UNIVERSITY COLLEGE TATI (UC TATI)

FINAL EXAMINATION QUESTION BOOKLET	
COURSE CODE	: DEI 2113 / DEE 3143
COURSE	: CONTROL SYSTEMS
SEMESTER/SESSION	: 1-2024/2025
DURATION	: 3 HOURS

Instructions:

a) Answer all **4** questions.

b) All answers should be written in answer booklet.

c) Write legibly and draw sketches wherever required.

d) 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 terms below:

i. Control system (1 mark)

ii. Input (1 mark)

iii. Output (1 mark)

b) Control systems are important and present almost everywhere in our daily lives. State two (2) examples of:

i. God-created control systems (2 marks)

ii. Man-made control systems (2 marks)

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

(3 marks)

d) Describe two (2) disadvantages of open-loop system. (2 marks)

e) Describe three (3) main objectives of control systems analysis and design.

(6 marks)

QUESTION 2

a) Define the transfer function of a system. (1 mark)

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

c) Draw the block diagram for forward path and feedback path. (3 marks)

d) An open loop system consists of three elements in series, the elements having transfer functions of $\frac{1}{s}$, $\frac{(s+1)}{(s+3)}$ and $\frac{6}{(s+2)}$.

i. Produce the block diagram of this system (3 marks)

ii. Determine the overall transfer function of the system. (4 marks)

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

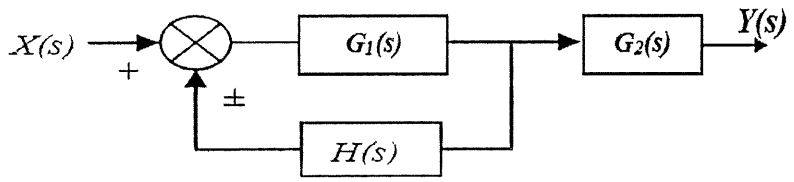

Figure 1

QUESTION 3

a) Define the following terms:

i. Laplace transform. (1 mark)

ii. Inverse Laplace transform (1 mark)

b) Determine the Laplace transformation of these functions using table Laplace transformation.

i. $f(t) = 5t^2$ (2 marks)

ii. $f(t) = e^{2t}\sin 3t$ (3 marks)

c) Determine the Inverse Laplace transformation of these functions using table Laplace transformation.

i. $G(s) = (e^{-3s} - e^{-4s})$ (3 marks)

ii. $G(s) = \frac{s}{s^2+9}$ (3 marks)

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

d) Given $G(s) = \frac{(s+2)}{(s+1)(s+4)}$ find $g(t)$ using partial fraction expansion. (10 marks)

QUESTION 4

a) State and sketch two (2) types of input in transfer function (4 marks)

b) Plot the system pole and zero based on the transfer function below:

$$G(s) = \frac{s+4}{(s+2)(s+5)}$$ (3 marks)

c) Figure 2 show the transfer function of first order system is given as:

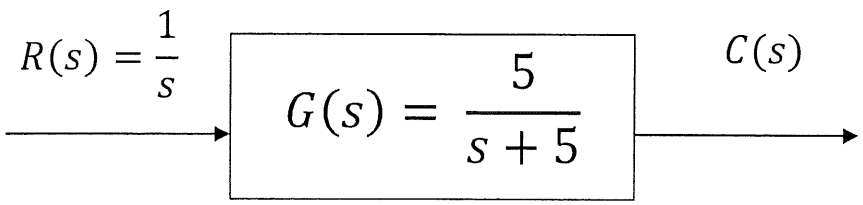

Figure 2

i. Find time constant, T_c. (2 marks)

ii. Find rise time time, T_r. (2 marks)

iii. Find settling time, T_s (2 marks)

iv. Determine output time response, c(t). (7 marks)

v. Based on answer in (i), identify forced and natural response. (2 marks)

d) The transfer function of second order system is given:

$$G(s) = \frac{0.04}{s^2 + 0.02s + 0.04}$$

Determine the:

i. Natural frequency, ω_n (1 mark)

ii. Damping ratio, ξ (2 marks)

iii. Peak time, T_p (3 marks)

iv. Settling time, T_s (3 marks)

v. Rise time, T_r (3 marks)

vi. Overshoot, %OS (3 marks)

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

FORMULA

1. $A = \pi r^2 s_{1,2} = -\zeta\omega_n \pm \omega_n\sqrt{\zeta^2 - 1}$
2. $\zeta = \frac{a}{2\omega_n}$
3. $j^2 = -1$
4. $\omega = \omega_n\sqrt{1 - \zeta^2}$
5. $T_r = \frac{\pi}{2\omega_n\sqrt{1-\zeta}}$
6. $T_p = \frac{\pi}{\omega_n\sqrt{1-\zeta}} = \frac{\pi}{\omega_d}$
7. $T_s = \frac{4}{\zeta\omega_n} = \frac{4}{\sigma_d}$
8. $\%OS = e^{-\left(\zeta\pi/\sqrt{1-\zeta^2}\right)} x\ 100\%$
9. $T_c = \frac{1}{a}$
10. $T_r = \frac{2.2}{a}$
11. $T_s = \frac{4}{a}$

Table of Laplace Transforms

	$f(t)=\mathcal{L}^{-1}\{F(s)\}$	$F(s)=\mathcal{L}\{f(t)\}$		$f(t)=\mathcal{L}^{-1}\{F(s)\}$	$F(s)=\mathcal{L}\{f(t)\}$
1.	1	$\frac{1}{s}$	2.	e^{at}	$\frac{1}{s-a}$
3.	$t^n,\quad n=1,2,3,\ldots$	$\frac{n!}{s^{n+1}}$	4.	$t^p, p>-1$	$\frac{\Gamma(p+1)}{s^{p+1}}$
5.	$\sqrt{t}$	$\frac{\sqrt{\pi}}{2s^{\frac{3}{2}}}$	6.	$t^{n-\frac{1}{2}},\quad n=1,2,3,\ldots$	$\frac{1\cdot3\cdot5\cdots(2n-1)\sqrt{\pi}}{2^n s^{n+\frac{1}{2}}}$
7.	$\sin(at)$	$\frac{a}{s^2+a^2}$	8.	$\cos(at)$	$\frac{s}{s^2+a^2}$
9.	$t\sin(at)$	$\frac{2as}{(s^2+a^2)^2}$	10.	$t\cos(at)$	$\frac{s^2-a^2}{(s^2+a^2)^2}$
11.	$\sin(at)-at\cos(at)$	$\frac{2a^3}{(s^2+a^2)^2}$	12.	$\sin(at)+at\cos(at)$	$\frac{2as^2}{(s^2+a^2)^2}$
13.	$\cos(at)-at\sin(at)$	$\frac{s(s^2-a^2)}{(s^2+a^2)^2}$	14.	$\cos(at)+at\sin(at)$	$\frac{s(s^2+3a^2)}{(s^2+a^2)^2}$
15.	$\sin(at+b)$	$\frac{s\sin(b)+a\cos(b)}{s^2+a^2}$	16.	$\cos(at+b)$	$\frac{s\cos(b)-a\sin(b)}{s^2+a^2}$
17.	$\sinh(at)$	$\frac{a}{s^2-a^2}$	18.	$\cosh(at)$	$\frac{s}{s^2-a^2}$
19.	$e^{at}\sin(bt)$	$\frac{b}{(s-a)^2+b^2}$	20.	$e^{at}\cos(bt)$	$\frac{s-a}{(s-a)^2+b^2}$
21.	$e^{at}\sinh(bt)$	$\frac{b}{(s-a)^2-b^2}$	22.	$e^{at}\cosh(bt)$	$\frac{s-a}{(s-a)^2-b^2}$
23.	$t^n e^{at},\quad n=1,2,3,\ldots$	$\frac{n!}{(s-a)^{n+1}}$	24.	$f(ct)$	$\frac{1}{c}F\left(\frac{s}{c}\right)$
25.	$u_c(t)=u(t-c)$ Heaviside Function	$\frac{e^{-cs}}{s}$	26.	$\delta(t-c)$ Dirac Delta Function	e^{-cs}
27.	$u_c(t)f(t-c)$	$e^{-cs}F(s)$	28.	$u_c(t)g(t)$	$e^{-cs}\mathcal{L}\{g(t+c)\}$
29.	$e^{ct}f(t)$	$F(s-c)$	30.	$t^n f(t),\quad n=1,2,3,\ldots$	$(-1)^n F^{(n)}(s)$
31.	$\frac{1}{t}f(t)$	$\int_s^\infty F(u)du$	32.	$\int_0^t f(v)dv$	$\frac{F(s)}{s}$
33.	$\int_0^t f(t-\tau)g(\tau)d\tau$	$F(s)G(s)$	34.	$f(t+T)=f(t)$	$\frac{\int_0^T e^{-st}f(t)dt}{1-e^{-sT}}$
35.	$f'(t)$	$sF(s)-f(0)$	36.	$f''(t)$	$s^2F(s)-sf(0)-f'(0)$
37.	$f^{(n)}(t)$	$s^nF(s)-s^{n-1}f(0)-s^{n-2}f'(0)\cdots-sf^{(n-2)}(0)-f^{(n-1)}(0)$			