# B.E. MECHANICAL ENGINEERING
## THIRD YEAR SECOND SEMESTER SUPPLEMENTARY EXAMINATION 2023

### ELECTROHYDRAULIC CONTROL SYSTEMS

Time: Three Hours                 Full Marks: 100

*All the parts of a question must be answered together.*

### Answer any FIVE questions

1.(a) Draw a block diagram of a closed-loop system and explain the overall operation. [14]
(b) Discuss the relative merits and demerits of open-loop and closed-loop control systems. [6]

[2] (a) Obtain expression for the steady state flow force for a spool valve with metered pump and tank ports. Does this force enhance or oppose the spool displacement? Assume any symbols required. [14]
(b) State the roles of an accumulator and an intensifier in a hydraulic circuit. [6]

[3] (a) Briefly describe the operation of a regenerative circuit with the help of a neat sketch. [10]
(b) Draw schematic of a simple Electrohydraulic Control System explaining role of each component. [10]

[4] (a) State relative merits and demerits of electrohydraulic system with respect to electrical system. [6]
(b) With the help of a simple sketch briefly describe the working of a solenoid-operated 4/3 on-off DCV. Give one example of the application of such type of valve. [7]
(d) A closed-loop system provides performance enhancement through accurate feedback $H(s)$ of the output measurement, nullifying uncertainties of the system transfer function $G(s)$ to a great extent – justify the statement by obtaining an expression for the closed-loop Transfer Function. [7]

[5] (a) For the system with transfer function $G(s) = \frac{2(s+9)}{(s^2+6s+8)}$, what is its characteristic equation? Find system poles and zeroes. [6]
(b) Indicate the stability of the characteristic polynomial using *Routh's Criterion*: $3s^3 + 6s^2 + 2s + 1$. [7]
(c) Show that for a closed-loop system with unity feedback and forward path transfer function $G(s)$ with input $D(s)$, the steady state error can be expressed as $e_{ss} = \lim_{s\to0}[sD(s)/\{1 + G(s)\}]$. [7]

[6] (a) Give a suitable friction model for a hydraulic cylinder with proper nomenclature. Draw the typical friction characteristics of a hydraulic cylinder. [12]
(b) Why does an axial-piston pump have odd number of pistons? What is the effect of increasing the number of pumping pistons? [8]

[7] (a) What is meant by frequency domain analysis? Starting from a general transfer function, obtain the Bode plot for a typical 1$^{st}$ order system. [14]
(b) Define gain margin and phase margin. [6]

[8] Write short notes on any FOUR of the following: [4×5]
(a) meter-out circuit;
(b) transient-state flow force in a spool valve;
(c) PID controller;
(d) pressure relief valve;
(e) counterbalance valve;
(f) force constant of a force motor.