INTI International College Penang

FINAL
ALTERNATIVE ASSESSMENT

(COVER PAGE)

Session	:	**August 2020**
Programme	:	Diploma in Electrical & Electronic Engineering (DEEI)
Course	:	**EEE2108: Modern Control Systems Engineering**
Date of Examination	:	16 December 2020 (Wednesday)
Time	:	8.00am – 11.00am Reading Time : Nil
Duration	:	3 Hours

Special Instructions :

Plotting of graph using computer software are NOT allowed in this exam.

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

Material permitted : Programmable Scientific Calculator

Materials provided :
Table of Laplace Transform (at Appendix)
Empty Bode Plot graph (at Appendix)

Examiner(s)	:	**Alan Wong Kam Mun**
Chief Moderator	:	Koay Ting Hoo

*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 ALTERNATIVE ASSESSMENT: AUGUST 2020 SESSION

Instructions: This paper consists of **FOUR (4)** questions. Answer all **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks.
Important notice: Computer software are NOT allowed in this exam except software to access the Question Paper and to submit the Answer Script. Answers are expected to be hand-written and required graph are to be manually plotted. Copy/paste and computer plotted graph will get zero marks.

Question 1

(a) For a system having characteristic equation $2s^4 + 4s^2 + 1 = 0$, use Routh-Hurwitz criterion to find the following:
 (i) the number of roots in the right half of s-plane.
 (ii) the number of roots in the left half of s-plan.
 (iii) the number of roots on the imaginary axis.

(13 marks)

(b) A system with characteristic equation $s^6+2s^5+7s^4+10s^3+14s^2+8s+8= 0$, use Routh-Hurwitz criterion to find:
 (i) the stability of the system.
 (ii) the 4 roots on the imaginary axis.

(12 marks)

Question 2

(a) For a unity feedback system with

$$G(s) = \frac{20(s+2)}{s^2(s+1)(s+5)}.$$

Find:
 (i) the system type number. (2 marks)
 (ii) the 3 error coefficients. (4 marks)
 (iii) the steady-state error for input $1 + 3t + t^2/2$. (8 marks)

(b) Given the transfer function for the operational amplifier circuitry is:

$$\frac{V_o(s)}{V_i(s)} = \frac{-R_2C_1s}{(1+R_2C_2s)(1+R_1C_1s)}$$

Where Vo(s) and Vi(s) are output and input to the amplifier circuitry and R_1= 100kΩ , R_2= 200kΩ , C_1=10μF and C_2=20μF.

 (i) Sketch the Bode |magnitude| plot using the semi-log graph paper at end of question paper.

(8 marks)

 (ii) From the sketch, describe the type of amplifier and the range of frequency response. (3 marks)

Question 3

(a) Sketch the Nyquist diagram for the system shown in Figure Q3(a) below where

$$G(s) = \frac{1}{(s+2)(s+4)}$$

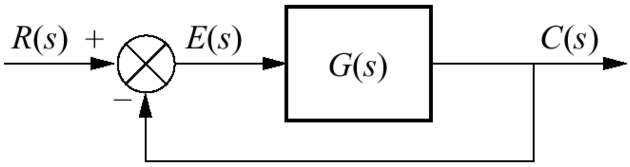


Figure Q3(a)

(8 marks)

(b) The response of a unity feedback closed-loop control system with loop gain, k of 10 is plotted on the Nichols chart shown in Figure Q3(b) below:

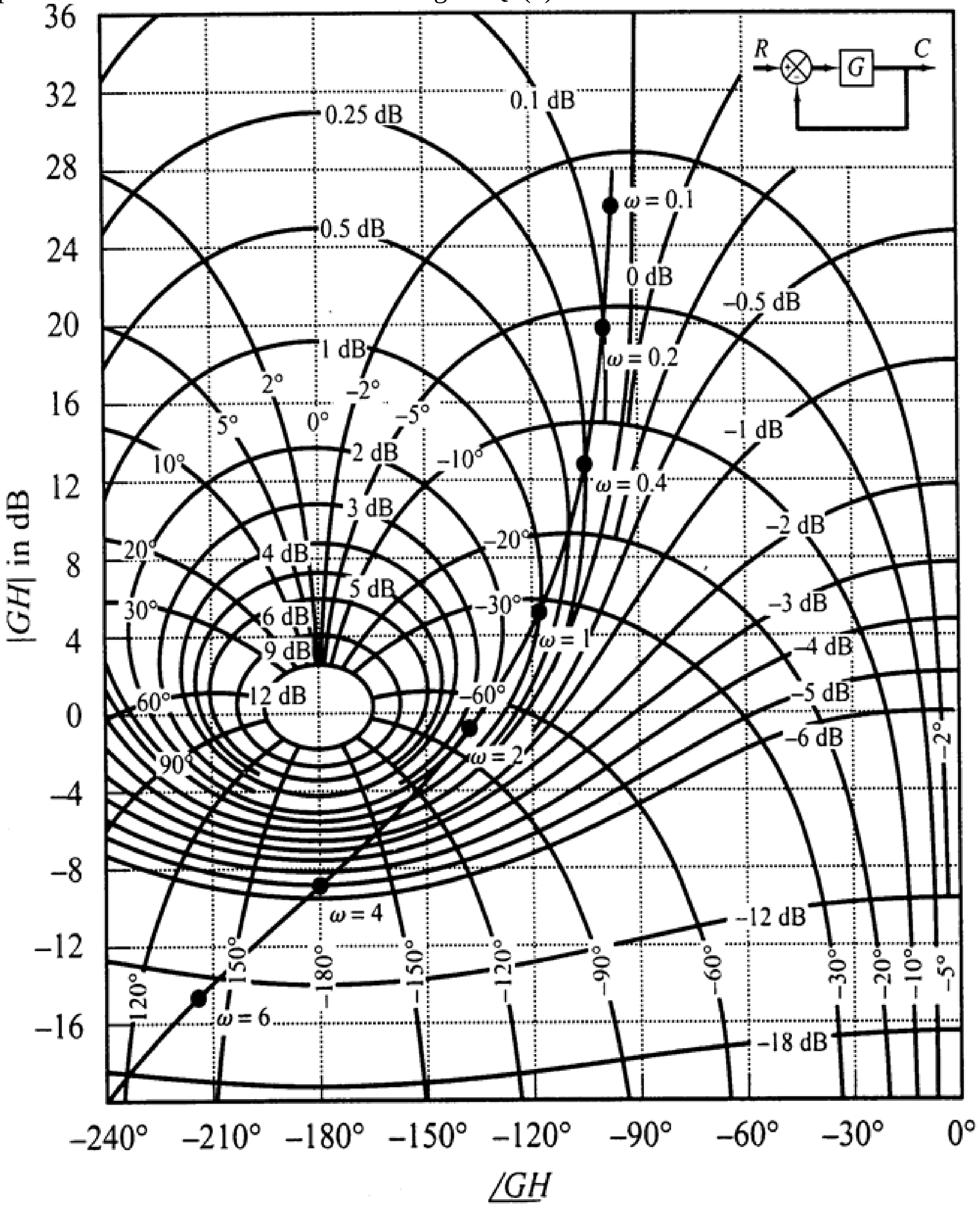


Fig Q3(b)

i) Make a table of the Open-loop and Closed-loop frequency response. (8 marks)

Find the:

ii) gain margin (1.5 marks)

iii) phase margin (1.5 marks)

iv) 3 dB bandwidth (1.5 marks)

v) peak resonance, $M_{p\omega}$ (1.5 marks)

vi) resonant frequency, ω_r (1.5 marks)

(c) Explain the way to increase both the gain margin and phase margin of the system in part (b). (1.5 marks)

Question 4

(a) For the system shown in Figure Q4 (a) below with $\zeta = 0.5$, find the:

(i) natural frequency, ω_n (3 marks)
(ii) k-value (1 marks)
(iii) rise time (3 marks)
(iv) peak time (1 marks)
(v) maximum overshoot (1 marks)
(vi) settling time for (2% error) (1 marks)

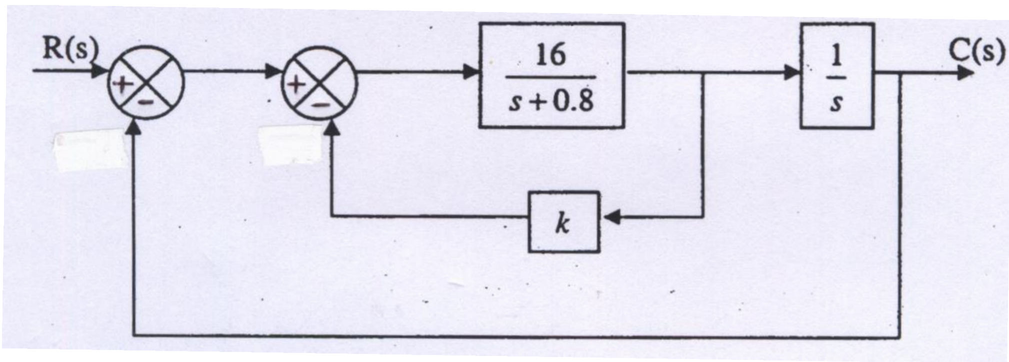


Figure Q4 (a)

(b) The open loop transfer function of a unity feedback control system is given as:

$$G(s) = \frac{10(s+2)}{s^2(s+1)}$$

Find:

(i) the position, velocity and acceleration error constants. (6 marks)

(ii) the steady state error when the input is

$$R(s) = \frac{3}{s} - \frac{2}{s^2} + \frac{1}{3s^3}$$

(9 marks)

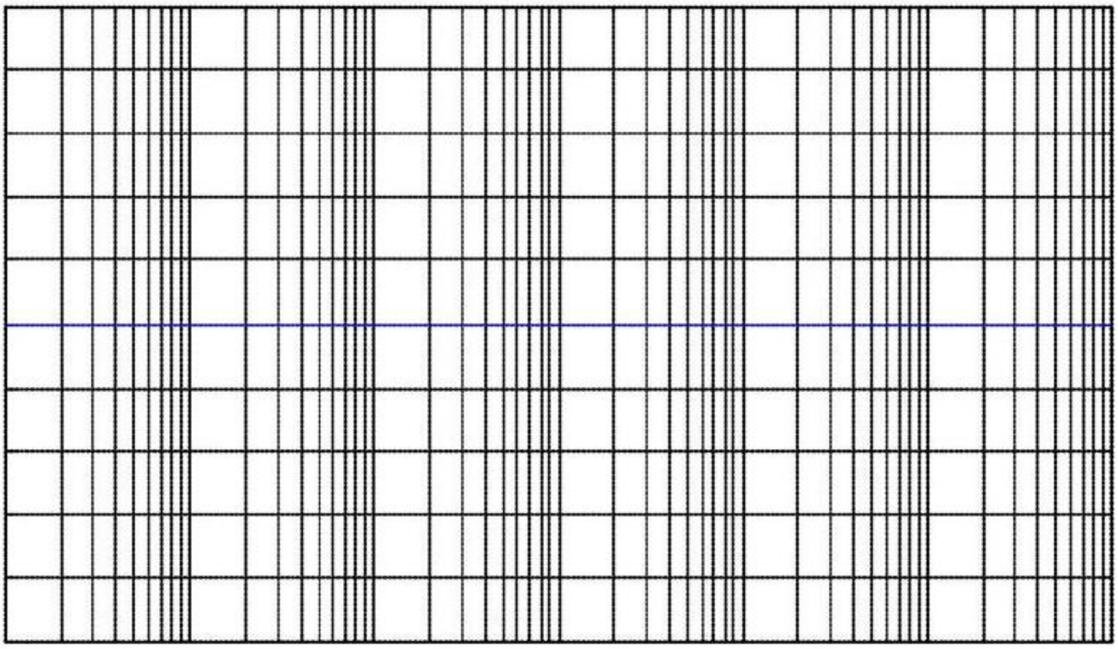
~THE END~

TABLE OF LAPLACE TRANSFORM

Number	$F(s)$	$f(t), t \geq 0$
1	1	$\delta(t)$
2	$1/s$	$1(t)$
3	$1/s^2$	t
4	$2!/s^3$	t^2
5	$3!/s^4$	t^3
6	$m!/s^{m+1}$	t^m
7	$1/(s+a)$	e^{-at}
8	$1/(s+a)^2$	te^{-at}
9	$1/(s+a)^3$	$\frac{1}{2!}t^2e^{-at}$
10	$1/(s+a)^m$	$\frac{1}{(m-1)!}t^{m-1}e^{-at}$
11	$\frac{a}{s(s+a)}$	$1-e^{-at}$
12	$\frac{a}{s^2(s+a)}$	$\frac{1}{a}(at-1+e^{-at})$
13	$\frac{b-a}{(s+a)(s+b)}$	$e^{-at}-e^{-bt}$
14	$\frac{s}{(s+a)^2}$	$(1-at)e^{-at}$
15	$\frac{a^2}{s(s+a)^2}$	$1-e^{-at}(1+at)$
16	$\frac{(b-a)s}{(s+a)(s+b)}$	$be^{-bt}-ae^{-at}$
17	$a/(s^2+a^2)$	$\sin at$
18	$s/(s^2+a^2)$	$\cos at$
19	$\frac{s+a}{(s+a)^2+b^2}$	$e^{-at}\cos bt$
20	$\frac{b}{(s+a)^2+b^2}$	$e^{-at}\sin bt$
21	$\frac{a^2+b^2}{s[(s+a)^2+b^2]}$	$1-e^{-at}\left(\cos bt+\frac{a}{b}\sin bt\right)$

BODE PLOT

$20\log_{10}|TF|$



Angle of TF