

INTI
International College Penang
LAUREATE INTERNATIONAL UNIVERSITIES*

FINAL
Examination Paper
(COVER PAGE)

Session : August 2017

Programme : Diploma in Electrical and Electronic Engineering (DEEI)

Course : EEE2108: Modern Control Systems Engineering

Date of Examination : 11 December 2017 (Monday)

Time : 11:00am – 1:00pm

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
Worksheet for Q6(b)(i) & Worksheet for Q6(b)(ii)

Examiner(s) : Chan Tse Wei

Moderator : Dr. Ooi Beng Lee

This paper consists of 6 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: AUGUST 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 1

- a. The following differential equation describes a control system:

$$\frac{d^3c}{dt^3} + 3\frac{d^2c}{dt^2} + 5\frac{dc}{dt} + c = \frac{d^3r}{dt^3} + 4\frac{d^2r}{dt^2} + 6\frac{dr}{dt} + 8r$$

The control system has zero initial conditions.

Produce the expression of the system's transfer function $C(s)/R(s)$.

[4]

- b. The following differential equation describes a control system:

$$\frac{d^2c}{dt^2} + 2\frac{dc}{dt} + 3c = r$$

The control system has the following initial conditions:

$$c(0) = 1, \quad \dot{c}(0) = -1$$

Produce a block diagram for the control system, derive its transfer function and all pertinent inputs and outputs.

[6]

- c. Figure-Q1(c) shows the schematic diagram modeling of a pneumatic system in which, $v_{in}(t)$ and $v_{out}(t)$ respectively represent the pneumatic system's input pressure and output pressure.

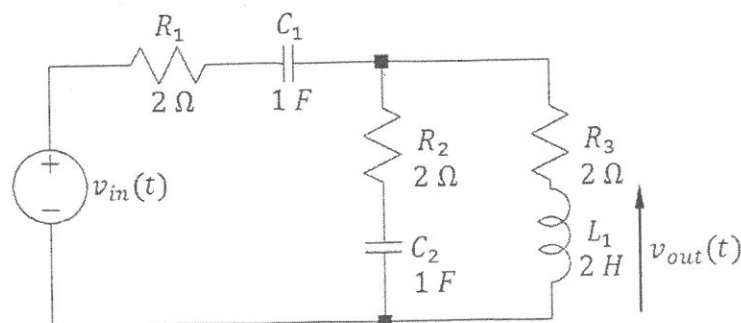


Figure-Q1(c)

- i. Produce the system's transfer function expression, $T(s) = V_{out}(s)/V_{in}(s)$, given that the system has zero initial conditions. [10]
- ii. Show that the pneumatic system produces zero output pressure if the input pressure is maintained constant. [5]

Question 2

- a.
 - i. Produce an equivalent block that represent $V_{out}(s)/V_{in}(s)$ in the system shown in Figure-Q2(a). [8]
 - ii. Calculate the system's damped frequency of oscillation. [5]
 - iii. If $V_{out}(s)$ in Figure-Q2(a) is applied to another system whose input must be limited to below 40 V, calculate the maximum step input value of $V_{in}(s)$. [5]

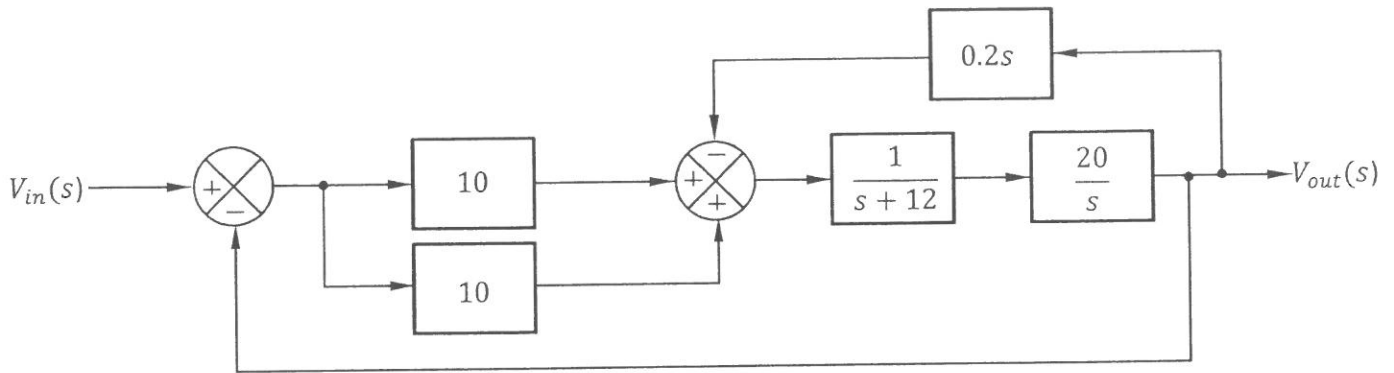


Figure-Q2(a)

- b. A control system is represented by the signal flow graph shown in Figure-Q2(b). R and C in Figure-Q2(b) are respectively the input and output of the system. The G 's and H 's in the figure are the transmittances of specific branches. Produce the transfer function expression for the system using signal flow graph technique. [7]

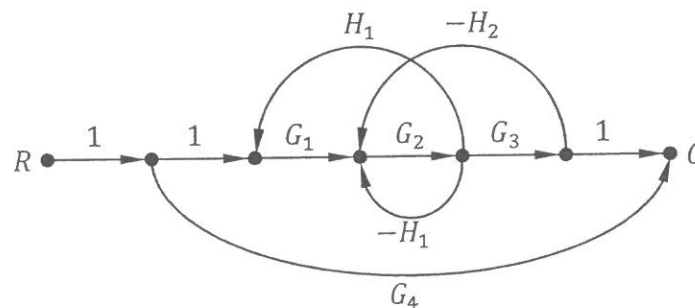


Figure-Q2(b)

Question 3

- a. i. Explain poles and zeros of a given control system. [4]
- ii. Explain the importance of knowing the locations of a system's poles in the s-plane. [3]
- iii. Explain the difference in transient behavior for two different second order systems having closed loops located at $s = -2 \pm j4$ and $s = -15 \pm j4$ respectively. [3]
- b. Map the transient responses "*Underdamped*", "*Critically Damped*", "*Overdamped*" and "*Undamped*" to the respective system pole locations shown in Figure-Q3(b)(i) to Figure-Q3(b)(iv). (Write your answers in the answer booklet in sequence.) [8]

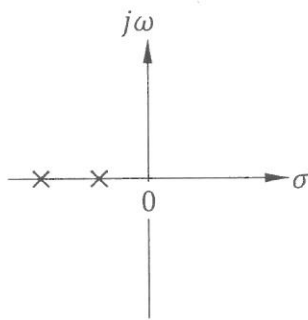


Figure-Q3(b)(i)

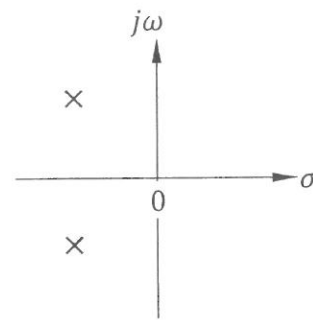


Figure-Q3(b)(ii)

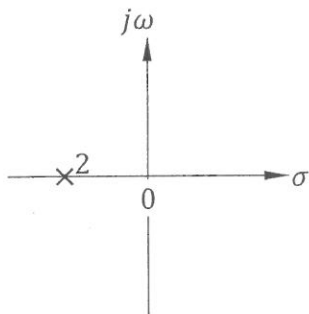


Figure-Q3(b)(iii)

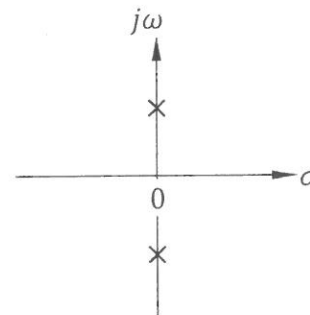


Figure-Q3(b)(iv)

- c. The closed-loop transfer function of a system is given by,

$$T(s) = \frac{s^2 + 4s - 3}{s^4 + 4s^3 + 8s^2 + 20s + 15}$$

Quantitatively explain the reason for this system to oscillate indefinitely in response to an impulse input.

[7]

Question 4

- a. i. The characteristic equation of a system is given by,

$$s^4 + 26s^3 + 123s^2 - 710s - 3400 = 0$$

State the absolute stability of the system. [2]

- ii. Quantitatively justify your answer given in part (a)(i). [5]

- b. A negative unity feedback system has an overall DC gain of 1. Its system positive gain, K in the feed-forward path is made variable. Figure-Q4(b) shows the s-plane plot of the system's open-loop poles and open-loop finite zeros.

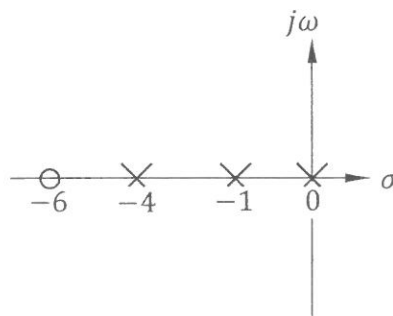


Figure-Q4(b)

- i. Formulate the system characteristic equation in polynomial form. [4]

- ii. Determine the range of K to ensure system stability. [5]

- c. i. Identify the type number of the system in Figure-Q4(c). [4]

- ii. Calculate the steady-state error of the system in response to $r(t) = 5tu(t)$. Where $u(t)$ is a unit step function. [3]

- iii. Suggest the improvement needed in the system to reduce the error of the system in Figure-Q4(c). [2]

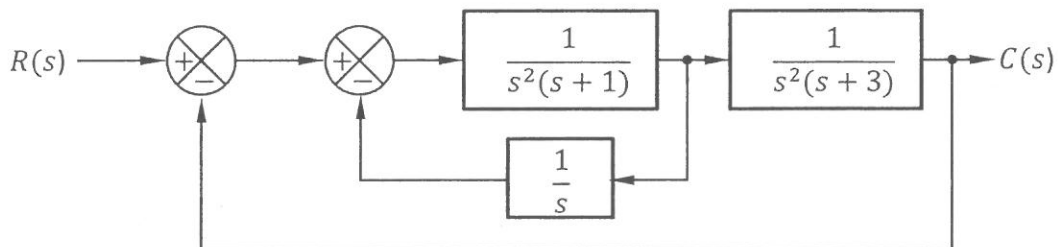


Figure-Q4(c)

Question 5

- a. Sketch the root locus for the system shown in Figure-Q5. Clearly show in the sketch,
- The $j\omega$ -axis crossing point and the associated K value (if any).
 - The breakaway and/or break-in points (if any).
 - The angles of departure and/or angles of arrival (if any).
- [20]
- b. Discuss the validity to approximate the system in Figure-Q5 to a first order system. [5]

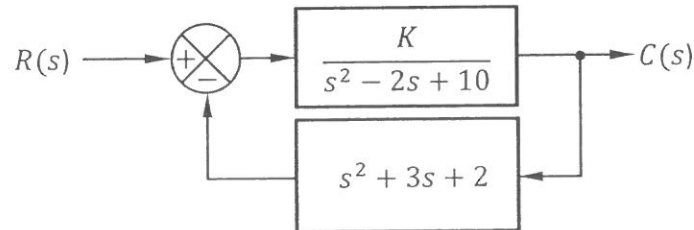


Figure-Q5

Question 6

- a. i. Explain frequency response of a physical system. [3]
- ii. List three commonly used plots for frequency response analysis. [3]
- iii. Briefly describe the approach to obtain a frequency response plot from a given transfer function. [4]
- b. The open-loop transfer function of a control system is given by,

$$G(s)H(s) = \frac{6}{s(s+1)(s+3)}$$

- i. Complete Table-Q6(b) in "Worksheet for Q6(b)(i)" by calculating the magnitude of GH in dB and the phase of GH in degree for all the listed frequency values. [4]
- ii. Construct the Nichols plot for the system using the data obtained in part (b)(i). Plot the graph in "Worksheet for Q6(b)(ii)". [4]
- iii. Estimate the gain margin and phase margin from the Nichols plot obtained in part (b)(ii). [6]
- iv. Comment on the stability of the system. [1]

~ The End ~

Student Name:	
Matriculation No.:	

Worksheet for Q6(b)(i)

ω (rad/s)	0.1	0.2	0.5	1.0	1.5	2.0	3.0
$ GH $ (dB)							
$\angle GH$ ($^{\circ}$)							

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Matriculation No.:	

Worksheet for Q6(b)(ii)

