Control Engineering			
Course Code	**21SM72**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	--	Total Marks	100
Credits	02	Exam Hours	03

Course objectives:

- Understand the basic concepts & mathematical modelling of systems.
- Modelling of mechanical, hydraulic, pneumatic and electrical systems.
- Representation of system elements by blocks and its reduction.
- Transient and steady state response analysis of a system.
- Frequency response analysis using polar plot.
- Frequency response analysis using bode plot.
- Analysis of system using root locus plots.

Teaching-Learning Process (General Instructions)
These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

Module-1	**8 Hours**
Introduction: Concept of automatic controls, Open loop and closed loop systems, Concepts of feedback, requirements of an ideal control system, Types of controllers-Proportional, Integral, Differential, Proportional & Integral, Proportional Differential and Proportional Integral Differential controllers.	
Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation

Module-2	**8 Hours**
Modelling of Physical Systems: Mathematical Models of Mechanical, Electrical, Thermal, Hydraulic and Pneumatic Systems. **Analogous Systems:** Direct and inverse analogues for mechanical, thermal and fluid systems. **Block diagram Algebra**: General representation of a feedback control system, transfer functions, rules of block diagram algebra, reduction of block diagram to obtain closed loop transfer function. Signal flow graphs, Mason's gain formula.	
Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation

Module-3	**8 Hours**
Steady state operation: Steady state analysis for general block diagram for a control system, steady state characteristics, equilibrium in a system. **Time Response of feedback control systems**: Standard test signals, Unit step response of First and Second order Systems. Time response specifications, Time response specifications of second order systems, steady state errors and error constants. Routh's stability criterion for a control system.	
Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation

Module-4	**8 Hours**
Root Locus Plots: Root locus method: Significance of Root locus, angle and magnitude conditions, breakaway points, angles of departure and arrival, construction of Root locus using general rules and steps, Lead and Lag compensation	
Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation

Module-5	**8 Hours**
Frequency Domain Analysis: Relationship between time and frequency response, Polar plot, Bode Plot, Nyquist plot and Nyquist stability criterion, Relative Stability, Phase and Gain Margins	
Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation

Course outcome (Course Skill Set)

At the end of the course the student will be able to:

1. Recognize control system and its types, control actions.
2. Determine the system governing equations for physical models (Electrical, Thermal, Mechanical, Electro Mechanical).
3. Calculate the gain of the system using block diagram and signal flow graph.
4. Illustrate the response of 1st and 2nd order systems.
5. Determine the stability of transfer functions in complex domain and frequency domain.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module

Suggested Learning Resources:

Books

J Nagrath and M Gopal, 'Control Systems Engineering', New Age International(P) Limited, Publishers, Fifth edition, 2005, ISBN: 81 - 224 - 2008-7.

Reference Books:

- K Ogata, 'Modern Control Engineering', Pearson Education Asia/ PHI, 4th Edition, 2002. ISBN 978 - 81 - 203 - 4010 - 7.
- Benjamin C. Kuo, 'Automatic Control Systems', John Wiley India Pvt. Ltd., 8th Edition, 2008.
- Joseph J Distefano III et al., 'Feedback and Control System', Schaum's Outline series, TMH, 2nd Edition, 2007.