Ref No: **Ex/PG/ELE/PE/T/124D/2025**

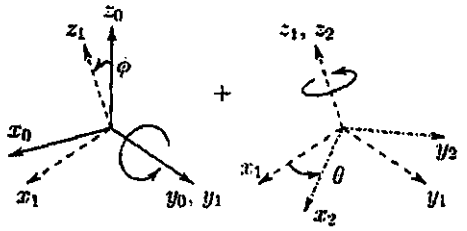
M.E. ELECTRICAL ENGINEERING 1ST YEAR 2ND SEMESTER EXAM 2025
MASTER IN CONTROL SYSTEM ENGG 1ST YEAR 2ND SEMESTER EXAM 2025

SUBJECT: - ROBOTICS AND AUTOMATION SCIENCE

Time: Three hours

Full Marks 100
(50 marks for each part)

Use a separate Answer-Script for each part

No. of Questions	PART I	Marks
	Answer Q.4 and ANY TWO from the rest.	
1. (a)	In robot dynamics, what are Lagrange's equations of motion? Derive in detail to show that the dynamics of a simple two-link planar arm is given as: $M(q)\ddot{q}+V(q,\dot{q})+G(q)=\tau$, where each symbol has its usual meaning.	09
(b)	In computed torque control of robot manipulators, how is the design of the PD controller carried out for outer loop? How are the choices of PD gains carried out?	08
2. (a)	As given in Fig. 1, determine the resultant rotation matrix R that represents a rotation of angle $\phi = 45°$ about the current y-axis, followed by a rotation of angle $\theta = 30°$ about the current z-axis. Also determine the resultant rotation matrix R' if these two rotations are performed in the reverse order and show that $R \neq R'$.  Fig. 1.	08
(b)	How is each homogenous transformation represented in Denavit-Hartenberg (DH) convention of forward kinematics? How can DH convention represent a homogeneous transformation by four parameters only, instead of six parameters? State the two coordinate frame assumptions made in DH convention and establish their significance.	09

[Turn over

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No. of Questions	PART I	Marks
3. (a)	How can Kalman filter be employed for robot navigation problems? Explain the basic philosophies of *prediction stage* and *measurement update stage* employed in Kalman filter. Prove that the *prediction stage* leads to the relation: $P_{t\|t-1} = FP_{t-1\|t-1}F^T + Q_t$, where each symbol has its usual meaning.	09
(b)	A system is given as: $\dot{x}(t) = A(t,x)x(t) + Bu(t)$ where $x(t) \in R^n$, $u(t) \in R^m$, and $A(t,x)$ comprises some elements that experience bounded variations. How can the method of equivalent control be employed to design sliding surface for this system? How is the desired characteristic polynomial chosen in this design? What are the special characteristics possessed by this system when it experiences sliding mode?	08
4.	Write short notes on ***any two*** of the following: *i*) Feedback linearizing transformation in robot dynamics. *ii*) Phenomenon of chattering in sliding mode control. *iii*) The general inverse kinematics problem in robotics. *iv*) Inner feedforward loop in computed torque control.	08×2 =16

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M.E. ELECTRICAL ENGINEERING FIRST YEAR SECOND SEMESTER EXAM 2025

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MASTER IN CONTROL SYSTEM ENGG FIRST YEAR SECOND SEMESTER EXAM 2025

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Time: Three hours **Full Marks 100**

(50 marks for each part)

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PART-II **Marks**

Answer any four, 2 marks for well-organized answers (12 X 4 + 2 = 50)

1. What is Sensor Fusion? Explain different levels of such a fusion strategy. (CO2) — 2+10

2. What is SCADA? What are the different components of it? Compare between different SCADA architectures. (CO2) — 2+4+6

3. A Rough Set based decision rule generation system uses a real valued data table as given below. Generate the discretized decision table using maximal discernible heuristics. Show the optimum set of cuts. (CO4) — 12

Objects	Condition Attributes		Decision Attribute
	A	B	
U_1	0.5	5.0	0
U_2	0.70	4.0	0
U_3	1.25	5.0	1
U_4	0.25	1.5	1
U_5	1.25	1.5	0
U_6	0.70	4.0	1
U_7	0.70	1.5	1

4. Draw and explain a ladder diagram related to Programmable Logic Controller (PLC) operation for 3 motors operating in the following conditions: — 12

i) "Start" push button starts motor M1 and also starts M2 and M3 after 15 seconds.

ii) "Stop" push button stops M3 and also stops motor M2 and M1 after 20 seconds

(CO2)

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Time: Three hours **Full Marks 100**

(50 marks for each part)

Use a separate Answer-Script for each part

5.	In a process plant, a model identification based system has been employed for automation to meet certain industry 4.0 requirement. The process, whose dynamics are not well known, is initially at steady state. An input signal is introduced to the system. The sampled values of the input as well as the output response at different time instants are as follows: **Sampling instant** / **Input variable (units)** / **Output variable (units)** 0 / 1.0 / 0.0 1 / 0.5 / 0.65 2 / 0.3 / 0.8 3 / 0.1 / 0.95 Identify the parameters of the process assuming first order model. (CO4)	12
6.	**Write a note on *any one*** (CO4)	12
a)	Model Identification based Automation System	
b)	Autonomous detection and localization of Partial Discharge Sources within a Power Apparatus	
c)	Artificial Intelligence aided development life-cycle of Autonomous Vehicles	