Uva Wellassa University of Sri Lanka
Faculty of Science and Technology
Department of Science and Technology
400 level 1st Semester Examination – Jul. / Aug. 2016
SCT 462 - 2 Control Theory

Instructions to candidates

Duration: (Two) hours

Number of questions: Four (04)

Mark allocation: 100

Answer all questions

1.

a.

i. Explain the terms open-loop and closed loop controls in the design of control systems.

ii. Describe the advantages and disadvantages of the open-loop and closed-loop controls.

iii. Using a block diagram show the componenets of a closed loop control system.

iv. What is the purpose of the sensor in a closed-loop control system?

v. What is the purpose of the actuator in a closed loop control system?

vi. Draw a block diagram to illustrate the closed-loop speed control system of a Turn tablw with a DC motor. Identify the actuator, process, plant and the disturbances of the system you have shown. (12 Mark)

b. Figure 1 shows an electrical circuit based on a operational amplifier. Assume that the operational amplifiers is ideal.

i. Applying Kirchchoff's laws, obtian the dynamic equation to describe the relationship between the input v_i and the output v_o

ii. Hence obtain the transfer function $E_o(s)/E_i(s)$. State any assumption you have made.

21

67

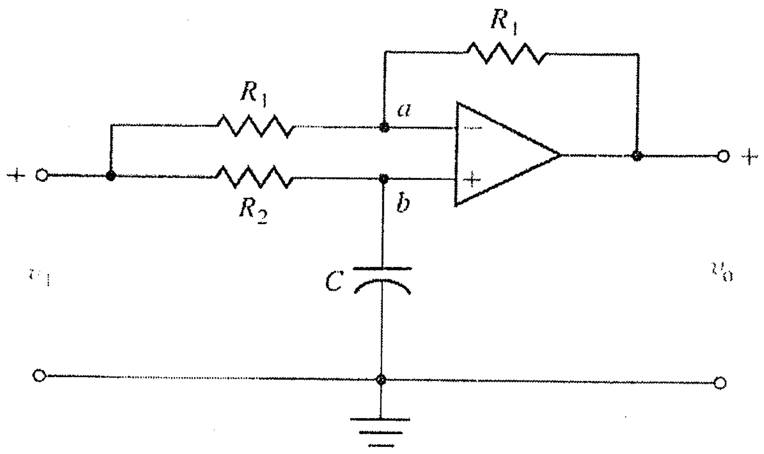
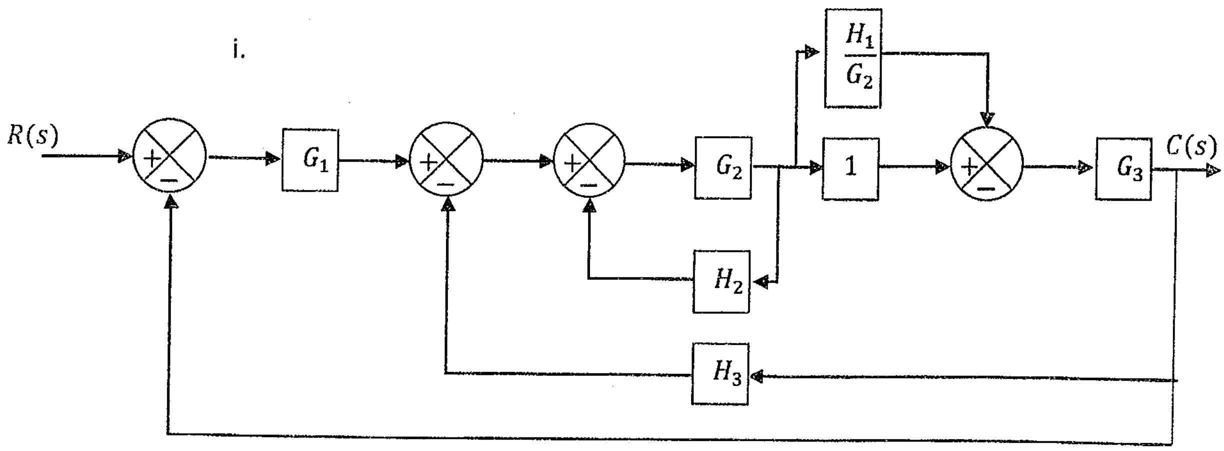


Figure 1 (13 Marks)

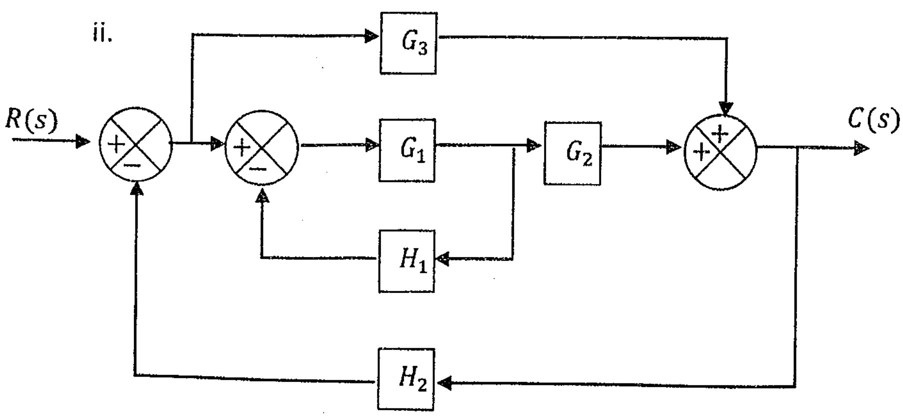
2.

a. Showing the block diagram reduction techniques you use, obtain the transfer function $C(s)/R(s)$ for each of following control system.

i.



ii.



(12 Mark)

b. Consider the three systems given by the following transfer functions.

$$1.\, G(s) = \frac{(3s-1)s}{s+2} \qquad 2.\ G(s) = \frac{(s+6)s}{s^2+8s+25} \qquad 3.\ G(s) = \frac{3s}{(s+3)(s^2+8s+25)}$$

i. Find the poles and zeros for the above three systems.

ii. Find the time function corresponding to the unit step input of each of the systems using partial franction expansions. (13 Mark)

3.

a.

i. State Final Value Theorem

ii. When the input is a unit step function to the following systems, use Final Value Theorem to find the final value of the output signal,

$$1.\, G(s) = \frac{(s+1)}{2s^2-3s+2} \qquad 2.\ G(s) = \frac{3(s+5)}{s^2+2s+7}$$

(07 Mark)

b. Drawing a suitable time response, explaine the terms rise time, settling time, overshoot and peak time associated with control system. (06 Mark)

c. For the system shawn in the Figure 3, Mass(m) = 1kg, spring coefficient(k) = 4N/m, damping coefficient (c) = 2Ns/m and evaluvate following,

i. Equation of time response ?
ii. Natural Frequency ?
iii. Damped Natural Frequency ?
iv. Final Value ?
v. Periodic Time ?
vi. Rise Time ?
vii. Peak time magnitude ?

viii. Settling Time (3%) ?

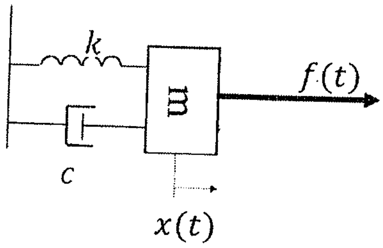


Figure 3

(12 Mark)

4.

a. A unity feedback system is shown in Figure 4.1 , Assume that k>0

i. It is required to design the system so that it gets 5 % overshoot and 1 s peak time. Determine whether both specification can be met simultaniousy by selecting a suitable value for k.

ii. What is the rise time the system can have with 5 % overshoot

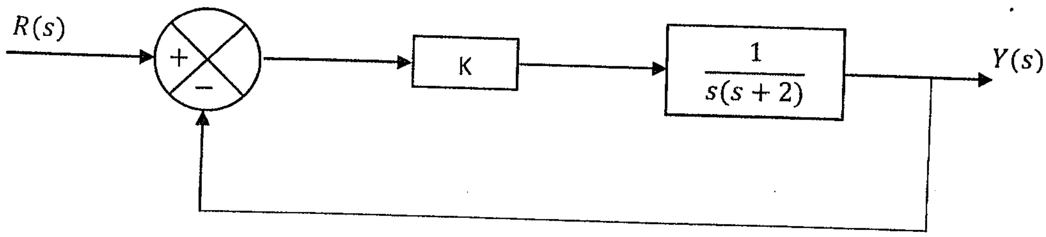


Figure 4.1

(hint : peak overshoot = $e^{\left(\frac{-\pi\zeta}{\sqrt{1-\zeta^2}}\right)} \times 100\ \%$ *)*

(10 Mark)

b. Consider the mechanical vibratory system shown in Figure 4.2. Assume that the displacement is measured from the equilibrium position in the absence of the sinusoidal excitation force. The initial conditions are $x(0) = 0$ and $\dot{x}(0) = 0$, and the input force $p(t) = P \sin \omega t$ is applied at $t = 0$. Assume that $m = 2\,kg, b = 24\,N-s/m, k = 200\,N/m, P = 5\,N.$ and $\omega = 6\,rad/s$. Obtain the complete solution $x(t)$.

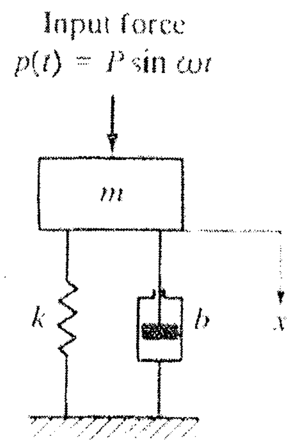


Figure 4.2. (15 Mark)

Table of Laplace Transforms

$F(s)$	$f(t), t \geq 0$
1	$\delta(t)$
$\frac{1}{s}$	$1(t)$
$1/s^2$	t
$\frac{2!}{s^3}$	t^2
$\frac{3!}{s^4}$	t^3
$\frac{m!}{s^{m+1}}$	t^m
$\frac{1}{s+a}$	e^{-at}
$\frac{1}{(s+a)^2}$	$t\,e^{-at}$
$\frac{1}{(s+a)^3}$	$\frac{1}{2!}t^2\,e^{-at}$
$\frac{1}{(s+a)^m}$	$\frac{1}{(m-1)!}t^{m-1}\,e^{-at}$
$\frac{a}{s(s+a)}$	$1-\,e^{-at}$
$\frac{a}{s^2(s+a)}$	$\frac{1}{a}(at-1+\,e^{-at})$
$\frac{b-a}{(s+b)(s+a)}$	$e^{-at}-e^{-bt}$
$\frac{s}{(s+a)^2}$	$e^{-at}(1-at)$
$\frac{a^2}{s(s+a)^2}$	$1-\,e^{-at}(1+at)$
$\frac{(b-a)s}{(s+b)(s+a)}$	$be^{-bt}-ae^{-at}$
$\frac{a}{(s^2+a^2)}$	$sinat$
$\frac{s}{(s^2+a^2)}$	$cosat$
$\frac{s+a}{(s+a)^2+b^2}$	$e^{-at}cosbt$
$\frac{b}{(s+a)^2+b^2}$	$e^{-at}sinbt$
$\frac{a^2+b^2}{s[(s+a)^2+b^2]}$	$1-\,e^{-at}(cosbt+\frac{a}{b}sinbt)$