SEMESTER S6

CONTROL SYSTEM LAB

(EE Branch)

Course Code	**PCEEL607**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	PCEET302/ PCEET601	**Course Type**	Lab

Course Objectives:

1. To make the students learn how to determine the parameters experimentally and model the given system.
2. To make the students learn the experimental determination of responses of dynamic systems and analyse its behaviour.
3. To make the students learn the different analysis and controller design tools using appropriate simulation software

Expt. No.	Experiments
1	**Transfer Function and State Space Modelling of Armature and Field Controlled DC Motor.** **Objective:** Obtain the transfer function and state space model of the armature and field-controlled DC motor by experiment.
2	**Transfer function of A.C. Servo motor.** **Objective:** Obtain the transfer function of AC Servo motor by experiment.
3	**Synchro Transmitter and Receiver for open loop position control.** **Objective:** a) Plot the characteristics of synchro. Error study of the synchro transmitter and receiver pair as a simple open loop position control in Direct mode and Differential mode.

4	**Step response and frequency response of a second order system realised using passive components** **Objective**: Design a second order (RLC network) system to analyse the following: a. The effect of damping factor ($0<\xi<1$, $\xi = 1$, $\xi > 1$) for a step input . b. Verification of the delay time, rise time, peak overshoot and settling time with the theoretical values for $0<\xi<1$. c. Effect of damping ratio on frequency response. d. Verification of resonant peak, resonant frequency and bandwidth for $0<\xi<1$.
5	**Realisation of lead compensator.** **Objective:** Design, set up and analyse the gain and phase plots of a lead compensator by hardware experimentation using i) passive elements and ii) active components
6	**Realisation of lag compensator.** **Objective:** Design, set up and analyse the gain and phase plots of a lag compensator by hardware experimentation using: i) passive elements and ii) active components.
7	**Performance of a typical process control system** **Objective:** Study of performance characteristics and response analysis of a typical temperature/ Flow/ Level control system.
8	**System Identification and Modeling** **Objective:** Obtain the frequency response and identify the transfer function of the given system(black box),

9	**Step response and frequency response of a second order system using simulation** **Objective:** To analyse the response of the second order system (in experiment 1) using (MATLAB/SCILAB/similar softwares) a. The effect of damping factor ($0<\xi<1$, $\xi = 1$, $\xi > 1$) for a step input . b. Comparison of the delay time, rise time, peak overshoot and settling time with the experimental values for $0<\xi<1$. c. The effect of damping ratio on frequency response. d. Comparison of resonant peak, resonant frequency and bandwidth with the experimental values for $0<\xi<1$.
10	**Performance Analysis using Root-Locus and frequency Response Methods in MATLAB/SCILAB/similar softwares.** **Objective:** 1. Plot the i) root locus ii) Bode plot and iii) Nyquist plot and iv) Nichols chart for the given transfer functions and analyse the following: **Root Locus:** a. Determine the critical gain, frequency of oscillation at critical gain. b. The effect of gain, K on the stability. c. Determine the gain corresponding to a given damping ratio and obtain the step response of the system for the corresponding gain. d. The effect of the addition of poles and zeros on the given system. **Frequency response:** e.Determination of Gain Margin and Phase Margin (stable and unstable, minimum/non-minimum phase system)

	f. The effect of controller gain K on the stability margin g. The effect of the addition of poles and zeros on the given system (especially the poles at origin). h. Determine the stability of a given minimum and non-minimum phase system using Nyquist stability criterion. i. Determine the bandwidth of a given system from open loop frequency response using Nichols chart.
11	**Design of lag, lead and lag-lead compensator using root locus.** **Objective:** Design a suitable compensator for the given system to satisfy the given time domain specifications using MATLAB/SCILAB/ similar software.
12	**Design of lag, lead and lag-lead compensator using frequency response.** **Objective:** Design a suitable compensator for the given system to satisfy the given frequency domain specifications using MATLAB/SCILAB/ similar software.
13	**State Space Model, Analysis and Controller Design** **Objective:** Analyse the given system (eg. DC Servo motor modelled in experiment no.1 for **speed** control) in state space and design a controller by pole-placement technique using MATLAB/SCILAB/ similar software. a. Determine the open loop stability, controllability and observability b. Design a state-feedback controller by pole-placement technique for a given specification.
14	**PID Controller Design** **Objective:** Design a PID controller for the given system (eg. DC Servo motor modelled in experiment no. 1 for **position** control) using SIMULINK/ MATLAB based tool boxes. a. Design of P, PI, PD, PID controller using the Ziegler-Nichols method. b. Design of a suitable controller (P/PI/PD/PID) to meet the desired specifications using root locus/frequency response.

Note: 1. A minimum of **12 experiments** are compulsory.
2. Experiment No. **11, 12, and 13** are mandatory.

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- ***Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.***
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Identify and conduct suitable experiments to determine the parameters to model a physical system.	**K3**
CO2	Conduct suitable experiments and determine the performance specifications.	**K3**
CO3	Analyse a linear continuous time system model using simulation tools.	**K3**
CO4	Design suitable controllers/compensators to meet the performance requirements using simulation tools.	**K5**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	3	3	3	3	2	3	2
CO2	3	3	2	2	2	3	3	3	3	2	3	2
CO3	3	3	2	2	2	3	3	3	3	2	3	2
CO4	3	3	3	3	3	3	3	3	3	2	3	2

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Modern Control Engineering	Katsuhiko Ogata	Pearson	5th edition, 2009
2	Control Systems Engineering	Norman S. Nise	Wiley	5th edition, 2009
3	Control Systems Engineering	I. J. Nagrath, M. Gopal	New Age	5th edition, 2009

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Automatic Control Systems,	Kuo B. C.	Prentice Hall of India	
2	Control Systems Principles and Design	Gopal M.	Tata McGraw Hill.	
3	Modern Control Systems	Dorf R. C., Bishop R. H	Pearson Education India	

Continuous Assessment (25 Marks)

1. **Preparation and Pre-Lab Work (7 Marks)**

    - Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
    - Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. **Conduct of Experiments (7 Marks)**

    - Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
    - Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
    - Teamwork: Collaboration and participation in group experiments.

3. **Lab Reports and Record Keeping (6 Marks)**

    - Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
    - Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. **Viva Voce (5 Marks)**

    - Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. **Procedure/Preliminary Work/Design/Algorithm (10 Marks)**

    - Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.

- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

2. Conduct of Experiment/Execution of Work/Programming (15 Marks)

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. Result with Valid Inference/Quality of Output (10 Marks)

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. Viva Voce (10 Marks)

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. Record (5 Marks)

- Completeness, clarity, and accuracy of the lab record submitted