

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

3RD YEAR 2ND 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

4TH YEAR 2ND SEMESTER EXAMINATION, 2023

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

Time: 3 Hours

Full Marks: 100

| Question No. | <u>Question 1 is compulsory</u> <u>Answer Any Four questions from the rest (4×20)</u> | Marks |
|--------------|---|-------|
| Q1 | Answer <i>any Four</i> 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

- Q2 (a) For a standard 2nd order system obtain the expressions for unit step response for
 (i) un-damped condition and (ii) critically damped condition. 4+4
 Also indicate the respective pole locations for each case.
- (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 $F(s) = \mathcal{L}[f(t)] = \frac{2s+1}{s^2+s+1}$. 4
- (c) Use one-sided Laplace Transform to find the output $y(t)$ of a system given by

$$\frac{d^2y(t)}{dt^2} + 3\frac{dy(t)}{dt} + 2y(t) = 0$$
 8
 with $y(0^+) = 3, \dot{y}(0^+) = 1$.

- 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: 4
- 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.
- (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
- $$G(s) = \frac{1}{s(s+2)(s+4)}$$
- Determine the parameters of PID controller by Ziegler-Nichols tuning rule. 10
- 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.