Ref. No.: Ex/FET/OE/ELE/T/203/2023

BACHELOR OF ENGINEERING IN
CIVIL ENGINEERING/ INFORMATION TECHNOLOGY/ METALLURGICAL AND MATERIAL ENGINEERING

3^{RD} YEAR 2^{ND} SEMESTER EXAMINATION, 2023

BACHELOR OF ENGINEERING IN
ELECTRONICS AND TELE-COMMUNICATION ENGINEERING / CONSTRUCTION ENGINEERING / COMPUTER SCIENCE AND ENGINEERING/ POWER ENGINEERING / MECHANICAL ENGINEERING / PRODUCTION ENGINEERING / INSTRUMENTATION AND ELECTRONICS ENGINEERING

4^{TH} YEAR 2^{ND} SEMESTER EXAMINATION, 2023

Subject: BASIC LINEAR CONTROL SYSTEM ENGINEERING (OPEN ELECTIVE-II)

Time: 3 Hours **Full Marks: 100**

Question No.	Question 1 is compulsory Answer ***Any Four*** questions from the rest (4×20)	Marks
Q1	Answer ***any Four*** of the following: (4×5)	
(a)	Enlist the main advantages of Closed-loop Control system over Open-loop Control system?	5
(b)	What is Root Locus? Show that the Root Locus would always start from open loop poles (for gain K=0) and terminate at the open loop zeros (as K tends to infinity).	5
(c)	Determine if the system given by $$y(t) = \cos(100\pi t)\, x(t)$$ is time-invariant, linear, causal, and/or memoryless?	5
(d)	Obtain the unit impulse response of an LTI system described by $$\frac{d^2y(t)}{dt^2} + y(t) = x(t)$$ where, $y(t)$ and $x(t)$ are output and input, respectively. Assume zero initial condition.	5
(e)	The response of an LTI system to a step input, $u(t)$, is $y(t) = (1 - e^{-2t})u(t)$. Find the response of the system to an input $x(t) = 4u(t) - 4u(t-1)$.	5
(f)	Discuss "Direct acting" and "Reverse Acting" mode of Proportional control.	5

[Turn over

Ref. No.: Ex/FET/OE/ELE/T/203/2023

Q2 (a) For a standard 2^{nd} order system obtain the expressions for unit step response for (i) un-damped condition and (ii) critically damped condition. Also indicate the respective pole locations for each case. 4+4

(b) For a closed loop unity feedback system with forward path transfer function

$$G(s) = \frac{k}{s(s+6)}$$

show how the following responses may be obtained by varying the gain k

(i) over-damped with $\zeta=1.5$, 4

(ii) under-damped with $\zeta=0.75$ and 4

(iii) critically-damped. 4

Q3 (a) Define "Type" of a system? For a unity feedback system define the following terms and find the expressions for steady-state error in response to Step, Ramp and Parabolic inputs in terms of these constants: 2+6

(i) Static position error constant

(ii) Static velocity error constant

(iii) Static acceleration error constant

(b) Consider a negative feedback system with unity feedback gain with the forward path transfer function given by

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

(i) Draw the root loci of the system. 8

(ii) Determine the points where the root loci cross the imaginary axis and calculate the corresponding value of the gain K. 4

Q4 (a) State and derive (i) Final Value Theorem and (ii) Initial Value Theorem of Laplace Transformation. 4+4

(b) Find the initial value of $\frac{df(t)}{dt}$ for $F(s) = \mathfrak{L}[f(t)] = \frac{2s+1}{s^2+s+1}$. 4

(c) Use one-sided Laplace Transform to find the output $y(t)$ of a system given by 8

$$\frac{d^2y(t)}{dt^2} + 3\frac{dy(t)}{dt} + 2y(t) = 0$$

with $y(0^+) = 3, \dot{y}(0^+) = 1$.

Ref. No.: Ex/FET/OE/ELE/T/203/2023

Q5 (a) Show that, a system with a characteristic equation having all positive (or all negative) coefficients may not always be stable. 4

(b) Find out the number of RHP roots of following polynomial 6

$$F(s) = s^5 + s^4 + 2s^3 + 2s^2 + s + 1$$

(c) Draw an asymptotic Bode magnitude plot for the system 10

$$G(s) = \frac{10s}{(s+1)(s+5)}$$

Q6 (a) Justify the following statement:

For a type-0 system with Proportional controller, there always remains a steady-state offset in the unit step response, which can only be reduced, but cannot be eliminated, by varying the proportional gain. 4

(b) Describe, stating the assumption, the Ziegler Nichols method of PID controller tuning based on unit step test. 6

Consider a control system in which a PID controller is used to control the plant 10

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

Determine the parameters of PID controller by Ziegler-Nichols tuning rule.

Q7 (a) Define state and output equation for an LTI system. 2+2

Indicate the order of the vectors and the matrices involved in State and Output equations for an n-th order LTI system with p inputs and m outputs. 4

(b) Consider an LTI system given by the transfer function: 8+4

$$G(s) = \frac{s^2 + 2s + 3}{s^3 + 6s^2 + 5s + 20}$$

Obtain the state-space model of the system in the phase variable canonical form. Draw the corresponding block diagram indicating the individual states.