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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

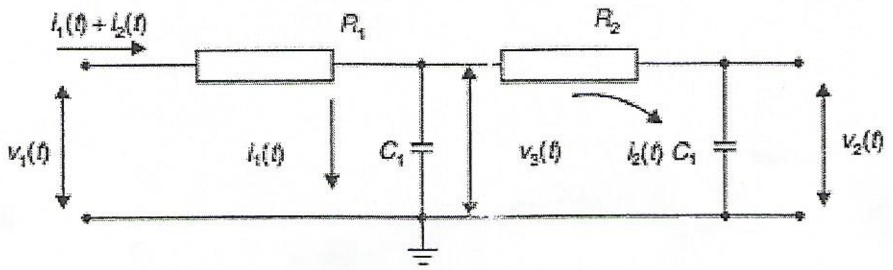


Figure 1: Electrical network for Question 1(b)

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,

i. determine $y(t)$ [5 marks]

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

Total for Question 1: 13

Question 2

marginally stable

(a) A system is defined by the transfer function $G(s) = \dfrac{2}{(s^2+4)(s+2)(s+5)}$. Comment on the stability of the system. [2 marks]

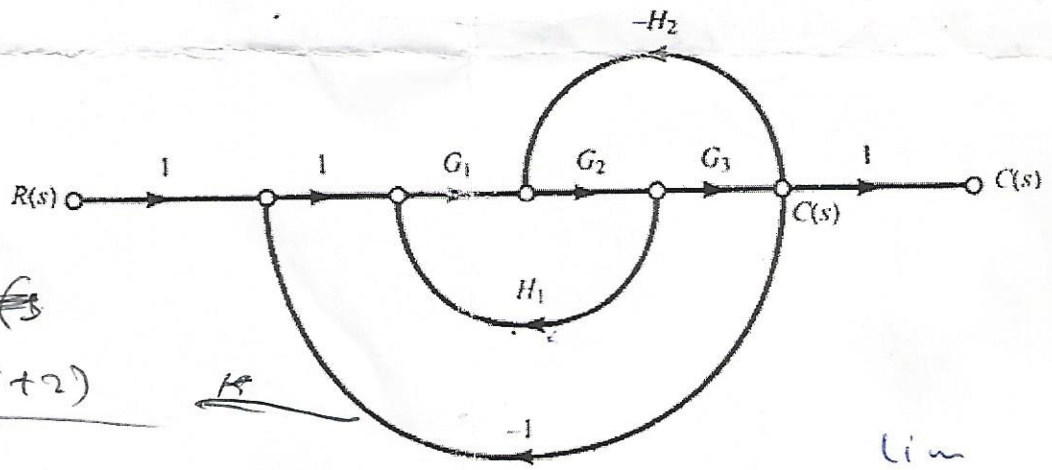
(b) In a unity feedback system with open loop transfer function

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

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]

10 − 2K



1(s+2)

K

lim

→ α

Figure 2: For Question 2

Total for Question 2: 13

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Question 3

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

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

S+6 + 1

and a feedback transfer function

$$H(s) = 1$$

Determine

i. the order of the system. [1 mark]

ii. the rise time, the delay time and the settling time [3 marks]

(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:

i. step input: $r(t) = 5u(t)$

ii. ramp input: $r(t) = 7tu(t)$

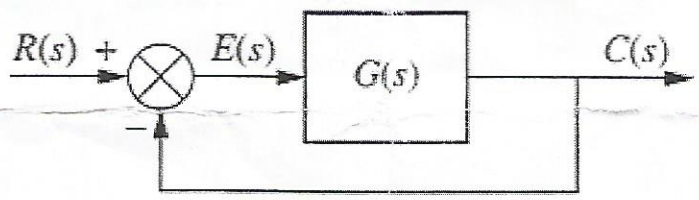


Figure 3: For Question 3b: Feedback system

[4 marks]

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

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

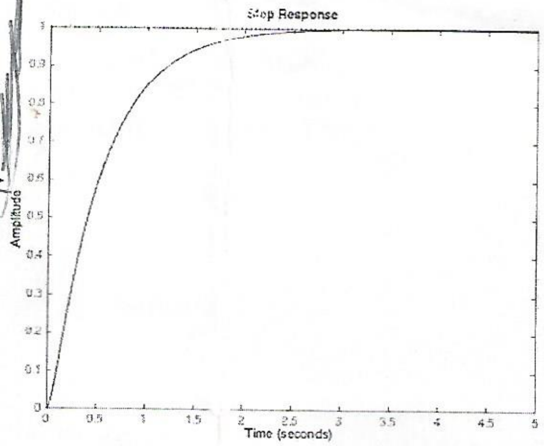
Match each system with its correct step response. [3 marks]

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

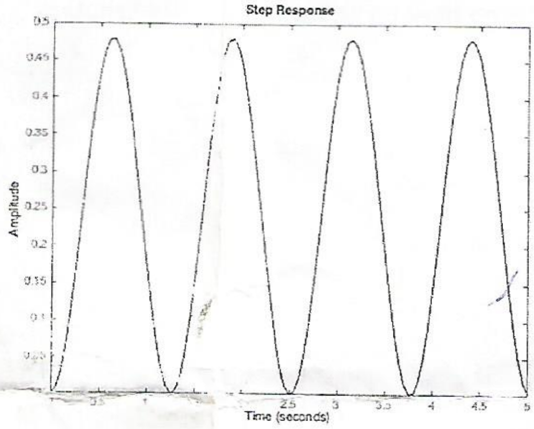
$$\frac{K}{s^2+2s}.$$

Find the value of K such that the step response has the minimum settling time at no overshoot. [3 marks]

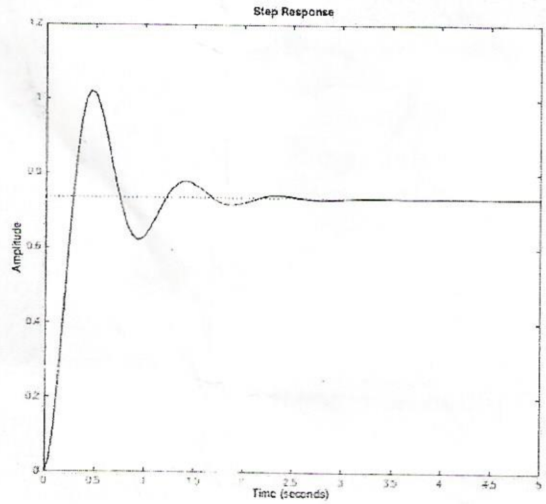
$$\lim_{s \to 3} \frac{s^2+s+1}{s^3-1} = \frac{9+3+1}{27-1} = \frac{13}{26}$$



(a)



(b)



(c)

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