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FINAL
Examination Paper

(COVER PAGE)

Session	:	**April 2017**
Programme	:	Diploma In Electrical And Electronic Engineering (DEEI)
Course	:	**EEE2108: Modern Control Systems Engineering**
Date of Examination	:	28 July 2017 (Friday)
Time	:	2:00pm – 4:00pm
Duration	:	2 Hours Reading Time : Nil
Special Instructions	:	

This paper consists of **SIX (6)** questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks.

IMPORTANT NOTE : THIS PAPER SHOULD NOT BE TAKEN OUT OF THE EXAMINATION HALL BY THE STUDENTS.

Materials Permitted :
Scientific Calculator (Model fx570 Series)

Materials Provided :
Laplace Transform Table
Formula Sheet

Examiner(s)	:	**Chan Tse Wei**
Moderator	:	Dr. Ooi Beng Lee

This paper consists of 7 printed pages, including the cover page.

INTI INTERNATIONAL COLLEGE PENANG

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING PROGRAMME (DEEI)
EEE2108: MODERN CONTROL SYSTEMS ENGINEERING
FINAL EXAMINATION: APRIL 2017 SESSION

Instructions: This paper consists of **SIX (6)** questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks. Marks for each sub-question are shown in square brackets. Present your answers neatly and clearly. The assessor reserves the rights to ignore your answers if they are ambiguous.

Question 1P

a. The electronic system shown in Figure-Q1(a) is used as lag-lead compensator in electronic control system. Derive its voltage transfer function, expressing it in factor form. [5]

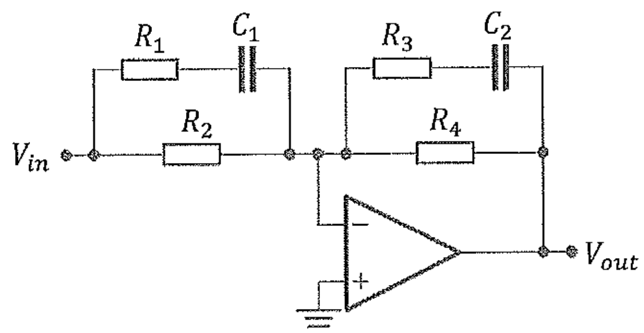

Figure-Q1(a)

b. Verify the voltage transfer function obtained in part (a) using Mason's gain formula. [10]

c. With the aid of block diagram algebra, simplify the block diagram shown in Figure-Q1(c) into a single block, containing the system's overall transfer function. [10]

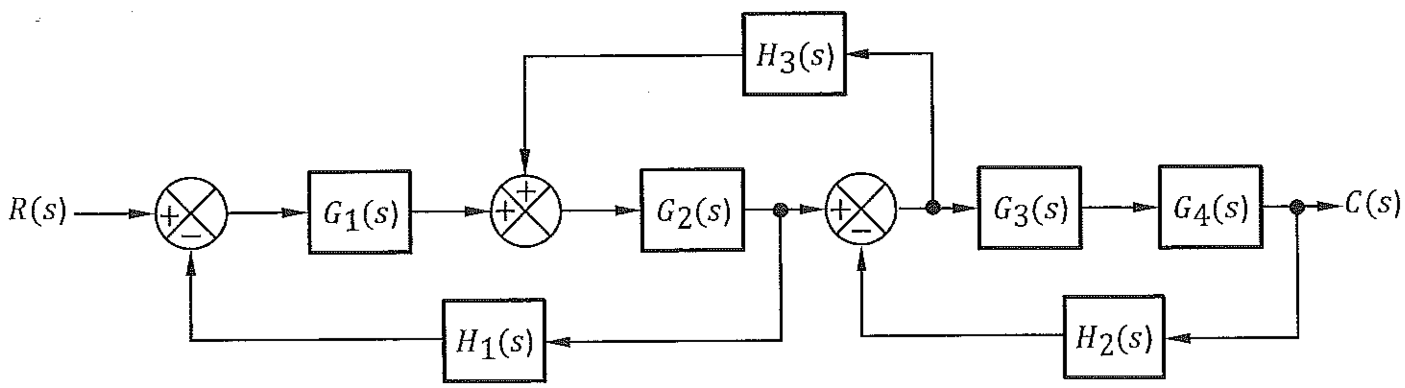

Figure-Q1(c)

Question 2

a. Justify the stability of the following systems respectively:

i. $\frac{C(s)}{R(s)} = \frac{10}{(s+2)(s-5)}$ [1]

ii. $\frac{C(s)}{R(s)} = \frac{s+5}{s^2+30s+200}$ [2]

iii. $\frac{C(s)}{R(s)} = \frac{s-2}{(s+5+j7)(s+5-j7)}$ [1]

iv. $\frac{C(s)}{R(s)} = \frac{35}{s^3+3s^2+23s+35}$ [2]

b. The dynamics of a system is mathematically modeled as follows:

$$\frac{d^2c(t)}{dt^2} + 5\frac{dc(t)}{dt} + 25c(t) = 25r(t)$$

Where, $c(t) = \text{system's output}$ and $r(t) = \text{system's input}$, all initial conditions of the system is zero.

i. Convert the equation model for frequency domain analysis. [3]

ii. Determine the system's steady-state output value if $r(t) = 10$. [4]

iii. Determine the system's steady-state error if $r(t) = 2t$. [4]

c. The transfer function of a control system is given by,

$$T(s) = \frac{128}{s^2 + a_1 s + 64}$$

where a_1 is a variable governed by one of the system's parameters. Briefly describe the system's step response for the following values of a_1:

i. $a_1 = 0$ [2]

ii. $a_1 = 8$ [3]

iii. $a_1 = 32$ [3]

Question 3

a. i. Explain how the elements in the first column of a Routh array justify for the stability of a system. [3]

ii. Explain how Routh array helps in manually setting up the root locus of a system. [3]

iii. Explain the condition where a system stability can be immediately identified without the need of Routh array. [3]

b. The characteristic equation of a feedback control system is $s^3 + 3Ks^2 + (K+2)s + 4 = 0$. Determine the range of K for which the system is stable. [6]

c. Determine all the pole location of a system whose transfer function is given by,

$$T(s) = \frac{10}{s^5 + 7s^4 + 6s^3 + 42s^2 + 8s + 56}$$ [10]

Question 4

a. Figure-Q4(a) shows a block diagram of a DC position control system, where,

θ_r = required angular position

θ_c = controlled angular position

A = amplifier gain value

K = Tachogenerator voltage

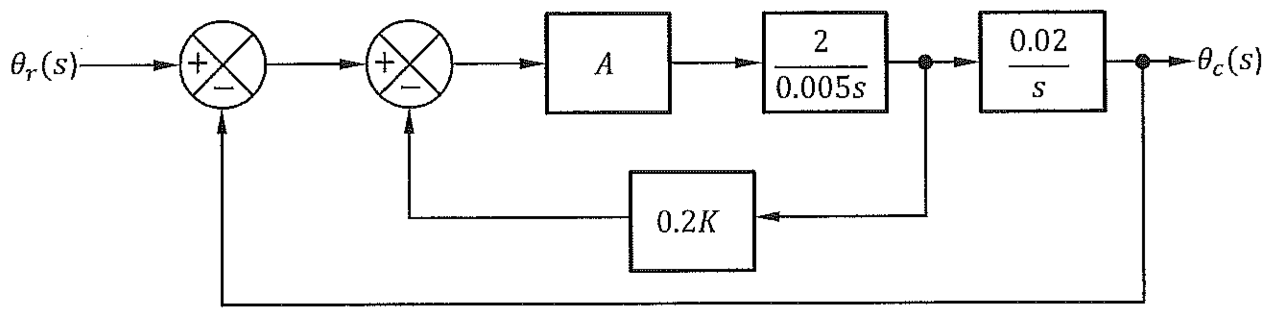

Figure-Q4(a)

Determine the required values of A and K so that the system exhibits an underdamped response with a damping factor of 0.8 and a damped natural frequency of 2.4 rad/s. [15]

b. Figure-Q4(b) shows the timing diagram of the response, $c(t)$ of a second order control system towards an input, $r(t)$. Based on the response plot, estimate the transfer function of the system. [10]

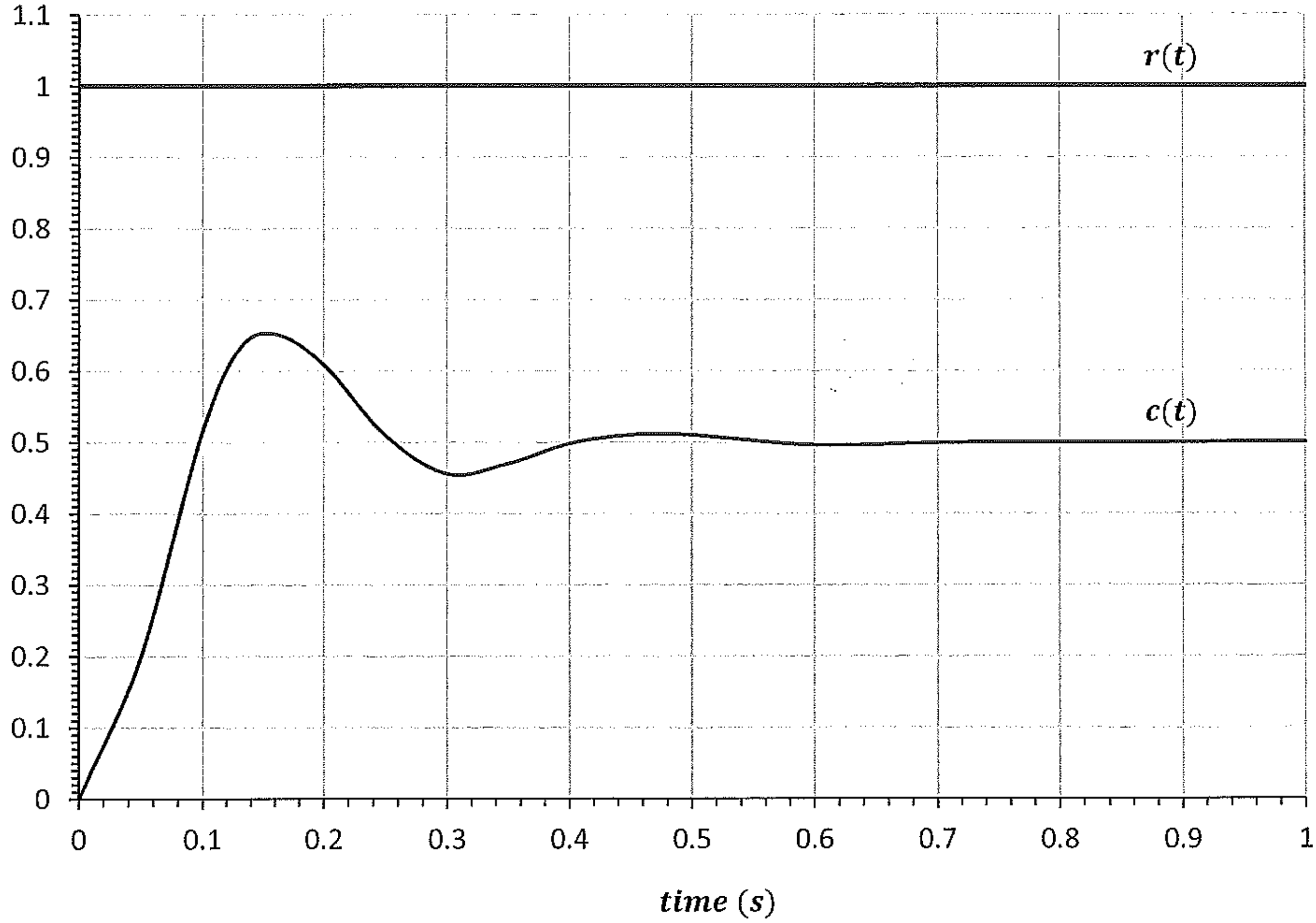

Figure-Q4(b)

Question 5

a. Figure-Q5(a) shows the root locus plot of a negative unity feedback control system.

i. Determine the open-loop transfer function, $G(s)$ of the system. [4]

ii. Calculate the breakaway point of the root locus plot. [4]

iii. Determine the gain value, K, that causes the system to exhibit critically damped response. [5]

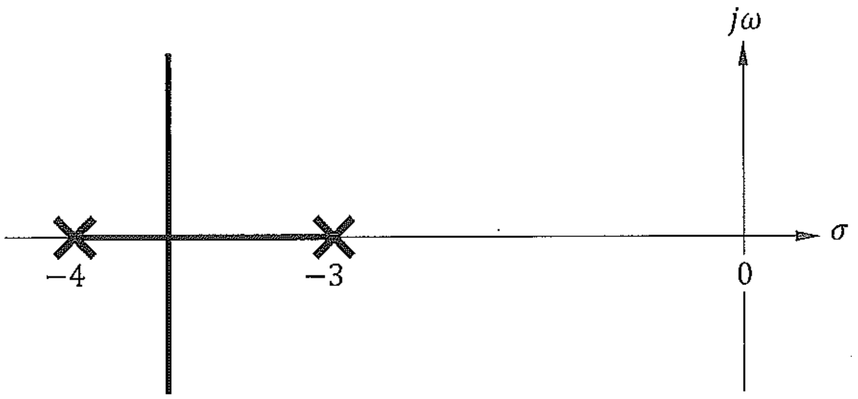

Figure-Q5(a)

b. A system has an open-loop transfer function given by,

$$G(s)H(s) = \frac{K(s+1)}{s^2(s+2)}$$

i. Sketch the root locus of the system. [6]

ii. Determine the values of K that cause the system unstable. [3]

iii. Determine the value of K that causes the system to have closed-loop poles located at $s = -1 \pm j$. [3]

Question 6

a. A type-0 negative unity feedback system has an open-loop transfer function given by,

$$G(s) = \frac{K}{1 + sT_1}$$

i. Calculate the static position error constant (K_p) of the system. [2]

ii. Sketch the Bode magnitude diagram of $G(s)$. [3]

iii. From the sketch obtained in part (a)(ii), identify the point that indicate the static position error constant of the system. [1]

b. A type-1 negative unity feedback system has an open-loop transfer function given by,

$$G(s) = \frac{K}{s(1 + sT_1)}$$

Assume $K > 1$ and $\frac{1}{T_1} > 1$.

i. Calculate the static velocity error constant (K_v) of the system. [2]

ii. Sketch the Bode magnitude diagram of $G(s)$. [4]

iii. From the sketch obtained in part (b)(ii), identify the points that indicate the static velocity error constant of the system. [2]

c. A type-2 negative unity feedback system has an open-loop transfer function given by,

$$G(s) = \frac{K}{s^2(1 + sT_1)}$$

Assume $K > 1$ and $\frac{1}{T_1} > 1$.

i. Calculate the static acceleration error constant (K_a) of the system. [2]

ii. Sketch the Bode magnitude diagram of $G(s)$. [5]

iii. From the sketch obtained in part (c)(ii), identify the points that indicate the static acceleration error constant of the system. [4]

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