KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2011/2012

FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE

SET 410: SYSTEMS AND CONTROL ENGINEERING

DATE: Tuesday 6th December, 2011 **TIME:** 8.00 a.m. – 10.00 a.m.

INSTRUCTIONS:

(i) There are a total of **Five** Questions.
(ii) Select any **Three** Questions, each of which carries **20 Marks**. .
(iii) Define all symbols used.
(iv) Marks will be awarded for procedure, methodologies used and not necessarily the final answer.

Q.1. (a) Fig. Q1 is a translational system consisting of a mass M attached to a spring of stiffness K and a dash pot of viscous friction coefficient f, on which a force F acts to cause a positive displacement x.

(i) Draw the free body diagram and its equivalent mechanical network. (7-Marks)

(ii) Obtain the Transfer Function of the Mechanical System (5 Marks)

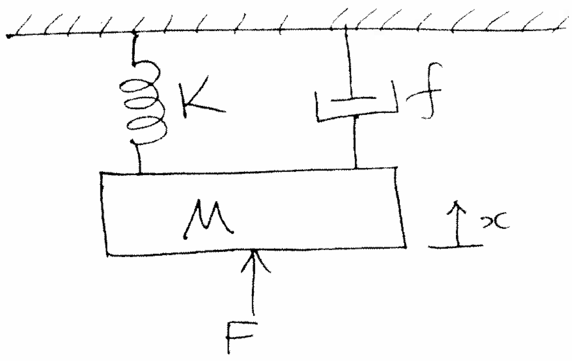

fig Q1

(b) With the help of suitable diagrams outline the Control System's performance specifications to a unit step input in the following domains:-

(i) Frequency. (4-Marks)

(ii) Time. (4-Marks)

Q.2. (a) Given a system $H(s)$ whose Transfer Function is $H(s) = \frac{K}{s(s+6)(s+1)}$.

(i) What value of K should be chosen to have a steady state error of 0.5 to a unit ramp input. (5-Marks)

(ii) Determine the minimum value of steady state error to a ramp which can be achieved with this system. (5-Marks)

(b) (i) Give the value of K for which the closed loop system will have approximately 15% overshoot to a step input. (5-Marks)

(ii) Determine the frequency of possible sustained oscillations and the corresponding value of K. (5-Marks)

Q.3. (a) (i) Discuss the Nyquist Stability Criterion.

(5-Marks)

(ii) How can the Routh Stability Criterion be applied to Transfer Functions which contain pure time delays i.e. functions of the form e^{-ST}?

(5-Marks)

(b) A system has poles in the s-plane located at -1, -3, and -5; and zeros at +1, -2, and -4.

(i) Is the system stable? (3-Marks)

(ii) Give correct reasons for your conclusions. (7-Marks)

Q.4. A unity feedback control system has the following open loop transfer function:-

$$H(s) = \frac{100}{s(s+100)}$$

(a) Plot the assymptotic Bode diagrams for the:-

(i) Open loop transfer function. (5-Marks)

(ii) Close loop system. (5-Marks)

(b) Determine the:-

		(i)	Bandwidth of the closed loop system.	(5-Marks)
		(ii)	The rise time for a step input.	(5-Marks)

Q5. (a) (i) Deduce from first principles the parametric equations for the M-Circles on an M-N diagram. (7-Marks)

(ii) Explain the significance of the circles in (i) above. (3-Marks)

(b) Sketch the Nyquist diagrams for the following open loop transfer functions in the frequency range $0 < \omega < \infty$.

(i) $H(s) = \frac{1}{s^2}$ (2-Marks)

(ii) $H(s) = \frac{(s+10)}{s^2}$ (3-Marks)

(iii) $H(s) = \frac{1}{s(s+\text{[illegible]})(s+10)}$ (3-Marks)

(iv) $H(s) = e^{-s}$ (2-Marks)