UNIVERSITY COLLEGE TATI

UNIVERSITY COLLEGE TATI (UC TATI)

FINAL EXAMINATION QUESTION BOOKLET

COURSE CODE	: DEI 2113/DEE 3143
COURSE	: CONTROL SYSTEMS
SEMESTER/SESSION	: 1-2022/2023
DURATION	: 3 HOURS

Instructions:

1. Answer all **4** questions.
2. All answers should be written in answer booklet.
3. Write legibly and draw sketches wherever required.
4. If in doubt, raise your hands and ask the invigilator.

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO

THIS BOOKLET CONTAINS 8 PRINTED PAGES INCLUDING COVER PAGE

QUESTION 1

a) Define the meaning of control system. (2 marks)

b) Control systems are important and present almost everywhere in our daily lives. State three (3) examples of:

   i. God-created control systems (3 marks)

   ii. Man-made control systems (3 marks)

c) Describe what will happen when there is a malfunction of control systems. (3 marks)

d) List down three (3) benefits of control system. (3 marks)

e) There are three main elements exist in any control systems. Draw a block diagram of a basic control system that has all those elements.

(3 marks)

f) There are two categories of control system available. State two (2) categories of the control system. (2 marks)

QUESTION 2

a) Illustrate summing junction, blocks and take off point. (3 marks)

b) Differentiate between forward and feedback path by drawing its block. (3 marks)

c) An open loop system consists of three elements in series, the elements having transfer functions of $\frac{2}{s}$, $\frac{(s+3)}{(s+7)}$ and $\frac{1}{(s+9)}$.

i. Develop the block diagram of this system (5 marks)

ii. Find the overall transfer function of the system. (5 marks)

d) Find the equivalent transfer function for Figure 1 below. (4 marks)

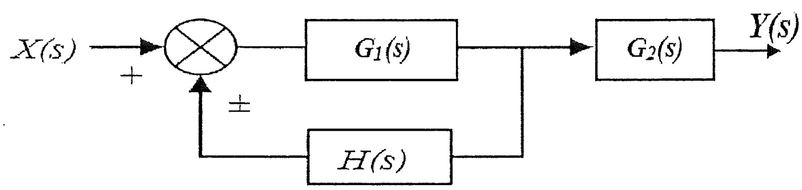

Figure 1

e) Given a block diagram in Figure 2. Find its overall transfer function in simplest form by using block diagram reduction.

(7 marks)

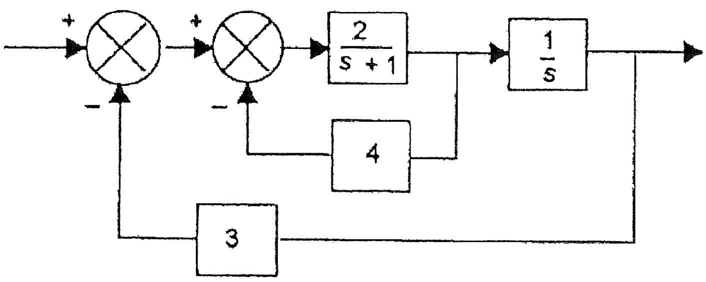

Figure 2

QUESTION 3

a) Find the Laplace transform for the following functions using the given Laplace transform table in Appendix A.

i. $f(t) = 2t^2$ (2 marks)

ii. $f(t) = e^{-4t}$ (2 marks)

iii. $f(t) = e^{-3t}\cos(5t)$ (3 marks)

b) Find the inverse Laplace transforms for the following transfer function using the given Laplace transform table in Appendix A.

i. $F(s) = \frac{2}{s+2}$ (3 marks)

ii. $F(s) = \frac{s}{s^2+16}$ (3 marks)

iii. $F(s) = \frac{5}{(s-2)^2+25}$ (4 marks)

c) Given $G(s) = \frac{(s+3)}{(s+2)(s+5)}$ find $g(t)$ using partial fraction expansion. (10 marks)

QUESTION 4

a) The output response of a system is the sum of two responses which are the forced response and natural response respectively. State the source for both responses.

(2 marks)

b) Find the location of poles and zeros for the following system on the s-plane.

i. $F(s) = \dfrac{(s-2)}{(s+2)(s+8)}$ (4 marks)

ii. $F(s) = \dfrac{17}{s^2+8s+17}$ (4 marks)

c) For the unit step response of a 1[st] order system shown in Figure 3, find

i. Time constant, τ (3 marks)

ii. Rise time, T_r (3 marks)

iii. Settling time, T_s (2 marks)

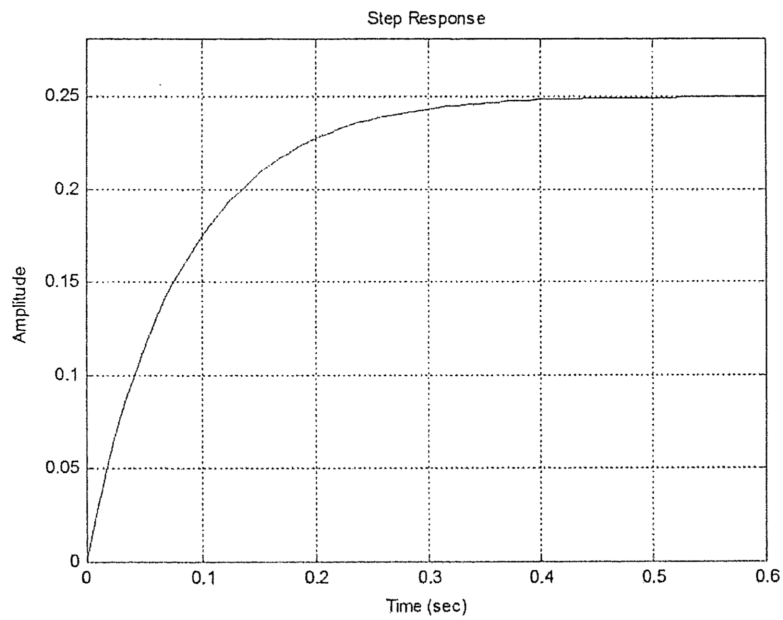

Figure 3

d) Given a transfer function as follow;

$$G(s) = \frac{81}{s^2 + 13s + 81}$$

Find the:

i. Natural angular frequency, ω_n (1 mark)

ii. Damping factor, ζ (2 marks)

iii. Nature of the response (2 marks)

iv. Rise time, T_r (4 marks)

---**End of question**---

APPENDIX A

Table 1: Laplace Transform Table

$f(t)$	$F(s)$
$\delta(t)$ (unit impulse)	1
$u(t)$ (unit step)	$\frac{1}{s}$
t (unit ramp)	$\frac{1}{s^2}$
t^n (n>-1)	$\frac{n!}{s^{n+1}}$
e^{-at}	$\frac{1}{s+a}$
$\sin bt$	$\frac{b}{s^2+b^2}$
$\cos bt$	$\frac{s}{s^2+b^2}$
$e^{-at}\sin\omega t$	$\frac{\omega}{(s+a)^2+\omega^2}$
$e^{-at}\cos\omega t$	$\frac{s+a}{(s+a)^2+\omega^2}$
$\frac{\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2}$	$\frac{\omega_n}{\sqrt{1-\xi^2}}e^{-\xi\omega_n t}\sin\omega_n\sqrt{1-\xi^2}t \quad (\xi<1)$
$\frac{\omega_n^2}{s\left(s^2+2\xi\omega_n s+\omega_n^2\right)}$	$1-\frac{\omega_n}{\sqrt{1-\xi^2}}e^{-\xi\omega_n t}\sin\left(\omega_n\sqrt{1-\xi^2}t+\theta\right)$ $where\ \theta=\cos^{-1}\xi \quad (\xi<1)$
$\frac{df(t)}{dt}$	$sF(s)-f(0)$
$\int_0^t f(t)dt$	$\frac{1}{s}F(s)$
$f(t-a)$	$e^{-as}F(s)$

APPENDIX B

1. Basic feedback: $\frac{G(s)}{1 \pm G(s)H(s)}$

2. $s_{1,2} = -\zeta\omega_n \pm \omega_n\sqrt{\zeta^2 - 1}$

3. $t_r = \frac{2.2}{a}$ / $t_r = \frac{\pi}{2\omega_n\sqrt{1-\zeta^2}}$

4. $t_p = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}}$

5. $t_s = \frac{4}{a}$ / $t_s = \frac{4}{\zeta\omega_n}$

6. $\%OS = e^{-\left(\zeta\pi/\sqrt{1-\zeta^2}\right)} x\, 100$

7. $\mathcal{L}[f(t)] = F(s) = \int_0^\infty f(t)e^{-st}\,dt$

8. $\mathcal{L}^{-1}[F(s)] = f(t) = \frac{1}{2j}\int_{-\infty}^{\infty} F(s)e^{st}\,d(s) = ft)u(t)$

9. Z-N Method

Ziegler Nichols Method			
Control Type	K_P	K_i	K_d
P	$0.5K_u$	-	-
PI	$0.45K_u$	$1.2K_p/T_u$	-
PD	$0.8K_u$	-	$K_pT_u/8$
PID	$0.6K_u$	$2K_p/T_u$	$K_pT_u/8$