# GUJARAT TECHNOLOGICAL UNIVERSITY

**Bachelor of Engineering**
**Subject Code: 3172007**
**Semester – VII**

**Subject Name: Modern Control Systems**

**Type of course:** Engineering (Programme Elective - I)

**Prerequisite:** Zeal to learn the course

**Rationale:** The course intends to provide foundations related to control engineering to graduate students. The course should enhance their ability to analyze and control multiple domain systems using techniques and tools related to control systems**.**

**Teaching and Examination Scheme:**

| Teaching Scheme | | | Credits | Examination Marks | | | | Total Marks |
|---|---|---|---|---|---|---|---|---|
| | | | | Theory Marks | | Practical Marks | | |
| L | T | P | C | ESE (E) | PA (M) | ESE (V) | PA (I) | |
| 3 | 0 | 2 | 4 | 70 | 30 | 30 | 20 | 150 |

**Content:**

| Sr. No. | Content | Total Hrs |
|---|---|---|
| 1 | **Introduction to Modern Control Systems –** Need and requirements of Modern Control Systems, Various Modern Control Systems Techniques, Performance Measure for Control Systems, Time & Frequency Domain Compensator Design, Outline of various compensation techniques: Phase-Lead, Phase-Lag, Phase-Lead-Lag, P/PI/PD/PID controllers. | 10 |
| 2 | **State Space Analysis –** Limitations of conventional control theory, Introduction to State-Space, State Variables, and State Vectors; State variable representation including Electrical, Mechanical, Electro-mechanical system; Conversion of state variable Models to Transfer function via direct, cascade, parallel decomposition, Solution of Homogeneous and Non-Homogeneous State equations in time-domain and frequency-domain, State-Transition Matrix, Concepts of Controllability and Observability. | 10 |
| 3 | **Nonlinear Control System Analysis –** Introduction to Nonlinear systems, Standard nonlinearities in control systems, Describing function analysis of nonlinear control systems, stability of sustained oscillations or limit cycle. Concepts of phase plane analysis, phase plane portraits, Phase Plane analysis of linear and nonlinear control system, Lyapunov stability theorems, Lyapunov functions for nonlinear systems. | 8 |
| 4 | **Digital/Discrete Time Control Systems Analysis –** Introduction to discrete time systems, Analog and Digital controllers, Z-transform, Derivation of z-transform of standard functions, Difference equation and its solution by the z-transform method, initial and final value theorem, Inverse z-transform using infinite series and partial fraction methods, pulse transfer function, pulse transfer function of closed-loop system using signal flow graph technique, Stability analysis in z-plane. | 9 |
| 5 | **Intelligent Control Systems –** Adaptive Control System, Model reference Adaptive Control, Fuzzy Control System, Neural Control System, Reinforcement Learning Control, Embedded Control System. | 5 |

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**Suggested Specification table with Marks (Theory):**

| Distribution of Theory Marks | | | | | |
|---|---|---|---|---|---|
| R Level | U Level | A Level | N Level | E Level | C Level |
| 15 | 15 | 15 | 15 | 20 | 20 |

**Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)**

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

**Reference Books:**


1. Control Systems: Principal and Design, M. Gopal , 4th Edition , Mc Graw Hill Education.
2. Control system Engineering, Norman Nise, 7th Edition, Willey India Edition.
3. Modern control system, Dorf, R.C., and R.H. Bishop, 10th Edition, Pearsons Education.
4. Handbook of Intelligent Control: Neural, Fuzzy and Adaptive Approaches, D. White and D. Sofge, editors., Van Nostrand Reinhold, New York.


**Course Outcomes:**

After successful completion of the course the students shall be able to:

| Sr. No. | CO statement | Marks % weightage |
|---|---|---|
| CO-1 | Design and Analyze control system using Lead, Lag, and Lag-Lead compensator with the help of the root locus and bode plot techniques for multidisciplinary applications of engineering. | 20 |
| CO-2 | Design of single input single output system, Multi Input Multi output system via modern control tool like state space analysis. | 20 |
| CO-3 | Stability analysis of State space system using state feedback control techniques. | 20 |
| CO-4 | Mathematical modeling, Analysis and stability of control system using discrete time analysis. | 20 |
| CO-5 | Students will learn fundamentals of intelligent/smart control systems used in automation | 20 |

**List of Experiments:**

1. Introduction to MATLAB & SIMULINK, and Control System Toolbox.
2. To study about Phase-Lead / Phase-Lag Controller.
3. To study about effect of Non-linearity in stable Control systems.
4. Phase-plane trajectory for Non-linear control systems.
5. To study about Z-Transform and its properties.
6. To study about stability analysis of Discrete-time Control Systems.
7. State-Space Analysis study with respect to Transfer function method for Stable Control Systems.
8. To study about fuzzy control Systems.
9. To study about Neural Control Systems.
10. Practical Application Development (Mini project / OEP)

**Major Equipment's:**

1. All these experimental study with Software Tool: MATLAB.
2. MATLAB contains Control Systems Toolbox, Digital Signal Processing Toolbox, Fuzzy Toolbox, and Neural Toolbox.
3. Control Experiment Equipment: PID Control, Non-linear Control Systems, Discrete-time Control Systems.

**List of Open-Source Software/learning website:**

- Demo versions of MATLAB and other control theory related soft wares are available free of cost for limited periods**.**
- NPTEL Swayam Courses may be utilized for additional learning.
- Python based Control Application Development.