

$$G(s) = \frac{5}{(2s+1)(s^2+s+1)}$$ [10]

c) From the Nyquist diagram, determine, stating your reasons, if the system is stable. [3]

d) Write a Matlab program to plot the Nyquist plot for the system. [4]

Question 5

A system has an open loop transfer function of

$$G(s) = \frac{1}{s(s+6)(s+4)}$$

a) Draw the root locus diagram for the system. [8]

b) For which gain values is the system over damped [4]

c) What is the gain when there is a damping ration of 0.5 [4]

d) Write a Matlab program to plot the root locus for the system. [4]

Question 6

A system has an open loop transfer function of

$$G(s) = \frac{1}{s(s+6)(s+4)}$$

a) Draw the Bode plot for the system. [10]

On the plot shoe clearly the

b) Gain cross over frequency [1]
c) Gain margin [1]
d) Phase cross over frequency [1]
e) Phase margin [1]

f) Determine if the system is stable stating your reason. [2]

e) Write a Matlab program to plot the Bode plot for the system. [4]

Question 7

a) Given that the input to a system, whose transfer function is G(s), is u(t) and the output of the system is y(t), show this on a block diagram and define the error e(t) [4]
b) Derive the error transfer function E(s) of the system in (a) [4]
c) For what type of systems are transfer functions techniques applicable? [2]
d) Show using a diagram the difference between open loop and closed loop systems [2]
e) What advantages do closed loop systems have over open loop systems [4]
f) Explain the concept of critical damping and two areas of application [4]

End of Exam