FINAL
ALTERNATIVE ASSESSMENT

(COVER PAGE)

Session	:	**April 2020**
Programme	:	Diploma in Electrical & Electronic Engineering (DEEI)
Course	:	**EEE2108: Modern Control Systems Engineering**
Date of Examination	:	5 August 2020 (Wednesday)
Time	:	2.00pm – 5.00pm Reading Time : Nil
Duration	:	3 Hours

Special Instructions :

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

Material permitted :
Non-Programmable Scientific Calculator

Materials provided :
Nil

Examiner(s)	:	**Mr Alan Wong Kam Mun**
Chief Moderator	:	Mr Richard Lai TF

*This paper consists of **6** printed pages, including the cover page*

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DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING PROGRAMME (DEEI)

EEE2108: MODERN CONTROL SYSTEMS ENGINEERING

FINAL ALTERNATIVE ASSESSMENT: APRIL 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) Use the Routh-Hurwitz criteria to find how many poles of the following closed-loop system are in the rhp (right hand pole), in the lhp (left hand pole), and on the jω-axis.

$$T(s) = \frac{S^3+7S^2-21S+10}{S^6+S^5-6S^4-S^2-S+6}$$

(15 marks)

(b) For a unity feedback system with the forward transfer function

$$G(s) = \frac{K(s+20)}{s(s+2)(s+3)}$$

find the range of K to make the system stable.

(10 marks)

Question 2

(a) For the operational amplifier circuit shown in Figure Q2(a) below,

(i) Find the transfer function, $\frac{V_o(s)}{V_i(s)}$ (6 marks)

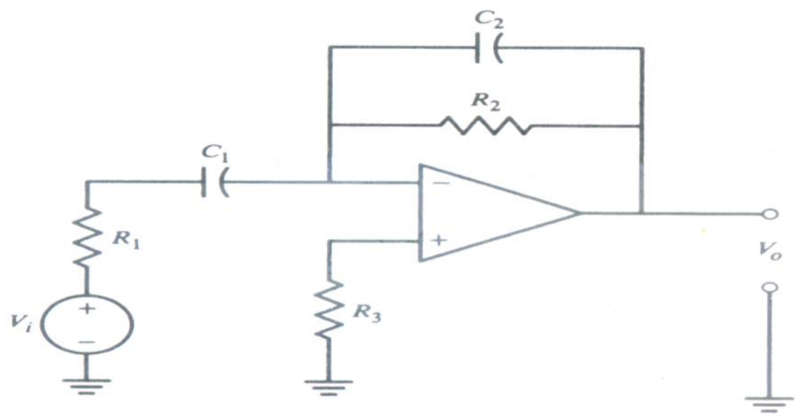


Figure Q2(a)

(ii) Sketch the Bode |magnitude| plot, given R1= 100kΩ , R2= 200kΩ , C1=10μF ,C2=20μF and R3= 0 Ω. (6 marks)

(iii) Based on the sketch from (ii) describe the type of amplifier and the range of frequency response. (3 marks)

(b) The open-loop frequency response of a unity-feedback system is given below.

ω(rad/s)	1	2	3	4	5
$\lvert G \rvert$ dB	12.6	3.92	-2.22	-7.0	-11.0
$\angle$G (in degree)	-127	-152	-168	-179	-188

Transfer the Open-loop frequency response data into a Nichols chart and determine the:

(i) closed-loop frequency response (tabulate in table form)

(5 marks)

(ii) gain margin <GM>
(iii) phase margin <PM>
(iv) resonance peak <Mp>
(v) resonance frequency <ω_r>
(vi) bandwidth <BW>

(5 marks)

Question 3

For unity feedback system $\boldsymbol{G(s) = \frac{k}{(s+2)(s+9)(s-1)}}$

Determine the following:

(a) Number of root-locus branches (3 marks)

(b) Number of root-locus asymptotes for the behaviour at infinity (3 marks)

(c) The intersection point of the asymptotes on the real-axis (3 marks)

(d) The angles of asymptotes made with the real-axis (3 marks)

(e) Break-in and/or break-away point (4 marks)

(f) The imaginary-axis crossing points of the root-locus (4 marks)

(g) Draw the root-locus. (5 marks)

Question 4

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

(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)

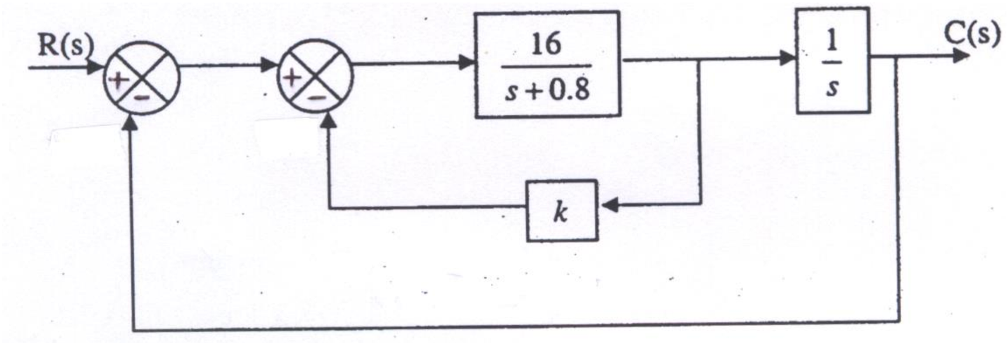


Figure Q4 (a)

(b) For a unity feedback control system the open loop transfer function 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

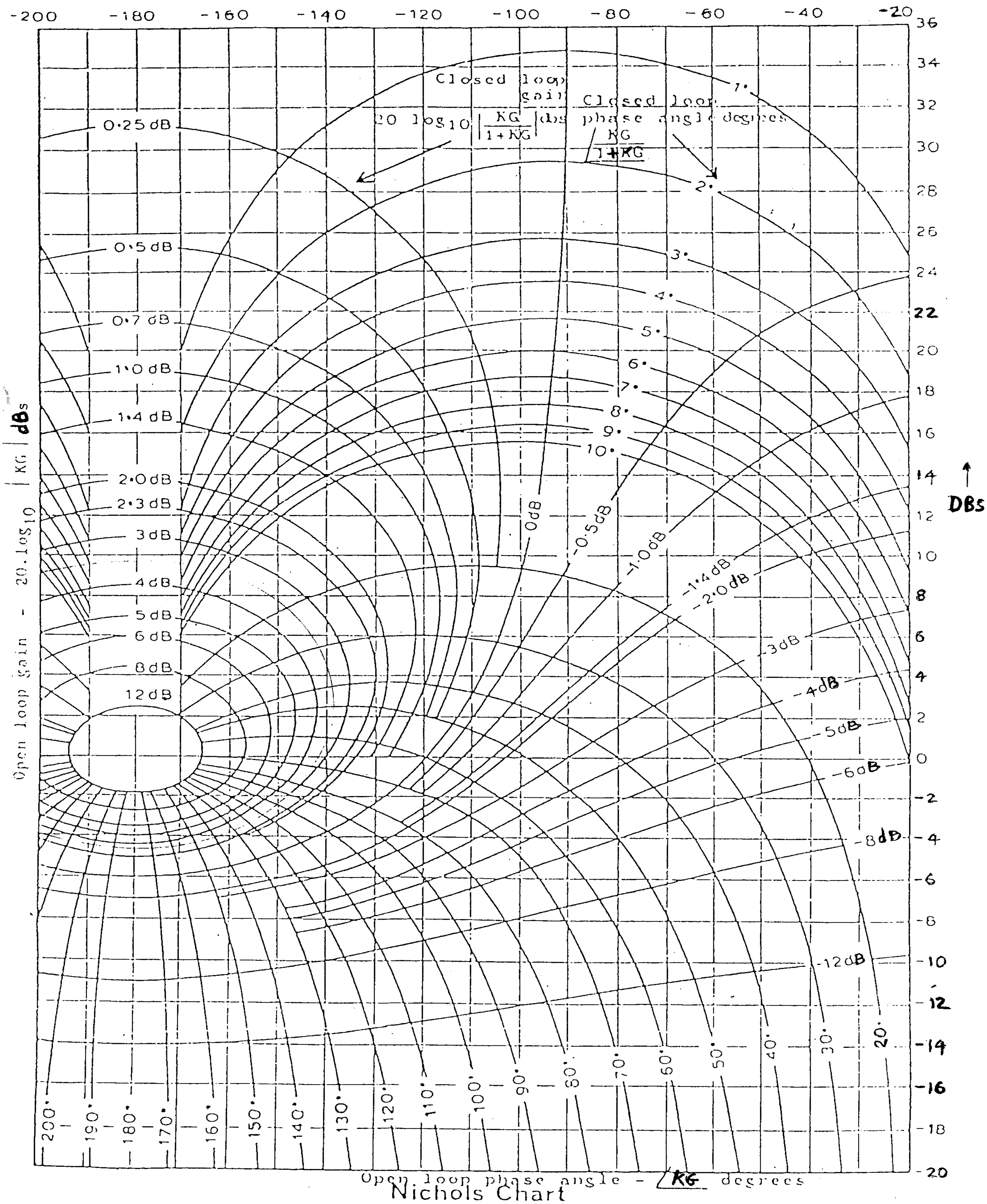
$$R(s) = \frac{3}{s} - \frac{2}{s^2} + \frac{1}{3s^3}$$

(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	$\frac{a^2+b^2}{s[(s+a)^2+b^2]}$	$1-e^{-at}\left(\cos bt+\frac{a}{b}\sin bt\right)$



Nichols Chart