PROGRAM	: NATIONAL DIPLOMA *ELECTRICAL ENGINEERING*
SUBJECT	: **CONTROL SYSTEMS III**
CODE	: **ASY331**
DATE	: SUPPLEMENTARY EXAMINATION JANUARY 2020
DURATION	: 11:30 to 14:30
WEIGHT	: 40:60
TOTAL MARKS	: 100

UNIVERSITY OF JOHANNESBURG

EXAMINER	: DR. C.S. CHABALALA
MODERATOR	: MRS. J. BUISSON-STREET
NUMBER OF PAGES	: 6 PAGES INCLUDING THE ANNEXURE

INSTRUCTIONS

1. 100 MARKS = 100%. TOTAL MARKS AVAILABLE = 100
2. ATTEMPT ALL QUESTIONS.
3. USE THE ANSWER BOOK PROVIDED UNLESS OTHERWISE INSTRUCTED.
4. DO NOT COMBINE ANSWERS TO DIFFERENT SUB-SECTIONS OF QUESTIONS.
5. ALL DIAGRAMS AND SKETCHES MUST BE DRAWN NEATLY AND IN PROPORTION.
6. ALL DIAGRAMS AND SKETCHES MUST BE LABELLED CLEARLY.
7. ALL WORK DONE IN PENCIL, EXCEPT DIAGRAMS AND SKETCHES, WILL BE CONSIDERED AS ROUGH WORK AND WILL NOT BE MARKED.
8. MARKS WILL BE DEDUCTED FOR WORK THAT IS POORLY PRESENTED.
9. QUESTIONS MAY BE ANSWERED IN ANY ORDER, BUT ALL PARTS OF A QUESTION, MUST BE KEPT TOGETHER.
10. ONLY ONE POCKET CALCULATOR PER CANDIDATE MAY BE USED.

QUESTION 1 [25 Marks]

1.1 Determine the transfer function for the control system in Figure 1, by using block reduction algebra. Do not use Mason's or Kirchhoff's methods. (10)

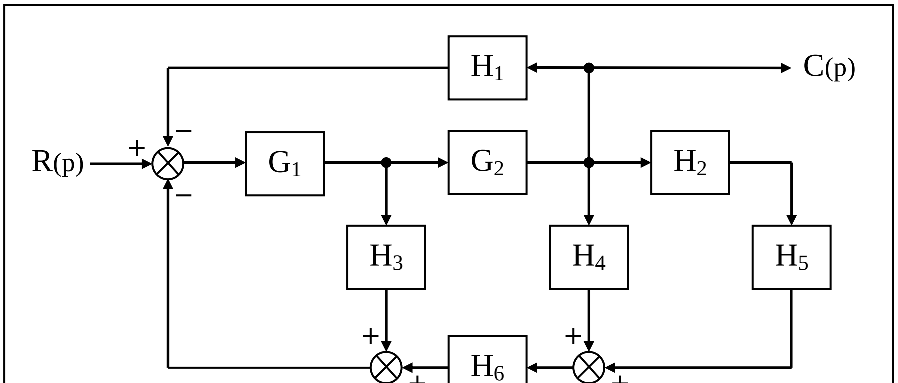

Figure 1

1.2 Determine the transfer function: $V_o(p)/V_i(p)$, of the electrical circuit shown in Figure 2. (8)

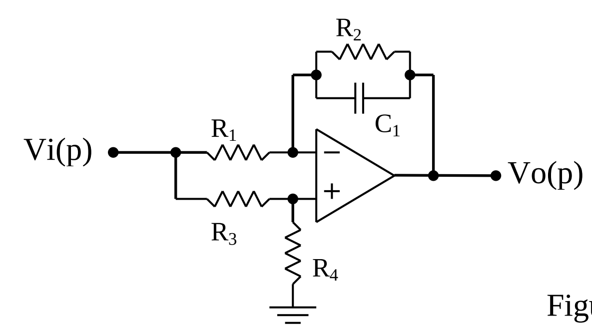

Figure 2

1.3 With the aid of a labelled block diagram explain what a closed-loop control system is. (5)

1.4 Discuss the advantage of implementing a closed-loop control system? (2)

QUESTION 2 [25 Marks]

2.1 Using block diagrams and mathematical derivations, show how negative feedback can be used to achieve the desired plant output, reject input and output disturbances and attenuate measurement noise. (5)

2.2 Consider a system that is governed by a second order differential equation of the form given below: -

$$4\frac{d^2}{dt^2}y(t) + 8\frac{d}{dt}y(t) + 3y(t) = 5u(t)$$

a) Determine its transfer characteristics in the Laplace domain $g(s) = \frac{y(s)}{u(s)}$ (5)

b) Determine the system's time response y(t) when a unit step input u(s) is given. (5)

c) Plot the response of the system within a time range $t = 0[s] - 15[s]$. Use the sheet in the annexure to plot your graph. (4)

d) Compute the initial and final values of the output. Do they agree with the plot? (6)

QUESTION 3 **[25 Marks]**

3.1 Using first order plant models, show that the response of a plant (time constant) depends on its pole location in the s-plane. (5)

3.2 Find and plot the poles and zeros of the system $g(s) = \frac{s^2+2s-3}{s^2+3s+2}$ and classify the system as stable, marginally stable or unstable where applicable. (10)

3.3 The step response in Figure 3 below is that of a unity feedback (sensor transfer function = 1) closed loop system, whose controller k(s) = 3. Determine the plant model g(s). Clearly show your measurements or estimations derived from the plot. (10)

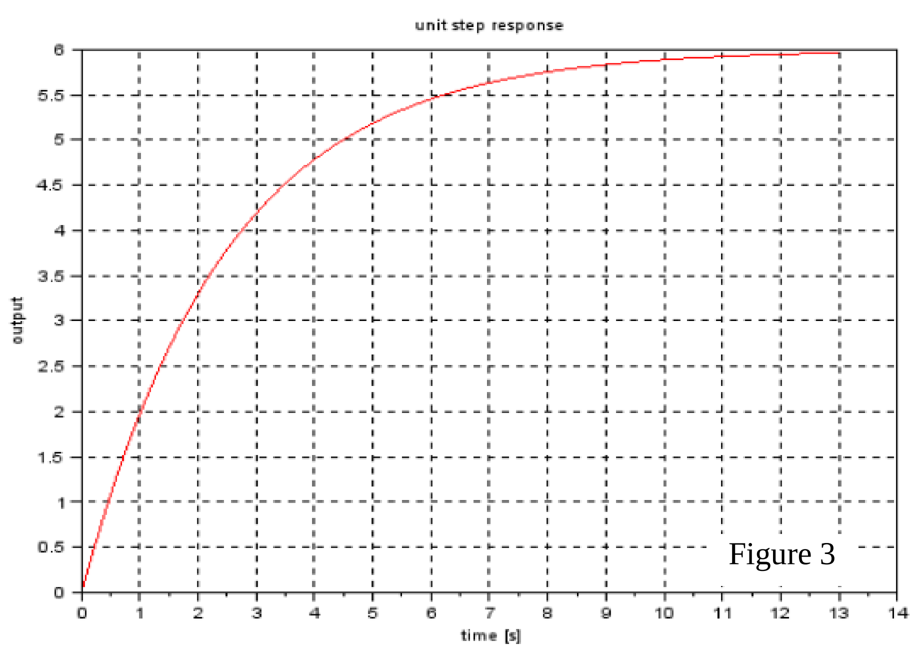

Figure 3

QUESTION 4 **[25 Marks]**

4.1 Illustrate with a sketch, the output of the following system with the given input. (5)

$$g(s) = \frac{2s+3}{3s^2+4.5s+1.5}; \quad \text{input is } x(s) = \frac{2}{s}$$

4.2 Consider the aircraft position tracking control system shown in Figure 4 below: -

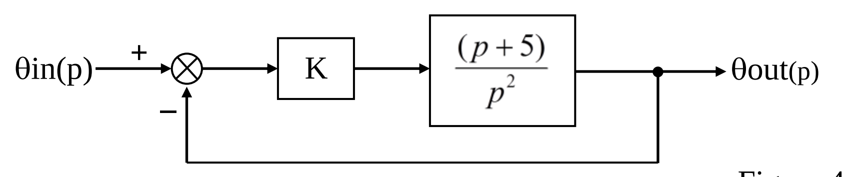

Figure 4

a) Determine the value of gain "K" that will ensure a constant steady state error of 5%. (5)

b) For the calculated gain "K" value, calculate how long the tracking system will initially take to reach the required steady state error of 5%. (5)

4.3 For the control system indicated in Figure 5, use the Routh Hurwitz criterion to determine the number of poles on the LHS and/or RHS of the P-plane. Is this system stable or unstable? Briefly explain your answer. (10)

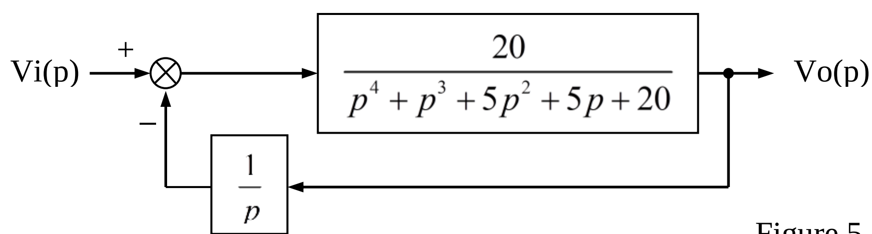

Figure 5

[END OF EXAM | ALL THE BEST]

ANNEXURE 1

Table 1: Common Laplace Transforms

Time domain	Laplace Transform	z Transform
$\delta(t)$	1	1
$u(t)$	$\frac{1}{s}$	$\frac{z}{z-1}$
t	$\frac{1}{s^2}$	$\frac{Tz}{(z-1)^2}$
t^2	$\frac{2}{s^3}$	$\frac{T^2 z(z+1)}{(z-1)^3}$
e^{-at}	$\frac{1}{s+a}$	$\frac{z}{z-e^{-aT}}$
$1-e^{-at}$	$\frac{a}{s(s+a)}$	$\frac{z(1-e^{-aT})}{(z-1)(z-e^{-aT})}$
$\sin(\omega t)$	$\frac{\omega}{s^2+\omega^2}$	$\frac{z\sin(\omega T)}{z^2-2z\cos(\omega T)+1}$
$\cos(\omega t)$	$\frac{s}{s^2+\omega^2}$	$\frac{z(z-\cos(\omega T))}{z^2-2z\cos(\omega T)+1}$
$e^{-at}\sin(\omega t)$	$\frac{\omega}{(s+a)^2+\omega^2}$	$\frac{ze^{-aT}\sin(\omega T)}{z^2-2ze^{-aT}\cos(\omega T)+e^{-2aT}}$
$e^{-at}\cos(\omega t)$	$\frac{s+a}{(s+a)^2+\omega^2}$	$\frac{z^2-ze^{-aT}\cos(\omega T)}{z^2-2ze^{-aT}\cos(\omega T)+e^{-2aT}}$

ANNEXURE 2

DETACH AND PLACE INSIDE YOUR ANSWER BOOK

Student Number:………………… Surname & Initials:…………………………………….