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DEPARTMENT OF COMPUTER AND ELECTRICAL ENGINEERING
ELNG 305: Classical Control Systems – Mid-semester Examinations

October, 2018

Duration: 1 hour

Instruction(s): Answer All Questions

Question 1

- (a) Using figures and/or examples, differentiate between closed loop and open loop systems. [2 marks]
- (b) An electrical network is shown in Figure 1. The differential equations relating the

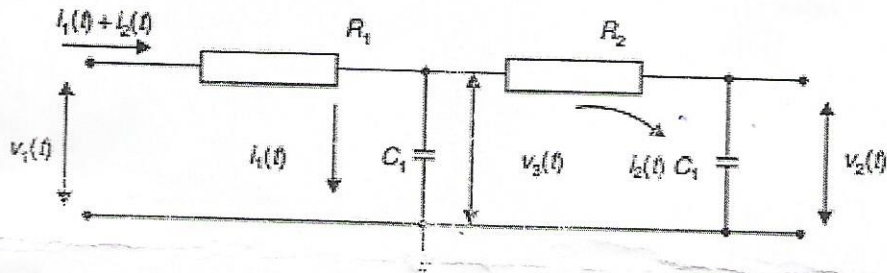


Figure 1: Electrical network for Question 1(b)

voltages and currents $i(t)$ are given below.

$$v_1(t) - v_3(t) = R_1(i_1(t) + i_2(t))$$

$$C_1 \frac{dv_3}{dt} = i_1(t)$$

$$C_2 \frac{dv_2}{dt} = i_2(t)$$

$$v_3(t) - v_2(t) = R_2 i_2(t)$$

- i. Derive the transfer function, $\frac{V_2(s)}{V_1(s)}$ of the network.

[4 marks]

- (c) The transfer function of a system is

$$\frac{Y(s)}{R(s)} = \frac{15(s+1)}{s^2 + 9s + 14}$$

When $r(t)$ is a unit step,

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- i. determine $y(t)$ [5 marks]
- ii. what is the final value of $y(t)$ [2 marks]

Total for Question 1: 13

Question 2

- (a) A system is defined by the transfer function $G(s) = \frac{2}{(s^2 + 4)(s + 2)(s + 5)}$. Comment on the stability of the system. [2 marks]
- (b) In a unity feedback system with open loop transfer function

$$G(s) = \frac{2K}{s(s^2 + 2s + 5)}$$

The value of K is adjustable(+ve or -ve) and its value affects the stability of the system. With a Routhian table, determine the range of K where the system is stable, unstable or marginally stable. [5 marks]

- (c) Figure 2 (shown below) is the signal flow graph of a control system. Find the overall transmittance using the Mason's gain formula. [6 marks]

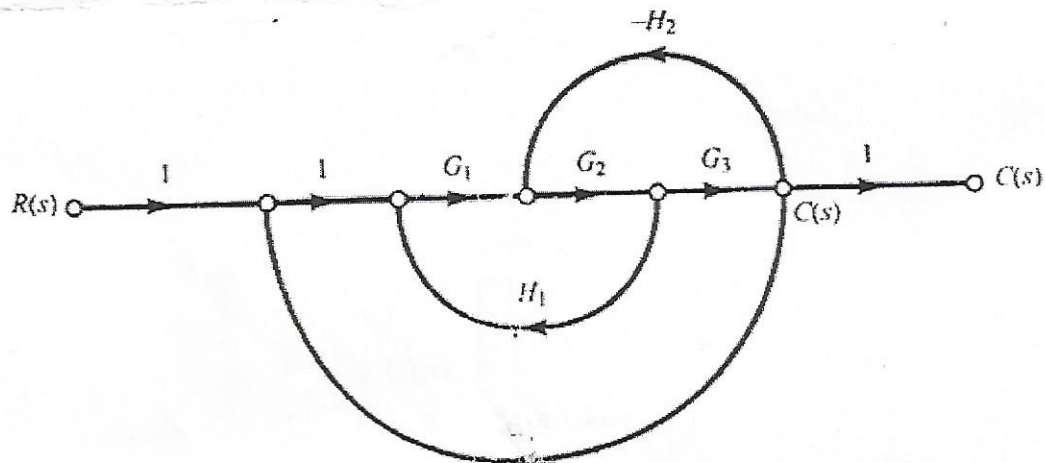


Figure 2: For Question 2

Total for Question 2: 13

Question 3

- (a) A negative feedback system has a forward path transfer function,

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

and a feedback transfer function

$$H(s) = 1$$

Determine

- the order of the system.
 - the rise time, the delay time and the settling time
- (b) For the unity feedback system shown in Figure 3, where

$$G(s) = \frac{45(s+8)(s+12)(s+15)}{s(s+38)(s^2+2s+28)}$$

find the steady-state errors for each of the following test inputs:

- step input: $r(t) = 5u(t)$
- ramp input: $r(t) = 7tu(t)$

[1 mark]

[3 marks]

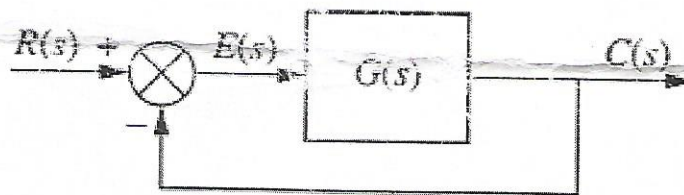


Figure 3: For Question 3b: Feedback system

[4 marks]

- (c) i. Figure 4 shows the step responses of three systems, SysX, SysY and SysZ. The transfer function of the systems are

$$SysX = \frac{36}{s^2 + 4s + 49}, \quad SysC = \frac{36}{s^2 + 20s + 36} \quad \text{and} \quad SysZ = \frac{6}{s^2 + 25}$$

Match each system with its correct step response.

[3 marks]

- ii. The open loop transfer function of a closed loop system is

$$\frac{K}{s^2 + 2s}$$

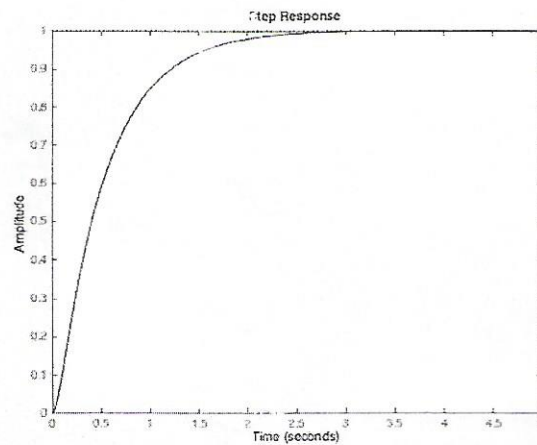
Find the value of K such that the step response has the minimum settling time at no overshoot.

[3 marks]

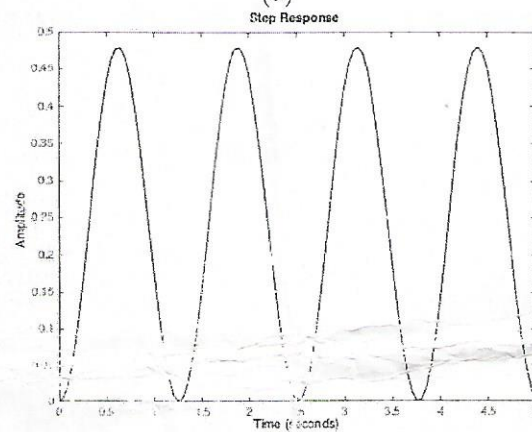
$\frac{1}{s^2}$

$\frac{1}{s^2}$	$\frac{1}{s}$	$\frac{1}{s}$
$\frac{1}{s}$	$\frac{1}{s^2}$	$\frac{1}{s^2}$

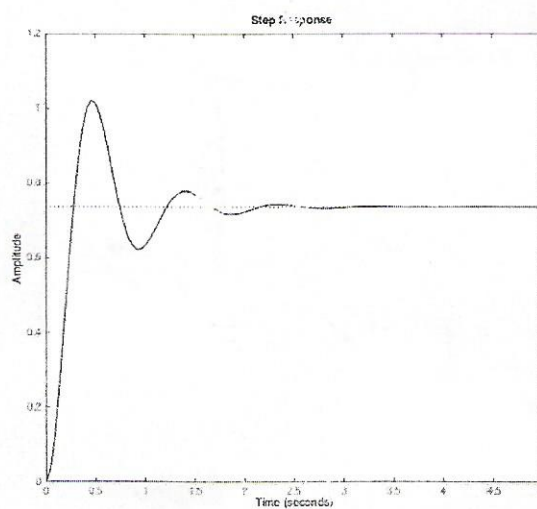
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(a)



(b)



(c)

Figure 4: For Question 3i: Step Responses of three systems