Minor Specialization
In
Systems and Control

for B. Tech. (other than Electrical Engineering)

Course Structure
&
Syllabi

DEPARTMENT OF ELECTRICAL ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

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DEPARTMENT OF ELECTRICAL ENGINEERING

Minor Specialization in ***Systems and Control***

Semester V

S. No.	Course Code	Course Title	Course Category	Type	Credits	L	T	P
1	EET-XYZ	Linear System Theory	Program Core	Theory	3	3	0	0
2	EET-XYZ	Discrete time Control Systems	Program Core	Theory	3	3	0	0

Semester VI

S. No.	Course Code	Course Title	Course Category	Type	Credits	L	T	P
1	EET-XYZ	Nonlinear Control Systems	Program Core	Theory	3	3	0	0
2	EET-XYZ	Fundamentals of Robotics	Program Core	Theory	3	3	0	0

Semester VII

S. No.	Course Code	Course Title	Course Category	Type	Credits	L	T	P
1	EET-XYZ	Optimal Control Theory	Program Core	Theory	2	2	0	0
2	EEP-XYZ	System Engineering Lab	Program Core	Theory	1	0	0	2

Semester VIII

S. No.	Course Code	Course Title	Course Category	Type	Credits	L	T	P
1	EEP-XYZ	Mini Project	Program Core	Project	3	0	0	6

Department	**: Department of Electrical Engineering**
Course Code	**: EET-XYZ**
Course Name	**: Linear System Theory**
Credits	**: 3 (L - 3 T - 0 P – 0)**
Course Type	**:** ***Program core***

Course Contents

Description of systems: Causality, time-invariance, time-varying, linearity, lumpedness, impulse response, convolution integral, transfer function, state-space representation, high-order differential representation, concept of equilibrium, linearization.

Modeling, State-space solutions and realizations: Mathematical model of physical systems in state-space domain, solution of time-invariant and time-varying systems, equivalent state-space models, realization, Cayley-Hamilton theorem.

Stability: Definition of stability notions, input-output stability, time and frequency domain conditions for BIBO stability, Concept of Lyapunov stability.

Controllability and Observability: Concept of controllability, controllable and reachable subspaces, tests for controllability, introduction to the concept of observability, tests for observability, duality in LTI systems.

Feedback control and Observer design: Importance of feedback control, Proportional-integral control, concept of state feedback control, pole-placement technique, Ackerman's approach, introduction to linear quadratic regulator, full-order and reduced-order observer design, observer based compensator design.

Books:

[1] Linear system theory and design by Chi-Tsong Chen, 4th edition, Oxford University press.

[2] Modern Control Theory, 3rd Edition by William L Brogan.

[3] Modern Control System Theory, by Madan Gopal (Author), New Edge publications.

[4] Control System Design An introduction to state-space methods by Bernard Friedland, Dover publications.

COURSE OUTCOMES (COs)

After the completion of the course, students should be able to:

CO1- distinct several types of systems and the **mathematical tools** required to describe them,

CO2- write state models of dynamical systems and to obtain the **solutions and its properties**,

CO3- investigate the **qualitative behaviour** of linear systems,

CO4- understand, design and implementation of the feedback **control techniques**.

Department	**: Department of Electrical Engineering**
Course Code	**: EET-XYZ**
Course Name	**: Discrete Time Control System**
Credits	**: 3 (L - 3 T - 0 P – 0)**
Course Type	***: Program core***

Course Contents

Signal Processing in Digital Control: Basic digital control system, advantages of digital control and implementation problems, basic discrete time signals, z-transform and inverse z-transform, modeling of sample- hold circuit., pulse transfer function, solution of difference equation by z-Transform method.

Design of Digital Control Algorithms: Steady state accuracy, transient response and frequency response specifications, digital compensator design using frequency response plots and root locus plots.

State Space Analysis and Design: State space representation of digital control system, conversion of state variable models to transfer functions and vice versa, solution of state difference equations, controllability and observability, design of digital control system with state feedback.

Stability of Discrete System: Stability on the z-plane and Jury stability criterion, bilinear transformation, Routh stability criterion on rth plane. Lyapunov's Stability in the sense of Lyapunov, stability theorems for continuous and discrete systems, stability analysis using Lyapunov's method.

Optimal digital control: Discrete Euler Lagrange equation, max. min. principle, optimality & Dynamic programming, Different types of problem and their solutions.

Books:

[1] B.C.Kuo, "Digital Control System",Saunders College Publishing.

[2] M.Gopal, "Digital Control and State Variable Methods", Tata McGraw Hill.

Reference Books.

[1] J.R.Leigh, "Applied Digital Control", Prentice Hall, International.

[2] C.H. Houpis and G.B.Lamont, "Digital Control Systems:Theory, hardware, Software",Mc Graw Hill.

COURSE OUTCOMES (COs)

After the completion of the course, students should be able to:

CO1: Understand discrete-time signals and sample-hold circuit modeling with z-transforms.

CO2: Learn to design digital control algorithms for steady-state accuracy, transient, and frequency response, using frequency response plots and root locus.

CO3: Gain proficiency in state space analysis and design for digital control systems, including representation, conversion, and state feedback techniques.

CO4: Develop an understanding of stability analysis for discrete systems using techniques like Jury and Routh stability criteria, as well as Lyapunov's method.

Department	**: Department of Electrical Engineering**
Course Code	**: EET-XYZ**
Course Name	**: Nonlinear Control Systems**
Credits	**: 3 (L - 3 T - 0 P – 0)**
Course Type	***: Program core***

Course Contents

Introduction to Nonlinear Systems: Overview of nonlinear systems, Distinction between linear and nonlinear systems, Importance of nonlinear control in practical applications.

Classification of Nonlinearities: Basic types of nonlinearities, Polynomial nonlinearities, Trigonometric nonlinearities, Exponential and logarithmic nonlinearities, Piecewise-linear nonlinearities, Time-varying nonlinearities.

Analysis of Nonlinear Systems: Phase plane analysis, Stability analysis, Lyapunov stability theory, Input-output stability, Equilibrium points and their stability, Bifurcations and their effects on system behavior.

Nonlinear Control Strategies: Feedback linearization, Sliding mode control, Back stepping control, Lyapunov-based control, Passivity-based control, Nonlinear Observers.

Case studies and examples from various engineering disciplines: Robotics, Aerospace systems, Power systems, Chemical processes, Biological systems.

Books:

[1] J. J. Slotine and W. Li Applied Nonlinear Control, Prentice-Hall, 1991.

[2] M. Vidyasagar, Nonlinear Systems Analysis, SIAM, 2002

[3] H. J. Marquez, Nonlinear Control Systems: Analysis and Design, John Wiley Intersciencce, 2003.

[4] J. E. Gibson Nonlinear Automatic Control, McGraw-Hill,1963.

COURSE OUTCOMES (COs)

After the completion of the course, students should be able to:

CO1: Understand the fundamentals of nonlinear systems, including their distinction from linear systems and their importance in practical applications.

CO2: Classify different types of nonlinearities encountered in engineering systems, such as polynomial, trigonometric, exponential, logarithmic, piecewise-linear, and time-varying nonlinearities.

CO3: Analyze nonlinear systems using phase plane analysis and stability analysis techniques.

CO4:Explore various nonlinear control strategies, including feedback linearization and sliding mode control.

CO5: Apply nonlinear control concepts to real-world case studies and examples from diverse engineering disciplines.

Department	**: Department of Electrical Engineering**
Course Code	**: EET-XYZ**
Course Name	**: Fundamental of Robotics**
Credits	**: 3 (L-3 T-0 P-0)**
Course Type	**: Program core**

Course Contents

Introduction to Robotics: Evolution of robots and robotics, robot anatomy, links, joints, degrees of freedom, arm configuration, wrist configuration, end-effector, work space. Homogeneous transformation: rotation, translation, composition of homogeneous transformations, and mapping between rotated and translated frames.

Kinematics of Robots: Kinematic modeling of the manipulator, Denavit-Hartenberg notation, D-H procedure for fixing joint coordinate frames, robot parameters, kinematic relationship between adjacent links, manipulator transformation matrix. Inverse kinematics for PUMA, SCARA manipulators.

Jacobians: Velocities and static forces, linear and rotational velocity of rigid bodies, manipulator Jacobians, singularities, static forces in manipulators, Jacobians in the force domain, Cartesian transformation of velocities and static forces.

Dynamics and Control: Dynamic modeling, Lagrange-Euler formulation, Newton- Euler formulation, trajectory planning, joint space techniques, cartesian space formulation, control of manipulator, PID control scheme, computed torque control, force control of robotic manipulators.

Books:

[1]. Robotics by K.S. Fu, R.C. Gonzalez, C.S.G. Lee, McGraw-Hill Book Company, 1987.

[2]. Introduction to Robotics by J.J. Craig, Prentice Hall International, 2005.

[3]. Robot Manipulators: Mathematics, Programming and Control by Richard Paul, MIT Press, 1981.

[4]. Fundamentals of Robotics by Robert Shilling, Prentice-Hall, 2003.

COURSE OUTCOMES (COs)

On completion of the course, the student will be able to:

CO1: Identify and describe the components and anatomy of robotic system.

CO2: Compute forward and inverse kinematics for a small serial kinematic chain.

CO3: Consider trade-offs among position control, velocity control, and force control when solving a robot control problem.

CO4: To introduce the dynamics and control of manipulators.

Department	: Department of Electrical Engineering
Course Code	: **EET-XYZ**
Course Name	: **Optimal Control Theory**
Credits	: **2 (L - 2 T - 0 P – 0)**
Course Type	: *Program core*

Course Contents

Static optimization and performance measures: Introduction and concept of optimization, optimization with and without constraints, formulation of performance measure for several optimal control problems, introducing constraints on systems, examples.

Dynamic programming: The optimal control law, the principle of optimality and its application to decision making, dynamic programming concept.

Calculus of Variations and Optimal Control Design: Variation and optimum of functional, fundamental theorem of calculus of variations, determination of extremum of functional for several cases, constrained minimization of functional, variation approach to optimal control problem, Hamiltonian formulation, linear regulator problems.

Books:

[1] Optimal control theory-An introduction by Donald E. Krik, Dover publications New York.

[2] Calculus of variations and optimal control theory-A concise introduction by Daniel Liberzon, Princeton University Press 2012.

[3] Optimal control: linear quadratic methods by Brian D. O. Anderson, Dover, 2007.

[4] Optimal control by Frank L. Lewis, Draguna L. Vrabie, and Vassilis L. Syrmos, third edition, John Wiley & Sons, Inc.

COURSE OUTCOMES (COs)

After the completion of the course, students should be able to:

- CO1- **distinct** dynamic and static optimization and **formulate optimal control problem**,
- CO2- **understand** the **principal of optimality** and its applications,
- CO3- **appreciate** the calculus of variations in **dealing** with optimal control problems and **design of optimal control strategies.**

Department : Department of Electrical Engineering

Course Code : **EEP-XYZ**

Course Name : **System Engineering Lab**

Credits : **1 (L - 0 T - 0 P – 2)**

Course Type : ***Program core***

Course Contents

List of Experiments:

[1] Speed control of an AC Servo motor & effect of capacitance connected in series with the reference winding.

[2] System identification and calculation of process parameters.

[3] To plot the open-loop time response first order and second-order system for standard test signals.

[4] To design proportional (P), integral (I) and derivative (D) controller for a second-order system and analyze its effect on transient response of a type-0 second order.

[5] To design proportional (P), integral (I) and derivative (D) controller for a second-order system and analyze its effect on transient response of a type-1 second order.

[6] To design PI and PID controller for a second-order system and analyze its effect on transient response of a second order (a) Type-0 (b) Type-1 systems.

[7] Introduction to different components of MATLAB.

[8] To write MATLAB code and plot the step time response using transfer function of a given open loop second order system (for all possible value of damping ratio).

[9] To write MATLAB code and observe the transient or/and steady-state performance of a given second order underdamped system with P, I, PI and PID controller.

[10] To perform MATLAB simulation of a second order mechanical and electrical system.

[11] To perform MATLAB simulation of a power electronic circuit and compare its open-loop and closed-loop behavior.