DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY

(Established a University of Technology in the State of Maharashtra)

(under Maharashtra Act No. XXIX of 2014)

P.O. Lonere, Dist. Raigad, Pin 402 103,

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PROPOSED CURRICULUM POSTGRADUATE PROGRAMME

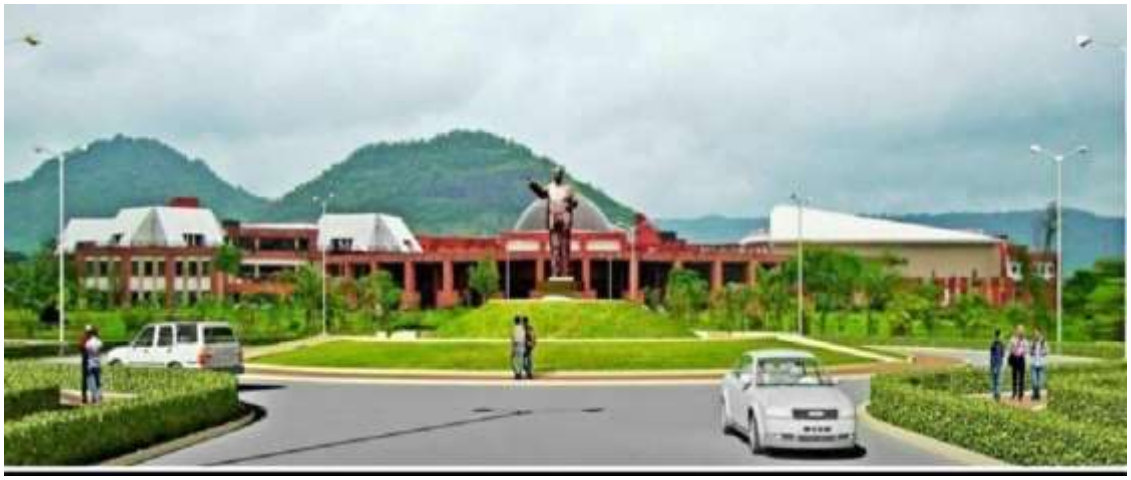
M.TECH

Control systems Engineering (12294) (Affiliation Institute)

Two Year (Four Semester) Course

In line with New Education Policy 2020 guidelines

WITH EFFECT FROM THE ACADEMIC YEAR 2024-2025



M. Tech (Control System Engineering)

Program Educational Objectives:

1. To prepare graduates meet the challenges of modern society through viable engineering solutions.
2. To prepare graduates to develop economically viable cutting-edge technology for local industry. Need.
3. To prepare graduates to inspire the next generation graduates as successful engineer/ entrepreneur, scientist and researcher.

Program Outcomes:

1. Ability to apply knowledge of science, mathematics, and engineering principles for solving problems.
2. Ability to identify, formulate and solve electrical power system problems
3. Ability to understand and use different software tools in the domain of Power electronics, power system and control system simulations.
4. Ability to design and conduct experiments and analyze and interpret data.
5. Ability to coherently work in a multidisciplinary team.
6. Demonstrate sensitivity towards professional and ethical responsibility.
7. Ability to communicate effectively in writing as well as through public speaking.
8. Demonstrate ability to appreciate and engage in lifelong learning.
9. Demonstrated knowledge of contemporary issues.
10. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
11. Broad education is necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.

Dr. Babasaheb Ambedkar Technological University

Teaching and Examination Scheme for

M. Tech. (Control System Engineering)

Inline with New Education Policy 2020 guidelines (Effective from Academic Year 2024-25)

First Semester

Sr. No.	Course Category	Course Code	Course Title	Teaching Scheme			Evaluation Scheme					Credit
				L	T	P	MSE	ESE	CA	OR/PR	Total	
1	PCC	24AF2294PC101	Modelling and Dynamic System	3	1	--	20	60	20	--	**100**	4
2	PCC	24AF2294PC102	System Identification	3	1	--	20	60	20	--	**100**	4
3	PCC	24AF2294PC103	Modern Control System	3	1	--	20	60	20	--	**100**	4
4	PCE	24AF2294PE104	Elective-I	3	1	--	20	60	20	--	**100**	3
5	PCE	24AF2294PE105	Elective-II	3	1	--	20	60	20	--	**100**	3
6	ELC	24AF2294SE106	Seminar I	--	--	04	--		25	25	**50**	2
7	PCE	24AF2294PCL107	PG Lab-I	--	--	04	--		25	25	**50**	2
8	Audit Course	24AF2294AU108	Yoga for Stress Management	2	--	04	--		50	--	**50**	AU
			Total	**17**	**05**	**12**	**100**	**300**	**200**	**50**	**650**	22

24AF2294PE104: Elective –I	24AF2294PE105: Elective-II
A) Optimization Techniques	A) Advanced Drives and Control
B) Optimal Control	B) Industrial Automation and Control
C) Robust Control	C) Computational Methods
D) Power Electronics and Control	D) Decentralized Control

Second Semester

Sr. No.	Course Category	Course Code	Course Title	Teaching Scheme			Evaluation Scheme					Credit
				L	T	P	MSE	ESE	CA	OR/PR	Total	
1	PCC	24AF2294PC201	Sliding mode Control	3	1	--	20	60	20	--	**100**	4
2	PCC	24AF2294PC202	Multivariable Control	3	1	--	20	60	20	--	**100**	4
3	PCE	24AF2294PE203	Elective-III	3	1	--	20	60	20	--	**100**	3
4	OE	24AF2294OE204	Open Elective-I	3	1	--	20	60	20	--	**100**	3
5	PCE	24AF2294PC205	Energy Management and Auditing	3	1	--	20	60	20	--	**100**	3
6	AEC/VEC/IKS	24AF2294AE206	IKS Bucket #	3	0	--	20	60	20	--	**100**	2
7	PCE	24AF2294PCL207	PG Lab-II	--	--	04	--	--	25	25	**50**	2
8	ELC	24AF2294MP208	Mini-Project	--	--	04	--	--	25	25	**50**	1
9	Audit Course	24AF2294AU209	Disaster Management	2	--	--	--	--	50	--	**50**	AU
			Total	**20**	**05**	**08**	**120**	**360**	**150**	**50**	**750**	22

24AF2294PE203: Elective–III	24AF2294OE204: Open Elective– I
A) Digital Control Systems	A) Modern Optimization Techniques.
B) Fractional Order Modeling and Control	B) Industrial Load Modelling and Control
C) Embedded control	C) Energy storage system.
D) High Performance Electric Drives	D) Intelligent systems
E) Research Methodology and IPR	E) Advanced DSP

24AF2294AE206: Indian Knowledge System (IKS)
A) Concepts and Applications in Engineering
B) Humanities and Social Sciences

Third Semester

Sr. No.	Course Category	Course Code	Course Title	Teaching Scheme			Evaluation Scheme					Credit
				L	T	P	MSE	ESE	CA	OR/PR	Total	
1	OE	24AF2294OE301	Open Elective-II	3	1	--	20	60	20	--	**100**	3
2	MDM	24AF2294MD302	Multidisciplinary Minor	3	1	--	20	60	20	--	**100**	3
3	INP	24AF2294SE303	Internship	--	--	--	--	--	50	50	**100**	6
4	ELC	24AF2294SE304	Seminar II	--	--	--	--	--	50	50	**100**	2
5	ELC	24AF2294PR305	Project-I	--	--	4	--	--	50	50	**100**	6
			Total	**6**	**02**	**4**	**40**	**120**	**190**	**150**	**500**	20

24AF2294OE301: Open Elective-II	24AF2294MD302: Multidisciplinary Minor
A) Entrepreneurship	A) Stochastic Control
B) Environment and Development	B) Industrial load Modelling and control
C) Student Psychology	C) Ethical Hacking
D) Principles Of Economics	D) Artificial Intelligence and Machine Learning
E) Business To Business Marketing (B2B)	E) Components And Applications of the Internet of Things

Fourth Semester

Sr. No.	Course Category	Course Code	Course Title	Teaching Scheme			Evaluation Scheme					Credit
				L	T	P	MSE	ESE	CA	OR/PR	Total	
1	ELC	24AF2294PR401	Project-II	--	--	--	--	--	100	100	**200**	20
			Total	--	--	--	--	--	**100**	**100**	**200**	20
			Grand Total								**2000**	

*****PG Lab-I and PG Lab-II– Practical shall be based on courses of the respective semester.

Abbreviations: PCC (Program Core Course), PEC (Program Elective Course), ELC (Experiential Learning Courses), OE (Open Elective), AEC (Ability Enhancement Courses), VEC (Value Education Courses), IKS (Indian Knowledge System), MDM (Multidisciplinary Minor), INP (Internship)

Credit Distribution				
SEM-I	**SEM-II**	**SEM-III**	**SEM-IV**	**Total**
22	**22**	**20**	**20**	**84**

DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY LONERE

24AF2294PC101: MODELLING AND DYNAMIC SYSTEM

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 4**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

1. To lay emphasis on the qualitative and geometric properties of ordinary differential equations and their solutions, helping the student to get a feel for the subject.
2. To emphasize through examples and connections with mechanics the physical reasoning used as a substitute for much longer formal mathematical reasoning.
3. To introduce the students to the modern language and theories of vector fields flows, one parameter transformation groups, symmetries etc.

Course Outcomes:

1. The students shall be able to go beyond the routine presentation of algorithms for solving special classes of equations.
2. The students shall be able to integrate the geometric viewpoint in their scientific thought process.
3. The students shall be able to build a clear connection between differential equations, their qualitative properties and the modeling and behavior of physical systems.

Course Content

Unit I. Modeling by first principal approach of simple mechanical, electrical, thermal, chemical systems.

Unit II. Modeling by energy approach using Lagrangian and Hamiltonian

Unit III. Linearization of nonlinear models,

Unit IV. State space approach for analyzing the dynamic models.

Unit V Modeling and analysis of some typical systems such medical disease and treatment, rocket launcher, resource management etc., Numerical models using impulse response, step response

References:

1. K. Ogata., "System Dynamics", Pearson Prentice-Hall, 4th Edition, 2004.
2. M. Gopal., "Modern Control Systems Theory", 2nd Edition, JohnWiley,1993
3. E.O. Doeblin., "System Modeling and Response", John Wiley and Sons,1980.
4. Desai and Lalwani., "Identification Techniques", Tata McGraw Hill,1977.
5. Goldstain., "Classical Mechanics".

24AF2294PC102: SYSTEM IDENTIFICATION

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 4**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

1. The main objective of this course is to teach the fundamental aspects of system identification, i.e., estimating dynamic models from sampled data.
2. At the end of the course, the student would have learnt various aspects of identification such as: (i) estimation of non-parametric and parametric models, (ii) notions of model quality (bias, variance, etc.) (iii) choosing model structures, (iv) methods for estimation of transfer function models and (v) data pre-processing for identification.
3. While the lectures will cover the theory, the assignments and computer-based exercises will give an opportunity to implement and learn the practical aspects.
4. The course will cover estimation of non-parametric, parametric (transfer function and state-space) and gray-box models. Frequency-domain interpretations of the model quality and parameter estimates are also a part of the course curriculum.

Course Outcomes:

1. Students will learn how to choose an appropriate model for a system starting from the available input/output data. They also will learn how to set a suitable complexity for the model and how to optimize the involved parameters using data.
2. Moreover, ability will be given to deal with state estimation methods both in a linear as well as in a nonlinear context.

Course Content

Unit I. Review of probability theory and random variables. Transformation (function) of random variables, conditional expectation

Unit II. Development of first principle models and liberalization. State estimation for linear perturbation models (Luenberger observer),

Unit III. Development of grey box models, discrete time series models: FIR and ARX models

Unit IV. development of ARX models by least square estimation unmeasured disturbance modeling: ARMAX, OE, Box-Jenkins's models

Unit V. Parameter estimation using prediction error method and instrumental variable method, maximum likelihood estimation, Distribution of bias and variance errors, input signals, recursive approaches to identification, controller design.

TextBooks/Reference:

1. Papoulis, “Probability, Random Variables and stochastic processes”, 2nd Ed., McGraw Hill, 1983.
2. George E.P.Box, Gwilym M. Jenkin, George C. Reinsel, “Time series analysis forcasting and Control”.
3. L. Ljung, “System Identification Theory for the user”, Prentice-Hall, 1999.
4. Rik Pintelon, John Schouleens., “System Identification”, IEEE Press.
5. Young, Peter, “Recursive Estimation and Time Series Analysis”, Springer Verlag Berlin, 1984.
6. Soderstrom and Stoica, “System Identification”, Prentice Hall, 1989.

24AF2294PC103: MODERN CONTROL SYSTEM

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 4**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objective: •

1. To introduce different types of system and identify a set of algebraic equations to represent and model a complicated system into a more simplified form to interpret different physical and mechanical systems in terms of electrical system to construct equivalent electrical models for analysis.
2. To employ time domain analysis to predict and diagnose transient performance parameters of the system for standard input functions and identify the needs of different types of controllers and compensator to ascertain the required dynamic response from the system
3. Formulate different types of analysis in frequency domain to explain the nature of stability of the system.

Course Outcomes:

1. Categorize different types of system and identify a set of algebraic equations to represent and model a complicated system into a more simplified form.
2. Characterize any system in Laplace domain to illustrate different specification of the system using transfer function concept.
3. Interpret different physical and mechanical systems in terms of electrical system to construct equivalent electrical models for analysis.
4. Employ time domain analysis to predict and diagnose transient performance parameters of the system for standard input functions.
5. Formulate different types of analysis in frequency domain to explain the nature of stability of the system.
6. Identify the needs of different types of controllers and compensator to ascertain the required dynamic response from the system.

COURSE CONTENTS:

UNIT I: STATE SPACE ANALYSIS

The Concept of State and State Models, State Diagram, State Space and State Trajectory, State Space Representation using Phase Variable and Canonical Variables, Solution of State Equation, State Transition Matrix and its Properties, Eigen Values, Eigen Vectors, Model Matrix, Diagolization, Generalized Eigen vectors, Computation of State Transition Matrix using Laplace Transformation, Power Series Method, Cayley-Hamilton Method, Similarity Transformation Method. Controllability and Observability Tests: Kalman's test, Gilbert's Test, Controllability and Observability Canonical Forms.

UNIT II: POLE PLACEMENT TECHNIQUES

Controller Design by State Feedback, Necessary and Sufficient Condition for Arbitrary Pole Placement-State Regulator Problem and State Regulator Design, Evaluation of State Feedback Gain Matrix K, Selection of Location of Desired Closed Loop Poles, State Observer Design, Full Order/Reduced Order Observer Design, Observer Based State Feedback Control, Separation Principle.

UNIT III: NONLINEAR CONTROL SYSTEM

Introduction, Properties of Nonlinear System, Behavior of Non-Linear System, Classification of Nonlinearities, Common Physical Nonlinearities: Saturation, Friction, Backlash, Dead-Zone, Relay, On-Off Nonlinearity, Nonlinear Spring, Limit cycle, Jump resonance. Phase-Plane Method, Singular points, Stability of Nonlinear System, Construction of Phase Trajectories, Describing Functions Method, Stability Analysis by Describing Function Method. Lyapunov's Stability Analysis, Lyapunov's Stability Criterion, Direct Method of Lyapunov and the Linear Systems, Method of Construction of Lyapunov Functions for Nonlinear Systems.

UNIT IV: OPTIMAL CONTROL

Introduction to Optimal Control, Parameter Optimization: Servomechanism, Optimal Control Problem: Transfer Function and State Variable Approach, State Regulator Problem, Infinite Time Regulator Problem, Output Regulator and the Tracking Problem, Parameter Optimization: Regulators.

UNIT V: DIGITAL CONTROL SYSTEMS

Introduction to Discrete Time Systems, Necessary for Digital Control System, Spectrum Analysis of Sampling Process, Signal Reconstruction, Difference Equations, Z transforms, and the Inverse Z transform, Pulse Transfer Function, Time Response of Sampled Data Systems, Stability using Jury Criterion, Bilinear Transformation.

REFERENCES:

1. Katsuhiko Ogata, Modern Control Engineering Prentice-Hall of India, New Delhi.
2. I. J. Nagarath and M. Gopal, Control system Engineering, New Age International (P) Ltd.
3. Katsuhiko Ogata, State Space Analysis of Control Systems, Prentice Hall Inc, New Jersey.
4. Benjamin C. Kuo and Farid Golnaraghi, Automatic Control Systems, 8th Edition, John Wiley &Sons.
5. H. Khalil, Nonlinear Control systems, Prentice Hall Inc, New Jersey.
6. Brogan W. L., Modern Control theory, Prentice Hall International, New Jersey.
7. Jean-Jacques E, Slotine, Weiping Li, Applied Nonlinear Control, Prentice Hall Inc., New Jersey.
8. Donald Kirk, Optimal Control Theory, an Introduction, Prentice Hall, Inc, Englewood Cliffs, New Jersey.
9. Brain D., Anderson and J. B. Moore, Optimal Control, Prentice Hall.
10. Andrew P., Sage, Optimum Systems Control, Prentice Hall.

11. M. Gopal , Digital Control & State Variable Methods, TMH.
12. A. NagoorKani, Control System, RBA Publications.

ELECTIVE-I

24AF2294PE104A: OPTIMIZATION TECHNIQUES

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives

To enable the student to:

1. To know the concept optimization
2. To know the Problem formulation steps
3. To find out the necessary conditions to find an optimum point
4. To find optimum point of a constrained linear programming problem
5. To find optimum point of an unconstrained non
6. linear programming.

Course Outcomes

At the end of this course, a student has the ability to:

1. To formulate and define an optimization problem.
2. To derive the necessary and sufficient conditions of an optimization problem.
3. To formulate and solve a linear programming problem.
4. Ability to solve an optimum point for an unconstrained nonlinear optimization problem
5. Ability to solve an optimum point for a constrained nonlinear optimization problem

UNIT I

Introduction to Optimization:

Introduction, Historical Development, Engineering Applications of Optimization, Statement of Optimization Problem.

UNIT II

Classical Optimization Techniques:

Introduction, Single variable optimization, Multivariable optimization with no constraints; Multivariable optimization with Equality constraints–Solution by Direct Substitution method, Method of constrained variation, Method of Lagrangian multipliers; Multivariable optimization with inequality constraints: Kuhn-Tucker conditions.

UNIT III

Linear Programming

Introduction, Applications of Linear Programming, Standard Form of a Linear Programming,Basic Terminology and Definitions, Exceptional cases, Simplex method, Big-M method, Two-phase method, Revised Simplex method, Duality, Decomposition Principle.

UNIT IV

Non-Linear Programming I

Unconstrained optimization-Univariate method, Pattern Directions, Powell's method, Gradient of a function, Steepest descent method, Conjugate Gradient Method, Newton's method, Marquardt Method, Quai-Newton Methods, Davidon Fletcher Powell Method, Broyden -Fletcher-Goldfarb-Shanno Method.

UNIT V

Non-Linear Programming II:

Constrained optimization-Characteristics of a Constrained Problem, Sequential linear programming, Basic approach in the methods of feasible directions, Zoutendijk's method of feasible directions, Sequential Quadratic Programming.

Textbook:

1. Engineering Optimization: Theory and Applications' By S. S. Rao, New Age International Publishers, Revised Third Edition, 2005.

ELECTIVE-I
24AF2294PE104B: OPTIMAL CONTROL

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

Students will be able to:

1. To provide a basic knowledge of the theoretical foundations of optimal control
2. To develop skills needed to design controllers using available optimal control theory and software
3. To implement optimization methods for optimal control.

Course Outcomes:

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

1. A student is able to know the problem formulation steps of optimal control theory.
2. A student is able to find an optimal controller that minimizing a performance measure.
3. Solve problems on Calculus of Variation
4. Demonstrate concept of LQR Design and Dynamic programming techniques.
5. Demonstrate certain examples in MATLAB

Course Content

Unit I. Introduction, static and dynamic optimization, parameter optimization

Unit II. Calculus of variations: problems of Lagrange, Mayer and Bolza, Euler-Language equation and transversality conditions

Unit III. Lagrange multipliers, Pontryagins maximum principle; theory; application to minimum time, energy and control effort problems, and terminal control problem

Unit IV. Dynamic programming: Bellman's principle of optimality, multistage decision processes, application to optimal control,

Unit V. Linear regulator problem: matrix Riccati equation and its solution, tracking problem, computational methods in optimal control, Application of mathematical programming, singular perturbations, practical example

References:

1. Enid R. Pinch, "Optimal Control and Calculus of variation", Oxford University Press.
2. D.E.Kirk, "Optimal Control Theory", Prentice-Hall, 1970.
3. A.P.Sage and C.C.White II, "Optimum Systems Control", 2nd Ed., Prentice-Hall, 1977.

4. D.Tabak and B.C.Kuo, “Optimal Control by Mathematical Programming”, Prentice Hall, 1971.
5. B.D.O. Anderson and J.B.Moore, “Linear Optimal Control”, Prentice-Hall, 1971.
6. 6. F.L. Lewis, V.L. Symmos, “Optimal Control”, Second Edition, John Wiley, 1995

ELECTIVE- I

24AF2294PE104C: ROBUST CONTROL

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

Student will be able to

1. To provide the students with the principles and tools of robust control theory: nominal stability, nominal performance, robustness, uncertainty, robust stability, loop shaping, H∞ control, robust performance
2. To familiarize the computational tools for control systems available in Robust Control Toolbox (MATLAB).
3. To focus on an introduction to the fundamentals of robustness, uncertainty and design method of H∞ control.

Course Outcomes:

After completion of the course Student may get knowledge to

1. Compute nominal stability and nominal performance.
2. Explain robustness and uncertainty of systems.
3. Acquire the fundamentals of H∞ control, and based on this knowledge, design multivariable feedback control systems.
4. Understand robust performance.

UNIT – I Review of Classical Feedback Control

Review of classical feedback control: The control problem - Transfer functions - Deriving linear models - Frequency response - Feedback control - Closed loop stability - Evaluating closed - loop performance - Controller design - Loop shaping - Shaping closed loop transfer functions.

UNIT – II Introduction to Multivariable Control

Transfer functions for MIMO systems - Multivariable frequency response analysis - Control of multivariable plants - Introduction to robustness - General control problem formulation. Elements of Linear System Theory: Internal stability of feedback systems - Stabilizing controllers - System norms - Input - Output Controllability - perfect control and plant inversion - Constraints on S and T.

UNIT – III Limitations on Performance

In SISO Systems: Limitations imposed by RHP - zeros - Limitations imposed by RHP - poles - Performance requirements imposed by disturbances and commands - Limitations imposed by input constraints - Limitations imposed by uncertainty. In MIMO Systems: Constraints on S and T - Functional Controllability - Limitations imposed by RHP - zeros - Limitations imposed by RHP - poles - Performance requirements imposed by disturbances - Limitations imposed by input constraints - Limitations imposed by uncertainty.

UNIT - IV Uncertainty and Robustness for SISO Systems

Introduction to robustness - Representing uncertainty - parametric uncertainty - Representing uncertainty in the frequency domain - SISO robust stability - SISO robust performance - Examples of parametric uncertainty.

UNIT - V Robust Stability, Performance Analysis and Control System Design

General control formulation with uncertainty - Representing uncertainty - Obtaining P, N and M - Definition of robust stability and performance - Robust stability of the MΔ - structure - RS for complex unstructured uncertainty - RS with structured uncertainty: Motivation, The structured singular value and RS - Properties and computation of μ - Robust performance - Application: RP with input uncertainty - μ - synthesis and DK - iteration - Further remarks on μ - Trade - offs in MIMO feedback design - LQG control - H2 and H∞ control, H∞ loop - shaping design.

Textbooks:

1. Sigurd Skogestad and Ian Postlethwaite, Multivariable Feedback Control Analysis and Design - John Wiley & Sons Ltd., 2nd Edition, 2005.
2. D. W. Gu, P. Hr. Petkov and M. M. Konstantinov “Robust Control Design with MATLAB” Spring - Verlag London Ltd., 2005. 3. K. Zhou and J. C. Doyle. Essentials of Robust Control. Prentice Hall; ISBN: 0-13-525833- 2.

Reference Books:

1. Kennin Zhou, “Robust and Optimal Control”, Prentice Hall, Engle wood Cliffs, New Jersy.
2. Robust Control Toolbox User's Guide R2017a. MathWorks.

ELECTIVE – I

MTCSE104D: POWER ELECTRONICS AND CONTROL

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

1. To understand and acquire knowledge about various power semiconductor devices
2. To prepare the students to analyze and design different power converter circuits.

Course Outcomes:

1. Analyze the behavior of converters.
2. To control for the desired performance of the converters

Course Content

Unit I: Introduction

Concept of Power Electronics, Different types of power electronics devices, converter systems, areas of application, recent developments. Device characteristics, protection and operation: Terminal characteristics of major power electronics devices (SCR, BJT, MOSFET, IGBT, GTO, TRIAC,), ratings, protection, heating, cooling and mounting, series and parallel operation, firing circuits, Snubber circuits.

Unit II: Phase controlled rectifiers

Analysis and design of diode rectifier circuits and controlled rectifier circuits (for R, RL, R L E load), Phase control, power factor, DC load voltage, Polyphase rectifiers, Current and voltage waveforms analysis, Applications for DC motor drives. Effect of source impedance on the performance of converters, dual converters.

Unit III: Choppers

Principle of chopper operation, Control strategies, Types of chopper circuits and steady state analysis. Commutation in chopper circuits, buck, boost and buck-boost chopper, Discontinuous current analysis, non-ideal effects and dynamic performance, Applications for DC motor drives. Resonant converters–zero-voltage and zero current switching, PWM control and operation.

Unit IV: Inverters

Classification of inverters, Single-phase and three-phase Voltage source Inverters, Methods of controlling output voltage, frequency and phase, Reduction of harmonics in the inverter output voltage, Current source inverters and operations. Applications for AC motor drives, Pulse Width Modulation (PWM): Types of PWM, Microprocessor control, Harmonics and reactive power.

Unit V: AC Voltage Controller

Types of AC voltage controllers, Single phase voltage controllers, Sequence control of ac voltage controllers, 3-phase AC voltage controller operation Application of AC-AC Phase Control, Single-phase and poly phase control circuits, Applications for AC motor drives., Cyclo converters: Principles of Cyclo converters operation, Methods of controlling output voltage and frequency in cases of: Single phase to single phase, three phases to single phase, three phases to three phase operation. Applications: Power supply applications, few applications in residential and industrial systems, Electric utility**.**

Text/Reference Books

1. Power Electronics, P.C. Sen (TMH)
2. Power Electronics, Dubey (TMH)
3. Thyristorised Power Controllers, Dubey *et. al.* (TMH)
4. Power Electronics, Rashid Mohammed (PHI)
5. Power Electronics & Drives, V. Subrahmanyam, New Age

ELECTIVE–II

24AF2294PE105A: ADVANCED DRIVES AND CONTROL

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

1. Electrical drives play an important role as electromechanical energy converters in transportation, materials handling and most production processes.
2. The course tries to give unified treatment of complete electrical drive systems, including mechanical parts, electrical machines, power converters and control.

Course Outcomes:

1. To develop modeling of AC and DC drives
2. To understand and analyze speed control techniques of AC and DC drives

Course Contents:

Unit I: Introduction to motor drives: Classification, comparison of AC and DC drives, Basic elements, torque equations, component of load torque, multi-quadrant operation, equivalent drive parameters, components of power electronic drives, criteria for selection of drive components match between the motor and the load, calculation of time and energy in transient conditions, characteristics of mechanical systems, stability consideration, thermal consideration, thermal model of motor for heating and cooling, match between the motor and power electronics converter, closed loop control of drives.

Unit II: DC drives System model, motor rating, motor mechanism dynamics, drive transfer function, effect of armature current waveform, torque pulsations, adjustable speed drives, chopper fed and 1 phase converter fed drives, effect of field weakening.

Unit III: A.C. Drives Basic Principle of operation of 3 Phase motor, equivalent circuit, MMF space harmonics due to fundamental current, fundamental spatial MMF distributions due to time harmonics simulation, effect of time and space harmonics, speed control by varying stator frequency and voltage, impact of non-sinusoidal excitation on induction motors, variable square wave VSI drives, variable frequency CSI drives, line frequency variable voltage drives.

Unit IV: Induction Motor drives: Review of induction motor equivalent circuit, effect of voltage, frequency and stator current on performance of the m/c, effect of harmonics, slip power recovery schemes-static Kramer drive and dynamic d.q. model, small signal model, voltage and current fed scalar control, direct and indirect vector control, sensor less vector control, direct torque and flux control.

Unit V: Synchronous motor drives: Review of synchronous motor fundamental, equivalent circuit, dynamic d-q model, synchronous reluctance, sinusoidal and trapezoidal back emf permanent magnet motors, sinusoidal SPM machine drives, trapezoidal SPM machines drives, wound field machine drives, switched reluctance motor drives.

Closed loop control technique: Motor transfer function-P, PI and PID controllers, current control-Design procedure, phase locked loop (PLL) control-microcomputer control. Industrial applications and modern trends in drive, effect of RMS voltage variation on drive behavior.

References:

1. B. K. Bose, “Modern Power Electronics and AC drives”, Pearson Education, Asia, 2003.
2. M. H. Rashid, “Power Electronics”, Third Edition, PHI
3. G. K. Dubey, “Fundamentals of Electrical Drives”, Narosa Publishing house.
4. V. Subrahmanyam, “Electric Drives-Concepts and Applications”, TMH
5. G. K. Dubey, “Power Semiconductor controlled drives”, PH 1989.
6. R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control”, PH, 1998.
7. P. Vas, “Sensor less vector and direct torque control”, Oxford Press, 1998.
8. W. Leonard, “Control of Electric Drives”, Springer Verlag, 1985.

ELECTIVE – II

24AF2294PE105B: INDUSTRIAL AUTOMATION AND CONTROL

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives

1. The course is designed to give a solid grounding of fundamental concepts of industrial automation systems and their control.
2. The course specifically focuses on architecture, components, and techniques for automation in industries. The current state-of-the-art suggests paradigm shift from partial to fully automated operations in industries.
3. The level of the course is chosen to be such that all students aspiring to be a part of industrial advancements directly or indirectly in near future should acquire these concepts.

Course Outcomes

1. To understand architecture of industrial automation system
2. To understand industrial measurement system
3. To understand PID control technique
4. To understand and apply PLC technique
5. To understand various hydraulic control components and functions
6. To understand AC and DC drives specifications and control functions

Course Contents:

Unit I: Introduction Architecture industrial automation system, development trends in industrial automation, classification of existing systems, and functionality of industrial automation system. Relay and contactor logic, AC and DC relays and their role for load control. Power and Auxiliary contactors and their usage for load control.

Unit II: Industrial Measurement System Characteristics Sensors and control logic, control using potential free output sensors Control using PO, PC, NO, NC type output sensor, 2W(2wire), 3W(3 wire), 4W(4wire) and 4WC sensors, Linear potentiometer Timer hardware architecture, Controlling industrial system using timers Controlling industrial system using counters. Temperature Measurement, Pressure, Force and Torque Sensors, Motion Sensing, Flow Measurement, Signal Conditioning, Data Acquisition Systems.

Unit III: Automatic Control Introduction, P-I-D Control, manual and auto PID Control Tuning, Feed forward Control Ratio Control, Time Delay Systems and Inverse Response Systems, Special Control Structures. Temperature controller hardware architecture.

Unit IV: PLC Introduction to Sequence Control, PLC, RLL (Relay Ladder Logic), Sequence Control. Scan Cycle, Simple RLL Programs, Sequence Control. More RLL Elements, RLL Syntax, A Structured Design Approach to Sequence, PLC Hardware Environment, Introduction To CNC Machines, Contour generation and Motion Control, Allen Bradley PLC and SIEMEN PLC.

Unit V: Industrial Control Basics of hydraulics, Hydraulic components their functions and symbols Hydraulic actuators, Pumps and its operation, pump control, Hydraulic valves (Direction control, pressure and flow control), special valves, pressure gauges and switches, hydraulic logic circuits, Hydraulic Control System, Multiple pressure and speed operations, Industrial Hydraulic Circuit, Pneumatic systems and components Pneumatic Control Systems, compressor operation and control, air treatment.

Industrial Drives AC Drive basics, Electrical specifications and hardware architecture, AC drive and AC motor specification matching. AC drive power wiring and Interfacing input and output signals. Operation and control of AC motor in scalar mode. Operation and control of AC drive in vector. control mode. Performance verifications of special features of AC drive. Requirement and specifications of input and output chokes, braking applications, methodology and specifications of braking resistors. Selection of power, motor and signal cables for AC drive application. Wiring and lay outing guidelines of AC drive. Energy Savings with Variable Speed Drives, DC Motor Drives, DC and BLDC Servo Drives.

References/Textbook(s)

1. Lingefeng Wang, Kay Chen Tan, "Modern Industrial Automation and Software Design" John Wiley& Sons Inc.
2. K. L.S. Sharma, “Overview of Industrial Process Automation”, Elsevier
3. Kok Kiong “Drives and Control for Industrial Automation”, Springer

ELECTIVE – II

24AF2294PE105C: COMPUTIONAL METHODS

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

The course is designed to provide M. Tech. Students across all engineering discipline a view of using various computational techniques and tools for analysis, decision making and solution of engineering problems. Following are the course objectives:

1. Students will be able to develop mathematical models of lower-level engineering problems.
2. Students will learn how to solve nonlinear equations numerically.
3. Students will be introduced to fundamental matrix algebra concepts and shown how to solve simultaneous linear equations numerically.
4. Students will learn how to curve fit (interpolation and regression) discrete date.
5. Students will learn how to numerically integrate continuous and discrete functions.
6. Students will learn how to numerically solve ordinary differential equations that are initial value or boundary value problems.

Course Outcomes:

In the course Computational Methods, the program objectives are met as follows.

1. Understand the concept and steps of problem solving - mathematical modeling, solution and implementation.
2. Knowledge and understanding of, and the ability to use, mathematical techniques.
3. Ability to understand and apply mathematical reasoning in several different areas of mathematics.

Course Contents:

UNIT I: Algebraic Equations

Formulation and solution of linear system of equations, Gauss elimination, LU, QR decomposition, iteration methods (Gauss-Seidal), convergence of iteration methods, Singular value decomposition and the sensitivity of rank to small perturbation

UNIT II: Interpolation & Regression Methods

Newton ‘s divided difference, interpolation polynomials, Lagrange interpolation polynomials, Linear and non-linear regression, multiple linear regression, general linear least squares

UNIT III: Transform Techniques

Vector spaces, Basis vectors, Orthogonal/Unitary transform, Fourier transform, Laplace transform

UNIT IV: Optimization Techniques for Engineers

Local and global minima, Line searches, Steepest descent method, Conjugate gradient method, Quasi Newton method, Penalty function

UNIT V: Graph Theory

Graphs and Matrices, simple graph, cyclic graph, complete graph, properties of the Laplacian matrix and relation with graph connectivity. Non-negative matrices. Applications of graph theory to engineering problems.

References/Textbooks

1. Numerical Methods for Engineers ‘, Steven C. Chapra and Raymond P. Canale, McGraw Hill
2. Probability and Statistics in Engineering and Management Studies‖, Hines and Montrogmery, John
3. Graphs and Matrices‖, R. B. Bapat, TRIM Series, Hindustan Book Agency, 2011
4. Algebraic Graph Theory —, C. Godsil and G. Royle, Springer, New York, 2001 (Available in Indian edition)

ELECTIVE–II

24AF2294PE105D: DECENTRALIZED CONTROL

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

1. To introduce the students to the idea of and issues related to Complex systems
2. To build an appreciation of the need for decentralized information and control structures to enable fast control action in response to local input, and perturbations in large systems
3. To interweave theories from optimization, output feedback, graph theory, overlapping decompositions and reliability for analyzing and controlling complex systems.

Course Outcomes:

1. The students shall be able to appreciate the need for effective utilization of graph theoretic tools for analysis, estimation and control of modern Large – scale /complex systems.
2. The students shall be able to develop and apply efficient graph algorithms for handling complex systems
3. The students shall also to be able to decompose Large systems appropriately and analyze their stability

Course Contents:

UNIT I: Structured systems & Robust --Stabilization

Graphs and Dynamic Systems, Input and Output Reachability, Partitions and Condensations, Structural Controllability and Observability, Plant and Feedback Structures, Structurally Fixed Modes**.** Connective Stability, Vector Liapunov Functions, Stabilization, Connective Stabilizability, Graph Theoretic Algorithm

UNIT II: Optimization

Sub optimality. Complex Systems, Robustness of Suboptimal Control, Optimality and Robustness, Decentrally Optimal Systems.

UNIT III: Estimation and Control

An Interconnected Observer, Decentralized Feedback, Separation Property, Decentralized Observer, Stochastic Control, Estimation, Incomplete State Information, Structural Perturbations, Degenerate Control.

UNIT IV: Output Control

Dynamic Output Feedback, Structured Almost Invariant Subspaces, Graph-Theoretic

Characterization, Decentralized Stabilizability, Adaptive Control, Known Subsystems, Adaptive Output Feedback

UNIT V: Decomposition Techniques

Input Decompositions, Stabilization, Input-Output Decompositions, Sequential Optimization, Epsilon Decomposability, Decomposition Algorithm, Control Applications, Nested Connective Stability, Block Diagonal Dominance.

Overlapping Decompositions & Reliable Control

Preliminaries, The Inclusion Principle, Optimization, Nonlinear Systems, Multiple Control Systems, Reliability of Control Structures, Design of Reliable Control, Maintained Control Systems.

References/Textbooks

1. Decentralized Control of Complex Systems‖- Dragoslav Siljak, Mathematics in Science, Vol.184, Academic Press Ltd.
2. Control of Complex Systems: Structural Constraints and Uncertainty‖ – Aleksandar Zecevic, Springer Publications, New York, Dordrecht, Hieldeberg, London
3. Efficient Modeling and Control of Large-Scale Systems‖ - Javad Mohammad pour, Karolos M. Grigoriadis, Springer Publications, New York, Dordrecht, Hieldeberg, London
4. Decentralized control of large-scale systems‖,-Edward J Davison; Amir G Aghdam, New York; London: Springer, 2010

24AF2294SE106: SEMINAR I

Weekly Teaching Hours	**TH: --**	**PR: 4Hr**		**Credit: 2**
Scheme of Marking	**TH: --**	**OR/PR: 25**	**IA: 25**	**Total: 50**

The seminar shall be on the state of the art in the area of wireless communication and computing and of the student choice approved by an authority. The student shall submit the duly certified seminar report in standard format, for satisfactory completion of the work duly signed by the guide and head of the Department/Institute concerned.

24AF2294PCL107: PG LAB I

Weekly Teaching Hours	**TH: --**	**PR: 4Hr**		**Credit: 2**
Scheme of Marking	**TH: --**	**OR/PR: 25**	**IA: 25**	**Total: 50**

Practicals of the Lab–I shall be based on the courses of first semester. The lab work shall consist of hands-on experiments on the different software and hardware platforms related to the syllabus.

24AF2294AU108: YOGA FOR STRESS MANAGEMENT

Weekly Teaching Hours	**TH: 2Hr**	**TU: --**		
Scheme of Marking	**PR: 04**	**--**	**IA: --**	**AUDIT**

Course Objectives:

1. Understand the physiological and psychological aspects of stress and its impact on overall well-being.
2. Learn and practice specific yoga postures, breathing exercises, and relaxation techniques to alleviate stress.
3. Explore the connection between mindfulness, meditation, and stress reduction, fostering mental clarity.
4. Discover holistic practices that promote better sleep, nutrition, and overall lifestyle habits for stress management.
5. Develop practical skills to manage stress in daily life, enhancing resilience and promoting emotional balance.

Course Outcomes:

1. Recognize the signs and sources of stress, understanding its effects on mental and physical well-being.
2. Master a variety of yoga techniques, including postures, breathing, and meditation, to effectively manage stress.
3. Acquire relaxation strategies that promote calmness, reduce anxiety, and enhance overall mental clarity.
4. Incorporate healthy habits inspired by yoga principles to foster better sleep, nutrition, and self-care routines.
5. Develop practical skills to navigate and cope with stress, enhancing emotional balance and promoting a more harmonious life.

UNIT I

Introduction to Yoga for Stress Management –

Introduction to Yoga for Stress Management - 2 Stress according to Western perspective

Stress Eastern Perspective Developmental process: Western and Eastern Perspective Stress Hazards and Yoga

UNIT II

Meeting the challenges of Stress - 1 Meeting the challenges of Stress - 2 Introduction to Stress Physiology Stress, Appetite and Dietary management- Modern and Yogic perspective Sleep and Stress: understanding the relationship for effective management of stress.

UNIT III

Stress Assessment methods- a valuable tool for stress management

Role of Yoga in prevention and management of stress-related disorders – a summary of research evidence. Concept of stress and its management - perspectives from Patanjali Yoga Sutra - Part 1 Concept of stress and its management - perspectives from Patanjali Yoga Sutra - Part 2 Concept of

stress and its management - perspectives from Patanjali Yoga Sutra - Part 3

UNIT IV

Concept of stress and its management - perspectives from Bhagavad Gita - Part 1 Concept of stress and its management - perspectives from Bhagavad Gita - Part 2 Concept of stress and its management - perspectives from Bhagavad Gita - Part 3

UNIT V

Bio-Psycho-Socio-Spiritual model of stress management Yoga practices for Stress Management Breathing practices – 1

Hands in and out breathing, Hands stretch breathing, Ankle stretch breathing Breathing practices – 2. Dog Breathing, Rabbit breathing, Tiger breathing, Sashankasana breathing Breathing practices – 3. Bhujangasana breathing, Ardha Shalabhasana breathing (alternate legs), Straight leg raising (alternate legs), Straight leg raising (both legs), Sethubandhasana lumbar stretch, Instant Relaxation Technique (IRT). Loosening Practices – 1

Shoulder Rotation, Side bending, standing twist, Hip rotation, Thigh strengthening Loosening practices – 2. Chakki Chalan, Bhunamasana Chalana, Alternative toe touching Loosening practices – 3. Side leg raising, Pavana muktasana kriya: Wind releasing pose movements, Quick Relaxation Technique (QRT)

UNIT VI

Asana practices – 1

Tadasana, Ardhakati Chakrasana, Ardha Chakrasana, Trikonasana, Vrikshasana Asana practices – 2 Vakarasana, Janu Sirshasana, Ushtrasana, Sashankasana, Asana practices – 3 Ardhamatseyndrasana, Paschimottanasana, Poorvottanasana, Gomukhasana Asana practices – 4. Makarasana, Bhujangasana, Salambha Shalabahasana, Dhanurasana Asana practices – 5

Setubandhasana, Sarvangasana, Mastyasana, Deep Relaxation Technique (DRT) Soorya Namaskar. Pranayama – 1. Kapalbhati kriya and Sectional Breathing Pranayama – 2

Nadishuddhi Pranayama Pranayama – 3. Bhramari, Sheetali, Sitkari and Ujjayi Om Meditation

Cyclic Meditation Integrated Yoga Module I Integrated Yoga Module II Integrated Yoga Module III

Textbooks/References:

1. H R Nagendra and R Nagarathna. Yoga for Promotion of Positive Health. Swami Vivekananda Yoga Prakashana. 2011.
2. Contrada, R., & Baum, A. (Eds.). The handbook of stress science: Biology, psychology, and health. Springer Publishing Company. 2010
3. Al'Absi, M. (Ed.). Stress and addiction: Biological and psychological mechanisms. Elsevier. 2011.
4. Van den Bergh, O. Principles, and practice of stress management. Guilford Publications. 2021.
5. Swami Muktibodhananda, Hatha Yoga Pradipika, Bihar Scool of Yoga, 1998
6. Swami Satyananda Saraswati, Four Chapters on Freedom, Bihar Scool of Yoga, 1975.
7. Swami Tapasyananda, Srimad Bhagavat Gita, Sri Ramakrishna Math, 2012

NPTELPLATFORM:

NPTEL Course	Name of Instructor	Host Institute	Link
Yoga for Stress Management	Dr. H R Nagendra., Dr. Mithila M V., Dr. Rajesh Nair.,	Swami Vivekananda Yoga Anusandhana Samsthana	https://onlinecourses.swayam2.ac.in/aic23_ge10/preview#:~:text=In%20this%20course%20we%20intend,meeting%20the%20challenges%20of%20stress

24AF2294PC201: SLIDING MODE CONTROL

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 4**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course objectives:

To enable the student to:

1. To know the concept of sliding mode control
2. To know the applications of sliding mode control
3. To learn the uses of sliding mode control
4. Properties of sliding mode control
5. To simulate a double integrator problem
6. To know about Reachability concept and to derive these conditions.
7. To know about the design of sliding surface
8. Concept of sliding mode observers

Course Outcomes:

At the end of this course, a student has the ability to:

1. To know the concept of sliding mode.
2. To verify the concept of reach
3. ability for simple problems with different control structures.
4. To design sliding mode controller for dc motor with uncertain parameters.
5. To know about null space and range space dynamics
6. To know the different algorithms of sliding surface design.
7. To know about the concept of sliding mode observers.

UNIT I

An Introduction to Sliding Mode Control:

Introduction, properties of sliding motion, typical controller design, pseudo-sliding witha smooth control action, a state-space approach.

UNIT II

Sliding mode control:

Introduction, problem statement, existence of solution and equivalent control properties of the sliding motion, The reachability problem, the unit vector approach, continuous approximations.

UNIT III

Sliding mode Design approaches:

Introduction, A regulator form-based approach, a direct eigen structure assignment approach, Incorporation of a tracking requirement, Design study of Pitch-pointing flight controller.

UNIT IV

Sliding mode controllers using output information:

Introduction, problem formulation, a special case of square plants, a general framework, dynamic compensation, observer based dynamic compensation, a model reference system using only outputs.

UNIT V

Sliding mode observers:

Introduction, sliding mode observers, synthesis of a discontinuous observer,

the Walcott-Zak observer revisited, sliding mode observers for fault detection.

Textbooks/References:

1. Sliding Mode Control: Theory And Applications (Series in Systems and Control) by, CEdwards and S Spurgeon, Published by Taylor &Francis
2. Sliding Mode Control in Engineering (Automation and Control Engineering) by Wilfrid Perruquetti, Jean-Pierre Barbot published by Marcel Dekker, Inc, New York

24AF2294PC202: MULTIVARIABLE CONTROL

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 4**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

1. The students are expected to understand the key aspects of robust multivariable control system design, including system properties in time- and frequency-domain, formulation of the control problems, notions of system performance, and controller design.
2. Proficiency evaluation will be conducted through homework sets and take-home exam sets, which will include some control design tasks. Some computation tasks will be done with MATLAB.

Course Outcomes:

1. Understand types of MIMO systems and models, their mathematical properties, analyze the system to relate these properties to the physical properties of the system.
2. Demonstrate the control design strategies and understand the purpose for specific strategy to be applied.
3. Design the control algorithms for MIMO systems for desired performance and stability
4. Implement the control algorithms for MIMO systems on MATLAB-SIMULINK platform and compute the performance

Course Content

Unit I. Examples of multivariable control systems, state space, polynomial and stable fraction models, polynomial matrices, transmission zero,

Unit II. Solution of state equations, controllability, observability and computations involved in their analysis. •

Unit III. Realization theory of multivariable systems and algorithms, stability and stabilizability.

Unit IV. Pole placement, observer design and stabilization theory, minimal realization, frequency domain design, decoupling,

Unit V. Model matching, spectral factorizations of systems, solution of the Ricatti equation, balanced realizations and their computations.

Textbooks/Reference:

1. Y. S. Apte, “Linear multivariable control system”.
2. W. M. Wonham, “Multivariable control systems”.
3. C. T. Chen, “Linear system theory and design”, 3rd edition, Oxford 1999.
4. John Bay, “Fundamentals of linear state space systems”, McGraw Hill, 1998.
5. Wilson Rugh, “Linear system theory”, 2nd edition, Prentice Hall, 1996. H.H. Rosenbrock,“Computer aided control system design.

ELECTIVE-III
24AF2294PE203A: DIGITAL CONTROL SYSTEMS

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Outcomes:

1. Obtain discrete representation of LTI systems
2. Analyze stability of open loop and closed loop discrete system
3. Design and analyze Discrete Controller Design state feedback controller and estimators
4. Design state feedback controller and estimators

Course Content

Unit I. Discrete time systems, discretization, sampling, aliasing, choice of sampling frequency, ZOH equivalent,

Unit II. State space models of discrete systems.

Unit III. Z-Transform for analyzing discrete time systems, transfer function,

Unit IV. Internal stability,

Unit V. Design of discrete time control using conventional methods, Stability of discrete time systems, state space analysis, pole placement and observer

TEXTBOOKS:

1. K. Ogata, “Discrete Time Control Systems”, Prentice Hall, 1995.
2. Kannan M. Moudgalya, “Digital Control”, John Wiley and Sons, 2004.
3. Kuo, Benjamin C, “Digital Control Systems”, New York: Holt, Rinehart and Winston, 1980. 4. M. Gopal, “Digital Control”, Mac Graw Hill.
5. G. F. Franklin, J. D. Powell, M.L. Workman, Digital Control of Dynamic Systems, Addison-Wesley, Reading, MA, 1998.

ELECTIVE-III
24AF2294PE203B: FRACTIONAL ORDER MODELING AND CONTROL

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Outcomes:

1. To illustrate concept of fractional calculus
2. To develop fractional order models.
3. To describe fractional control analysis in time domain and frequency domain
4. To design and analyze fractional control strategies

Course Content

Unit I. Review of basic definitions of integer-order (IO) derivatives and integrals and their geometric and physical interpretations, Definition of Riemann-Liouville (RL) integration, Definitions of RL, Caputo and Grunwald-Letnikov (GL) fractional derivatives (FDs), Various geometrical and physical interpretations of these FDs, Computation of these FDs for some basic functions like constant, ramp, exponential, sine, cosine, etc., Laplace and Fourier transform of FDs.

Unit II. Study of basic functions like Gamma function, Mittag-Leffler function, Dawson's function, Hyper geometric function, etc, Analysis of linear fractional-order differential equation (FDEs): formulation, Solution with different FDs, Initial conditions, Problem of initialization and the remedies.

Unit III. Concepts of 'memory' and 'non-locality' in real-world and engineering systems, nonexponential relaxation, 'Mittag-Leffler' type decay and rise, Detailed analysis of fractional-order (FO)modeling of: electrical circuit elements like inductor, capacitor, electrical machines like transformer, induction motor and transmission lines, FO modeling of viscoelastic materials, concept of fractional damping, Models of basic circuits and mechanical systems using FO elements, Concept of anomalous diffusion, non-Gaussian probability density function and the development of corresponding FO model, FO models of heat transfer, A brief overview of FO models of biological systems.

Unit IV. Review of basic concepts of complex analysis, Concepts of multivalued functions, branch points, branch cuts, Riemann surface and sheets, Fractional-order transfer function (FOTF)representation, Concepts like commensurate and no commensurate TFs, stability, impulse, step and ramp response, Frequency response, non-minimum phase systems, Root locus, FO pseudo state space (PSS) representation and the associated concepts like solution of PSS model, controllability, observability, etc.

Unit V. Detailed discussion and analysis of superiority of FO control over the conventional IO control

in terms of closed-loop performance, robustness, stability, etc., FO lead lag compensators, FO PID control, design of FO state-feedback, Realization and implementation issues for FO controllers, survey of various realization methods and comparative study.

Primer on MATLAB and Mathematica, Computation of FDs using MATLAB, Analytical expressions for FDs using Mathematica, Use of Mittag-Leffler functions and various special functions in MATLAB, Analysis of system of nonlinear FDEs using these softwares, Use of simulink in analysis of FO systems and control

Textbooks/References:

1. K. B. Oldham and J. Spanier,. The Fractional Calculus. Dover Publications, USA, 2006.
2. Kilbas, H. M. Srivastava, and J. J. Trujillo. Theory and Applications of Fractional Differential Equations. Elsevier, Netherlands, 2006.
3. Podlubny. Fractional Differential Equations. Academic Press, USA, 1999.
4. A. Monje, Y. Q. Chen, B. M. Vinagre, D. Xue, and V. Feliu. Fractional -order Systems and Control: Fundamentals and Applications. Springer-Verlag London Limited, UK, 2010.
5. R. L. Magin. Fractional Calculus in Bioengineering. Begell House Publishers, USA, 2006.
6. R. Caponetto, G. Dongola, L. Fortuna, and I. Petras. Fractional Order Systems: Modeling and Control Applications. World Scientific, Singapore, 2010.
7. K. S. Miller and B. Ross. An Introduction to the Fractional Calculus and Fractional Differential Equations. John Wiley & Sons, USA, 1993.
8. S. Das. Functional Fractional Calculus for System Identification and Controls. Springer, Germany, 2011.
9. Ortigueira. Fractional Calculus for Scientists and Engineers. Springer, Germany, 2011.
10. Petras. Fractional-Order Nonlinear Systems: Modeling, Analysis and Simulation. Springer, USA, 2011.
11. W. R. LePage. Complex Variables and the Laplace Transform for Engineers. Dover Publications, USA, 2010.
12. H. Ruskeepaa. Mathematica Navigator: Mathematics, Statistics and Graphics. Academic Press, USA, 2009.

ELECTIVE-III
24AF2294PE203C: EMBEDDED CONTROL

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

1. Tointroducestudentstomodernembeddedsystemsandtoshowhowtounderstand and program such systems using a concrete platform built around a modern embedded processor.

Course Outcomes:

1. To Define and explain embedded systems and the different embedded system design technologies explain the various metrics or challenges in designing an embedded system
2. To Become aware of the architecture of the ARM processor and its programming aspects (assembly Level
3. To Foster ability to understand the internal architecture Processor LPC 2148
4. To Understand key concepts of embedded systems like IO, timers, interrupts, interaction with peripheral devices
5. To Design real time embedded systems using the concepts of RTOS.

COURSE CONTENT

UNIT I: INTRODUCTION TO EMBEDDED SYSTEMS

Introduction to embedded system -Definition and Classification, Design challenges, Optimizing design metrics, time to market, applications of embedded systems and recent trends in embedded systems, memory management, Overview of Processors and hardware units in an embedded system, Software embedded into the system, communication protocols like SPI, I2C, CAN etc.

UNIT II: ARCHITECTURE OF ARM7TDMI

Introduction to ARM core architecture, ARM extension, family, Pipeline, memory management, Bus architecture, Programming model, Registers, Operating modes, instruction set, Addressing modes, memory interface.

UNIT III: ON CHIP PERIPHERALS AND INTERFACING LPC2148

Study of on-chip peripherals – Input/ output ports, Timers, Interrupts, on-chip ADC, DAC, RTC modules, WDT, PLL, PWM, USB, I2C, SPI, CAN etc.

UNIT IV: INTERFACING WITH LPC2148

Need of interfacing, interfacing techniques, interfacing of different displays including Graphic LCD, controlling a DC motor using PWM, Keypad controllers, stepper motor controllers.

UNIT V: REAL TIME OPERATING SYSTEMS

Definitions of process, tasks and threads, I/O Subsystems, Interrupt Routines Handling in RTOS, RTOS Task scheduling models, Handling of task scheduling and latency and deadlines

as performance metrics, Co-operative Round Robin Scheduling, Case Studies of Programming with RTOS.

INTRODUCTION TO ARM 9

ARM926EJ-S, Features, Specifications (LPC314x /LPC315x As reference controllers)

Textbooks/References:

1) Embedded Systems Architecture, Programming and Design, Rajkamal, TATA McGraw-Hill, First reprint Oct, 2003.
2) Embedded Systems Design, Second Edition, Steve Heath, Elsevier India Pvt. Ltd. 2007.
3) Andrew Sloss, Andew Sloss, "ARM System Developers Guide"
4) Introduction to Embedded systems, Shibu K V, Tata McGraw Hill First print – 2009.
5) An Embedded Software Primer, David E,Simon, Pearson Education Asia, 2000.
6) Embedded Systems Design, A unified Hardware /Software Introduction, Frank Vahid and Tony Givargis, John Wiley, 2002.
7)Computers as Components; Principles of Embedded Computing System Design Wayne Wolf,Harcourt India, Morgan Kaufman Publishers, First Indian Reprint 2001

ELECTIVE-III
24AF2294PE203D: HIGH PERFORMANCE ELECTRICAL DRIVES

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

COURSE OBJECTIVE

1. To explain the basic building blocks of high-performance electrical drives.
2. To develop mathematical models of AC & DC machines & use these models for designing high performance drives.
3. To impart a thorough understanding of power electronic converters for drives & Controller design also.

COURSE OUTCOME

1. Students should be able to identify the various building blocks of electrical drives &suggest improvements /additions to make it a high-performance drive.
2. Students should be able to model AC & DC machines & use these models to evaluate the performance of drives.
3. Students should be able to design controllers for better parameter control in drives.

Course Content

UNIT I: Introduction, Modeling of DC machines

UNIT II: Phase-controlled DC Motor Drives, Chopper-controlled DC Motor Drives

UNIT III: Permanent-Magnet Synchronous & Brushless DC Motor Drives, Polyphase Induction Machines

UNIT IV: Phase-controlled Induction Motor Drives, Frequency-controlled Induction Motor Drives

UNIT V: Vector-controlled Induction Motor Drives

TEXTBOOKS:

1) R Krishnan, Electric Motor Drives Modelling Analysis and Control
2) B K Bose, Power Electronics for AC drives
3) G K Dubey, Electrical Drives

ELECTIVE-III

24AF2294PE203E: RESEARCH METHODOLOGY AND INTELLECTUAL PROPERTY RIGHTS

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Outcomes

1. Ability to write and present a substantial technical report/document
2. Able to demonstrate a degree of mastery over the area of specialization

Unit I:

Meaning and sources of research problem, Objectives and Characteristics of research – Errors in selecting research problem, Research methods vs. methodology - Types of research of good research – Developing a research plan.

Unit II:

Investigations of a research problem - Selecting the problem - Necessity of defining the problem – Data collections-analysis- Importance of literature review in defining a problem

- Survey of literature -Necessary instrumentations.

Unit III:

How to write paper-conference articles preparation, thesis report writing, inclusion of references, journal reviewing process, journal selection process, filling about journal template, developing effective research proposal- plagiarism-research ethics

Unit IV:

Nature of Intellectual property, IPRs- Invention and Creativity - Importance and Protection of Intellectual Property Rights (IPRs) – procedure for grant of patents and patenting under PCT-types of patents-technological research and innovation- international cooperation on IP.

Unit V:

A summary of Patents-Copyrights-Trademarks, patent rights-licensing and transfer of technology databases-case studies on IPR-Geographical indications-new developments in IPR-protection of IPR right.

TEXTBOOKS:

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 420p.
3. Anderson, T. W., An Introduction to Multivariate Statistical Analysis, Wiley Eastern Pvt., Ltd., New Delhi
4. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, EssEss Publications.
5. Subbarau NR-Handbook of Intellectual Property Law and practise- S Viswanathan Printers and Publishing Private Limited 1998.

OPEN ELECTIVE - I
24AF2294OE204A: MODERN OPTIMIZATION TECHNIQUES

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Outcome:

1. To Understand the theoretical workings of the simplex method for linear programming and perform iterations of it by hand
2. To Understand the relationship between a linear program and its dual, including strong
3. To Perform sensitivity analysis to determine the direction and magnitude of change of a model ‘s optimal solution as the data change.
4. To Solve specialized linear programming problems like the transportation and assignment problems
5. To Solve network models like the shortest path, minimum spanning tree, and maximum flow problems
6. To Understand the applications of basic methods for, and challenges in integer

Course Content

UNIT I

FUNDAMENTALS OF OPTIMIZATION- Definition-Classification of optimization problems Unconstrained and Constrained optimization-Optimality conditions-Classical Optimization techniques (Linear and nonlinear programming, Quadratic programming, Mixed integer programming)-Intelligent Search methods (Optimization neural network, Evolutionary algorithms, Tabu search, PSO, Application of fuzzy set theory).

UNIT II

EVOLUTIONARY COMPUTATION TECHNIQUES

Evolution in nature-Fundamentals of Evolutionary Algorithms-Working Principles of Genetic Algorithm- Evolutionary Strategy and Evolutionary Programming-Genetic Operators-Selection, Crossover and Mutation-Issues in GA implementation- GA based Economic Dispatch Solution-Fuzzy Economic Dispatch including losses- Tabu search algorithm for unit commitment problem-GA for unit commitment-GA based Optimal power flow- GA based state estimation.

UNIT III

PARTICLE SWARM OPTIMIZATION

Fundamental principle-Velocity Updating-Advanced Operators-Parameter selection- Hybrid approaches (Hybrid of GA and PSO, Hybrid of EP and PSO) -Binary, discrete and

combinatorial PSO-Implementation issues-Convergence issues- PSO based applications to Drive Control

UNIT IV

ADVANCED OPTIMIZA TION METHODS

Simulated annealing algorithm-Tabu search algorithm-SA and TS for unit commitment-Ant colony optimization- Bacteria Foraging optimization.

UNIT V

MULTI OBJECTIVE OPTIMIZATION

Concept of pareto optimality-Conventional approaches for MOOP-Multi objective GA Fitness assignment-Sharing function- MOGA-Mult objective PSO and its application in Drive Control.

Textbooks/Reference:

1) D. P. Kothari and J. S. Dhillon, "Power System Optimization", 2ndEdition, PHI learning private limited, 2010.
2) Kalyanmoy Deb, "Multi objective optimization using Evolutionary Algorithms", John Wiley and Sons, 2008.
3) Kalyanmoy Deb, "Optimization for Engineering Design", Prentice Hall of India first edition, 1988.
4) Carlos A. Coello Coello, Gary B. Lamont, David A. Van Veldhuizen, "Evolutionary Algorithms for solving Multi Objective Problems", 2ndEdition, Springer, 2007.
5) Kwang Y. Lee, Mohammed A. ElSharkawi, "Modern heuristic optimization techniques", John Wiley and Sons, 2008.

OPEN ELECTIVE - I
24AF2294OE204B: INDUSTRIAL LOAD MODELLING AND CONTROL

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course objectives

To enable the student to:

1. To understand Industrial Load Management

Course Outcomes

By the end of the course, student will be able to:

1. Understands the Demand Side Management of Electrical Energy.
2. Understand the classification of electricity pricing.
3. Understands the Reactive power management in industries.
4. Understands Industrial load profiling.
5. Understands Selection of Schemes Optimal Operating Strategies, Peak load saving, Constraints Problem formulation.

Course Content

UNIT I

Electric Energy Scenario-Demand Side Management-Industrial Load Management, Load Curves- Load Shaping Objectives, Methodologies-Barriers, Classification of Industrial Loads Continuous and Batch Processes-Load Modelling...

UNIT II

Electricity pricing –Dynamic and spot pricing –Models, Direct load control-Interruptible load control, Bottom-up approach-scheduling- Formulation of load Models, Optimization and control algorithms-Case studies.

UNIT III

Reactive power management in industries, controls-power quality impacts, application of filters Energy saving in industries.

UNIT IV

Cooling and heating loads, load profiling, Modelling- Cool storage, Types-Control strategies, Optimal operation, Problem Formulation-Case studies.

UNIT V

Captive power units, Operating and control strategies, Power Pooling- Operation models, Energy banking, Industrial Cogeneration. Selection of Schemes Optimal Operating Strategies, Peak load saving, Constraints Problem Formulation-Case study, Integrated Load management for Industries.

Textbooks/Reference:

1. C. O. Bjork "Industrial Load Management-Theory, Practice and Simulations", Elsevier, the Netherlands,1989
2. C.W.Gellings and S.N.Talukdar,.Load management concepts. IEEE Press, NewYork, 1986, pp. 3-28
3. Y. Manichaikul and F.C.Schweppe,"Physically based Industrial load", IEEE Trans.on PAS, April1981
4. H.G.Stoll, "Least cost Electricity Utility Planning",Wiley Inter science Publication, USA, 1989.
5. I.J.Nagarath and D.P.Kothari,.Modern Power System Engineering. ,Tata Mc Graw Hill publishers,NewDelhi,1995

OEPN ELECTIVE - I

24AF2294OE204C: ENERGY STORAGE SYSTEMS

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

1. To study details of various energy storage systems along with applications
2. Enabling to identify the optimal solutions to a particular energy storage application/utility

Course Outcomes:

Upon successful completion of the course, the student will be able to

1. Understand need of energy storage systems
2. Acquire knowledge pertaining to various ways to store energy, its analysis and use
3. Focus and develop hydrogen storage and fuel cell systems though research

Course Content

UNIT I

Introduction: Necessity of energy storage, different types of energy storage, mechanical, chemical, electrical, electrochemical, biological, magnetic, electromagnetic, thermal, comparison of energy storage technologies

UNIT II

Energy Storage Systems: Thermal Energy storage, sensible and latent heat, phase change materials, Energy and exergy analysis of thermal energy storage, Electrical Energy storage- super-capacitors, Magnetic Energy Storage-Superconducting systems, Mechanical-Pumped hydro, flywheels and pressurized air energy storage

UNIT III

Chemical-Hydrogen production and storage, Principle of direct energy conversion using fuel cells, thermodynamics of fuel cells, Types of fuel cells, AFC, PEMFC, MCFC, SOFC, Microbial fuel cell, Fuel cell performance, Electrochemical Energy Storage- Battery, primary, secondary and flow batteries

UNIT IV

Design and Applications of Energy Storage: Renewable energy storage-Battery sizing and stand-alone applications, stationary (Power Grid application), Small scale application-Portable storage systems and medical devices,

UNIT V

Mobile storage Applications- Electric vehicles (EVs), types of EVs, batteries and fuel cells, future technologies, hybrid systems for energy storage.

Textbooks/Reference Books

1. Energy Storage - Technologies and Applications by Ahmed Faheem Zobaa, InTech.
2. Fundamentals of Energy Storage by J. Jensen and B. Sorenson, Wiley-Interscience, New York,
3. Handbook of battery materials by C. Daniel, J. O. Besenhard,Wiley VCH Verlag GmbH & Co. KgaA 4. Electric & Hybrid Vehicles by G. Pistoia, Elsevier B. V.
4. Thermal energy storage: Systems and Applications by Dincer I. and Rosen M. A., Wiley pub.
5. Energy Storage: Fundamentals, Materials and Applications, by Huggins R. A., Springer
6. Fuel cell Fundamentals by R. O'Hayre, S. Cha, W. Colella and F. B. Prinz, Wiley Pub.
7. Chemical and Electrochemical Energy System by R. Narayan and B. Viswanathan, University Press. 9. Battery Systems Engineering by C. D. Rahn and C. Wang, Wiley Pub.
8. Electrochemical Energy Storage for Renewable sources and grid balancing by P. T. Moseley and J. Garche, Elsevier Science
9. Compressed air energy storage by F. P. Miller, A. F. Vandome, M. B. John, VDM publishing

OPEN ELECTIVE - I

24AF2294OE204D: INTELLIGENT SYSTEMS

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

1. To explore soft computing tools for intelligent control.
2. To study fuzzy logic and its role in developing control strategy.
3. To apply artificial neural network and neuro-fuzzy tools for system identification and control

Course Outcomes:

1. To understand concepts of neural network
2. To understand various models of ANN
3. To understand various learning methods of ANN
4. To understand fuzzy theory and system development
5. To apply ANN and Fuzzy technique in engineering problems.

Course Contents

UNIT I

Introduction to Neural Networks Introduction, Humans and Computers, Biological Neuron, Biological and Artificial Neuron Models, Historical Developments. Essentials of Artificial Neural Networks: Artificial Neuron Model, Operations of Artificial Neuron, Types of Neuron Activation Function, ANN Architectures, Classification Taxonomy of ANN-Connectivity, Neural Dynamics: Activation and Synaptic, Learning Strategy: Supervised, Unsupervised, Reinforcement, Learning Rules.

UNIT II

Feed Forward Neural Networks Introduction, Perceptron Models: Discrete, Continuous and Multi-Category, Training Algorithms: Discrete and Continuous Perceptron Networks, Perceptron Convergence theorem. Multilayer feed forward Neural Networks. Credit Assignment Problem, Generalized Delta Rule, Derivation of Back propagation (BP) Training, Summary of Back propagation Algorithm, Learning Difficulties and Improvements.

UNIT III

Associative Memories Paradigms of Associative Memory, Pattern Mathematics, Hebbian Learning, General Concepts of Associative Memory: Associative Matrix, Association Rules, Hamming Distance, The Linear Associator, Matrix Memories, Content Addressable Memory, Bi-directional Associative Memory (BAM) Architecture, BAM Training Algorithms: Storage

and Recall Algorithm, BAM Energy Function, Proof of BAM Stability Theorem. Self Organizing Maps (SOM) and Adaptive Resonance Theory (ART). Introduction, Competitive Learning, Vector Quantization, Self-Organized Learning Networks, Kohonen Networks, Linear Vector Quantization, Stability Plasticity Dilemma, Feed forward competition, ART1, ART2.

UNIT IV

Fuzzy set Theory Fuzzy versus crisp, Crisp sets: operation, properties, partition and covering, fuzzy sets: membership function, Basic fuzzy set operations, properties of fuzzy sets, crisp relations: Cartesian product, operation and relations, fuzzy relations: Fuzzy Cartesian product, operation on fuzzy relations.

UNIT V

Fuzzy systems Crisp logic: Laws on prepositional logic, Inference in prepositional logic, predicate logic: Interpretation of predicate logic formula, Inference in predicate logic, fuzzy logic: Fuzzy quantifiers, fuzzy Inference, fuzzy rule-based system, defuzzification methods. Applications based on ANN and Fuzzy Logic Technique Neural network applications: Pattern recognition, control and Process Monitoring, fault diagnosis and load forecasting. Fuzzy logic application: Greg viot's fuzzy cruise controller, Air conditioner controller.

Textbooks/Reference:

1. Neural Network Design-Hagan, Demuth, Beale- Thomas Learning, Vikas Publishing House
2. Introduction to Artificial Neural Systems - Jacek M. Zuarda, Jaico Publishing House, 1997.
3. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharan and Rai - PHI Publication.
4. Neural and Fuzzy Systems: Foundation, Architectures and Applications, - N. Yadaiah and S. BapiRaju, Pearson Education
5. Neural Networks - James A Freeman and Davis Skapura, Pearson, 2002.
6. Neural Networks - Simon Hykins, Pearson Education 4. Neural Engineering by C. Eliasmith and CH. Anderson, PHI

OPEN ELECTIVE – I

24AF2294OE204E: ADVANCED DSP

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

Students will be able to:

1. At the completion of this course, the student should have in depth knowledge of processing digital signals.

Course Outcomes:

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

1. Know the analysis of discrete time signals.
2. To study the modern digital signal processing algorithms and applications.
3. Have an in-depth knowledge of use of digital systems in real time applications
4. To know about classical filter design and FIR design.
5. To know about to Multirate Signal Processing.

Course Contents

UNIT I

Review of Discrete – Time Signal & System representation in Z –Transform domain – Inverse Z – Transform – Properties – System characterization in Z – domain -- Equivalence between Fourier Transform and the Z-Transform of a Discrete signal.

UNIT II

Sampling in Fourier domain - Discrete Fourier Transform and its properties – Linear filtering using DFT–Resolution of DFT-FFT Algorithm–Radix-2FFTAlgorithm-DIT & DIF Structures-Higher Radix schemes.

UNIT III

Classification of filter design - Design of IIR filters – Bilinear transformation technique – Impulse invariance method–Step invariance method.

UNIT IV

FIR filter design –Fourier series method -Window function technique-finite Word Length Effects

UNIT V

Introduction to Multirate Signal Processing – Decimation – Interpolation-introduction to STFT WT

Textbook:

1. John G.Prokis and Dimitris G. Hanolakis,'Digital Signal Processing, Principles, Algorithms & Applications' 4thEdition, Pearson Education,2006.

Reference Books

1. Ludemann L. C., 'Fundamentals of Digital Signal Processing', Harper and Row publications,2009.
2. Antoniou A.'Digital Filters–Analysis and Design', TataMc-GrawHill, 2001.
3. Oppenheim and Schaffer,'Discrete time Signal processing',Pearson Education,2007

24AF2294PC205: ENERGY MANAGEMENT AND AUDITING

Weekly Teaching Hours	**TH: 03**	**Tu: 01**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Outcomes

1. To Identify and describe present state of energy security and its importance.
2. To Identify and describe the basic principles and methodologies adopted in energy audit of utility
3. To Describe the energy performance evaluation of some common electrical and thermal installations and identify the energy saving opportunities
4. To Analyze the data collected during performance evaluation and recommend energy saving measures

COURSE CONTENTS:

UNIT I: BASIC PRINCIPLES OF ENERGY AUDIT

Energy audit- definitions, concept, types of audits, energy index, cost index, pie charts, Sankey diagrams, load profiles, Energy conservation schemes- Energy audit of industries- energy saving potential, energy audit of process industry, thermal power station, building energy audit Need for energy management – energy basics – designing and starting an energy management program – energy audit process. Need for energy management – energy basics – designing and starting an energy management program – energy accounting – energy monitoring, targeting and reporting.

UNIT II: ENERGY COST AND LOAD MANAGEMENT

Important concepts in an economic analysis – economic models – time value of money –utility rate structures – cost of electricity – loss evaluation. Load management: demand control techniques – utility monitoring and control system-HVAC and energy management – economic justification.

UNIT III: ENERGY EFFICIENT MOTORS

Energy efficient motors, factors affecting efficiency, loss distribution, constructional details, characteristics - variable speed, variable duty cycle systems, RMS hp- voltage variation-voltage unbalance - over motoring - motor energy audit applications to Systems and equipment such as: electric motors – transformers and reactors – capacitors and synchronous machines.

UNIT IV: METERING FOR ENERGY MANAGEMENT

Relationships between parameters – Units of measure – typical cost factors – utility meters – timing of meter disc for kilowatt measurement – demand meters – paralleling of current transformers –

instrument transformer burdens – multitasking solid-state meters – metering location vs. Requirements – metering techniques and practical examples.

UNIT V: LIGHTING SYSTEMS AND COGENERATION

Concept of lighting systems – the task and the working space – light sources – ballasts –luminaries lighting controls – optimizing lighting energy – power factor and effect of harmonics on power quality cost analysis techniques – lighting and energy standards. Cogeneration: forms of cogeneration – feasibility of cogeneration – electrical interconnection.

ECONOMIC ASPECTS AND ANALYSIS

Economics Analysis-Depreciation Methods, time value of money, rate of return, present worth method, replacement analysis, life cycle costing analysis- Energy efficient motors- calculation of simple payback method, net present worth method- Power factor correction, lighting – Applications of life cycle costing analysis, return on investment.

TEXTBOOKS:

1) Eastop T.D and Croft D.R, “Energy Efficiency for Engineers and Technologists”, Logman Scientific& Technical, 1990.
2) Reay D.A., “Industrial Energy Conservation”, first edition, Pergamon Press, 1977.
3) IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE, 1996.
4) Amit K. Tyagi, “Handbook on Energy Audits and Management”, TERI, 2003.
5) Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, “Guide to Energy Management”, Fifth Edition, The Fairmont Press, Inc., 2006.

INDIAN KNOWLEDGE SYSTEM BUCKET#

24AF2294AE206A: CONCEPTS AND APPLICATIONS IN ENGINEERING

Weekly Teaching Hours	**TH: 03**	**Tu: --**		**Credit: 2**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

1. Introduce students to the foundational concepts, philosophies, and components of Indian knowledge systems, including ancient scriptures, philosophies, and traditional practices.
2. Introducestudentsto Vedic mathematical principles and computational techniques from ancient Indian texts, demonstrating their practical use in engineering calculations.
3. Explorethepotentialbenefitsofincorporatingyogicandmeditativepracticesinto engineering to enhance focus, creativity, and overall well-being.
4. Study architectural concepts from Indian traditions and evaluate how they can inform modern urban planning and sustainable architecture.
5. Encourage students to draw inspiration from IKS to develop innovative engineering solutions that align with ancient wisdom while meeting contemporary needs.

Course Outcomes:

1. Gain a comprehensive understanding of the philosophical, scientific, and technological aspects of Indian Knowledge Systems and their historical development.
2. Understand the philosophical understanding of IKS, including concepts like dharma, karma, and holistic thinking, and explore their relevance to engineering.
3. Understand Vedic mathematical principles and computational methods, and their potential relevance in solving modern engineering problems.
4. Investigate the connections between yoga, meditation, and stress management, and their potential impact on mental well-being in engineering contexts.
5. Reflect on the ethical, cultural, and social dimensions of integrating IKS concepts into engineering practices and applications.

UNIT I

Indian Knowledge System – An Introduction & Vedic Corpus.

What is IKS? Why do we need IKS? Organization of IKS, Historicity of IKS, Some salient aspects of IKS, Introduction to Vedas, A synopsis of the four Vedas, Sub-classification of Vedas, Messages in Vedas, Introduction to Vedāṅgas, Prologue on Śikṣā and Vyākaraṇa, Basics of Nirukta and Chandas, Introduction to Kalpa and Jyotiṣa, Vedic Life: A Distinctive Features.

UNIT II

Number system & Mathematics

Number systems in India - Historical evidence, Salient aspects of Indian Mathematics, Bhūta-Saṃkhyā system, Kaṭapayādi system, Measurements for time, distance, and weight, Piṅgala and the Binary system. Introduction to Indian Mathematics, Unique aspects of Indian Mathematics, Indian Mathematicians and their Contributions, Algebra, Geometry, Trigonometry, Binary mathematics, and

combinatorial problems in Chandaḥ Śāstra, Magic squares in India

UNIT III

Engineering Technology: Metal & Other applications

Wootz Steel: The rise and fall of a great Indian technology, The Indian S & T heritage, Mining and ore extraction, Metals and metalworking technology, Iron and steel in India, lost wax casting of idols and artefacts, Apparatuses used for extraction of metallic components. Irrigation systems and practices in South India, literary sources for science and technology, Physical structures in India, irrigation and water management, dyes and painting technology, the art of making perfumes, Surgical techniques, shipbuilding, sixty-four art forms (64 Kalās) status of Indigenous S & T.

UNIT IV

Town Planning and Architecture:

Perspective of Arthaśāstra on town planning, Vāstu-śāstra – The science of architecture eight limbs of Vāstu, town planning, temples in India: Marvelous stone architecture for eternity, temple architecture in India, Iconography.

UNIT V

Knowledge Framework and Classifications:

Indian scheme of knowledge, The knowledge triangle, Prameya – A vaiśeṣikan approach to physical reality, Dravyas – the constituents of the physical reality, Attributes – the properties of substances and Action – the driver of conjunction and disjunction, Sāmānya, viśēṣa, samavāya, Pramāṇa – the means of valid knowledge, Saṃśaya – ambiguities in existing knowledge, Framework for establishing valid knowledge, Deductive or inductive logic framework, Potential fallacies in the reasoning process, Siddhānta: established tenets in a field of study.

UNIT VI

Linguistics

Introduction to Linguistics, Aṣṭādhyāyī, Phonetics, word generation, computational aspects, Mnemonics, Recursive operations, Rule-based operations, Sentence formation verbs and prefixes, the role of Sanskrit in natural language processing.

Textbooks/References:

1. Mahadevan, B., Bhat Vinayak Rajat, Nagendra Pavana R.N. (2022),Introduction to Indian Knowledge System: Concepts and Applications, PHI Learning Private Ltd. Delhi.

NPTEL PLATFORM:

NPTEL Course	Name of Instructor	Host Institute	Link
Indian Knowledge System (IKS): Concepts and Applications in Engineering	Prof. B. Mahadevan, Dr. Vinayak Rajat Bhat, Dr. R Venkata Raghavan	(IIMB), Chanakya University, Bangalore	https://onlinecourses.swayam2.ac.in/imb23_mg53/preview

INDIAN KNOWLEDGE SYSTEM BUCKET#
24AF2294AE206B: HUMANITIES AND SOCIAL SCIENCES

Weekly Teaching Hours	**TH: 03**	**Tu: --**		**Credit: 2**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

1. Introduce students to the diverse range of Indian philosophical, cultural, and social knowledge systems that have evolved over millennia.
2. EncouragestudentstocriticallycompareIndianknowledgesystemswithother global philosophies and social theories, fostering a nuanced understanding.
3. Study Vedic texts, ancient scriptures, and philosophical treatisesto understand the core ideas and insights that inform Indian knowledge systems.
4. Investigate the intersections of spirituality, psychology, and well-being in Indian knowledge systems, exploring practices like meditation, yoga, and mindfulness.
5. Study the role of language, symbols, and communication in Indian knowledge systems, including Sanskrit as a language of knowledge transmission.

Course Outcomes:

1. Recognize the interdisciplinary nature of IKS, integrating traditional knowledge with contemporary concepts in humanities and social sciences.
2. Explore India's rich cultural heritage, including literature, art, music, dance, and rituals, and analyze their significance in shaping identity and social cohesion.
3. Explore Indian philosophical schools and their insights into consciousness, self- awareness, and psychological well-being.
4. Analyze India's cultural diversity, pluralism, and the coexistence of various belief systems, contributing to tolerance and social harmony.

UNIT I

Indian Knowledge System – An Introduction & Vedic Corpus

What is IKS? Why do we need IKS? Organization of IKS, Historicity of IKS, Some salient aspects of IKS, Introduction to Vedas, A synopsis of the four Vedas, Sub-classification of Vedas, Messages in Vedas, Introduction to Vedāṅgas, Prologue on Śikṣā and Vyākaraṇa, Basics of Nirukta and Chandas, Introduction to Kalpa and Jyotiṣa, Vedic Life: A Distinctive Features.

UNIT II

Philosophical Systems

An introduction to philosophical systems, development of philosophy unique features of philosophy, Sāṅkhya approach of philosophy, Introduction to Yoga, tenet of Nyāya philosophy principles of Vaiśeṣika, doctrine of Pūrva-Mīmāṃsā Darśana, thesis of Vedānta and synopsis of

Advaita philosophy of Viśiṣṭādvaita.

UNIT III

Wisdom through ages

Gateways of cestral wisdoms, introduction to Purāṇa, the Purāṇic repository, Issues of interest in Purāṇas, Introduction to Itihāsas, Key messages in Itihāsas, Wisdom through Nīti- śāstras, Wisdom through Subhāṣita.

UNIT IV

Health Wellness and Psychology:

Introduction to health, Āyurveda: approach to health, Sapta-dhātavaḥ: seven-tissues, role of agni in health, tri-doṣas, Āyurveda: definition of health, Psychological aspects of health, disease management elements, Dinacaryā: daily regimen for health & wellness, Importance of sleep, Food intake methods and drugs, Approach to lead a healthy life, Indian approach to psychology, the tri guṇa system & holistic picture of the individual, the Nature of Consciousness, consciousness studies and issues

UNIT V

Linguistics:

Introduction to Linguistics, Aṣṭādhyāyī, phonetics, word generation, computational aspects, mnemonics, recursive operations, rule-based operations, sentence formation, verbs and prefixes, role of Sanskrit in natural language processing.

UNIT VI

Governance and Public Administration:

Introduction to raja dharma, Arthaśāstra: a historical perspective, Elements of a kauṭilyan state, The king & the amātya, Janapada & durga, treasury and the state economy (Kośa), danda, Mitra, the administrative setup, relevance of Arthaśāstra, public administration in Epics.

Textbooks/References:

1. Mahadevan, B., Bhat Vinayak Rajat, Nagendra Pavana R.N.(2022),―Introduction to Indian Knowledge System: Concepts and Applications‖, PHI Learning Private Ltd. Delhi.
2. Pride of India: A Glimpse into India‘s Scientific Heritage, Samskrita Bharati, New Delhi.
3. Sampadand Vijay (2011).―The Wonder that is Sanskrit, Sri Aurobindo Society, Puducherry.
4. Acarya, P. K. (1996). Indian Architecture, Munshiram Manoharlal Publishers, NewDelhi.
5. Kapoor Kapil,Singh Avadhesh (2021).―Indian Knowledge Systems Vol–I&II‖, Indian Institute of Advanced Study, Shimla, H.P.
6. Dasgupta, S. (1975). A History of Indian Philosophy- Volume 1, Motilal Banarsidass, New Delhi.
7. P Lofker, K. (1963). Mathematics in India, Princet on University Press, New Jersey, USA"

NPTEL platform:

NPTEL Course	Name of Instructor	Host Institute	Link
Indian Knowledge System(IKS): Humanities and Social Sciences	Prof. B. Mahadevan, Dr. Vinayak Rajat Bhat, Dr. R VenkataRaghavan	Indian Institute of Management Bangalore (IIMB), Chanakya University, Bangalore	https://onlinecourses.swayam2.ac.in/imb23_mg55/preview

24AF2294PCL207: PG LAB-II

Weekly Teaching Hours	**TH: --**	**PR: 04Hr**		**Credit: 2**
Scheme of Marking	**TH: --**	**OR/PR: 25**	**CA: 20**	**Total: 50**

Practicals of the Lab - I shall be based on the courses of first semester. The lab work shall consist of hands-on experiments on the different software and hardware platforms related to the syllabus.

24AF2294MP208: MINI-PROJECT

Weekly Teaching Hours	**TH: --**	**PR: 04Hr**		**Credit: 1**
Scheme of Marking	**TH: --**	**OR/PR: 25**	**IA: 25**	**Total: 50**

The mini project shall be based on the recent trends in the industry, research and open problems from industry and society. This may include mathematical analysis, modelling, simulation, and hardware implementation of the problem identified. The mini project shall be of the student ‘s choice and approved by the guide. The student must submit the report of the work carried out in the prescribed format signed by the guide and head of the department/institute.

24AF2294AU209: DISASTER MANAGEMENT

Weekly Teaching Hours	**TH: 02**	**PR: --**		**Credit: --**
Scheme of Marking	**TH: --**	**OR/PR: --**	**IA: --**	**AUDIT**

Course Objectives:

1. Mastering strategies to manage disasters and ensure public safety during emergencies.
2. Identifying hazards, and vulnerabilities, and crafting plans to reduce disaster impact.
3. Collaborative Skills: Working across disciplines to address complex disaster challenges.
4. Developing, improving, and implementing disaster management policies. Community Empowerment: Educating and engaging communities for proactive disaster readiness.

Course Outcomes:

1. Learners will be able to understand the basic concept of disaster(s)and disaster management, their significance, and their types.
2. Learnerswilldeveloptheanalyticalskillstostudytherelationshipbetweenvulnerability, disasters, disaster prevention and risk reduction
3. LearnerswillgainapreliminaryunderstandingofapproachestoDisasterRisk Reduction (DRR)
4. Learners will be empowered with the awareness of institutional processes in the country for Disaster Management

UNIT I

Disaster Management: Disaster and Disaster Management –Concepts, Issues Concerned with Disaster Management. Disaster Management: Phases of Disaster Management, Phases of Disaster Management Types of Disasters: Bhopal Disaster: A Case Study, Types of Disasters- An Introduction, Natural Disaster, Man-made Disaster

UNIT II

Types of Disasters: Slow on set Disasters & Rapid on set Disasters, Simple and Complex, Tsunami: A Case Study Disasters, Tsunami: A Case Study, Cyclone Phallin 2013: A Case Study

UNIT III

Disaster Management in India -An overview: Evolution of Disaster Management in India, Disaster and Disaster Management in India, National Institute of Disaster Management, National Disaster Management Act 2005.

UNIT IV

Disaster Management in India –An Overview: The National Policy on Disaster Management, 2009. Refugee Problem: National Plan on Disaster Management 2016, Refugee Problems, Impact of Disaster on the lives of Refugees.

Refugee Problem: Problems of Women and Children during disasters, Principles of Psychosocial Care, Issues and Recovery During Emergency.

Refugee Problem: Relationship between Disasters, Development and Vulnerabilities, Relationship between Disasters, Development and Vulnerabilities.

UNIT V

Refugee Problem: Equity Issues in Disaster.

Refugee Problem: Issues of Rehabilitation and Resettlement among the Disaster Survivors, Stakeholders in Disaster Relief Management - An Introduction.

Stakeholders in Disaster Relief Management: Central Government.

Stakeholders in Disaster Relief Management: State Government, District Administration. Armed Forces.

UNIT VI

Stakeholders in Disaster Relief Management: Paramilitary Forces, Fire Services.

Disaster Risk Reduction: Disaster Risk Reduction Strategies, Risk Reduction Preparedness Plans.

Disaster Risk Reduction: Action Plans and Procedures, Early Warning Systems, Components of Disaster Relief, Factors contributing to Vulnerability.

Disaster Risk Reduction: Disaster Risk Reduction - Master Planning for the Future, Capacity Building Rehabilitation measures and long-term reconstruction, Understanding Kerala Disaster 2018.

Textbooks/References:

1. Coppola D P, 2007. Introduction to International Disaster Management, Elsevier Science (B/H), London.
2. Manual on natural disaster management in India, M C Gupta, NIDM, New Delhi
3. An overview on natural & man-made disasters and their reduction, R K Bhandani, CSIR, New Delhi
4. World Disasters Report, 2009. International Federation of Red Cross and Red Crescent, Switzerland
5. Encyclopaedia of disaster management, Vol I, II and IIIL Disaster management policy and administration, S L Goyal, Deep & Deep, New Delhi, 2006
6. Encyclopaedia of Disasters – Environmental Catastrophes and Human Tragedies, Vol. 1 & 2, Angus M. Gunn, Greenwood Press, 2008
7. Disasters in India Studies of grim reality, Anu Kapur& others, 2005, 283 pages, Rawat Publishers, Jaipur.
8. Management of Natural Disasters in developing countries, H. N. Srivastava & G.D. Gupta, Daya Publishers, Delhi, 2006, 201 pages
9. NaturalDisasters, David Alexander, Kluwer Academic London, 1999, 632 pages
10. DisasterManagementAct2005, Publisher by Govt. of India
11. Publications of National Disaster Management Authority (NDMA)on Various Templates and

Guidelines for Disaster Management
12. NIDM Publications.
13. HighPowerCommitteeReport,2001, J. C. Pant
14. Disaster Mitigation in Asia & Pacific, Asian Development Bank
15. National Disaster Management Policy,2009, GoI
16. Disaster Preparedness Kit, American Red Cross

NPTEL platform:

NPTEL Course	Name of Instructor	Host Institute	Link
Disaster Management	Naveen Kumar Nanjundan	University Of Hyderabad	https://onlinecourses.swayam2.ac.in/cec19_hs20/preview

OPEN ELECTIVE – II

24AF2294OE301A: ENTERPRENEURSHIP

Weekly Teaching Hours	**TH: 03**	**Tu: 1**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

1. To understand the role of entrepreneurs in driving innovation and economic growth.
2. Guide students through the process of developing a comprehensive business plan, including market research, financial projections, competitive analysis, and risk assessment.
3. Provide students with essential financial literacy skills, including budgeting, financial forecasting, and understanding different funding options such as bootstrapping, loans, venture capital, and angel investment.
4. Guide students through the process of developing, prototyping, and refining their products or services to meet customer needs and expectations.

Course Outcomes:

1. Students will be able to generate innovative business ideas by identifying market gaps, customer needs, and emerging trends.
2. Students will be capable of developing comprehensive business plans that encompass market research, financial projections, and strategic goals.
3. Students will gain skills in budgeting, financial forecasting,and managing financial resources for their entrepreneurial ventures.
4. Studentswillbeabletoidentifyandmanagepotentialrisksassociatedwithentrepreneurship, including financial, operational, and market risks.

UNIT I

Entrepreneurial Journey, Entrepreneurial Discovery, Ideation and Prototyping,

UNIT II

Testing, Validation and Commercialization, Disruption as a Success Driver

UNIT III

Technological Innovation and Entrepreneurship – 1, Technological Innovation and Entrepreneurship – 2, Raising Financial Resources.

UNIT IV

Education and Entrepreneurship, Beyond Founders and Founder-Families, India as a Start-up Nation

UNIT V

National Entrepreneurial Culture, Entrepreneurial Thermodynamics, Entrepreneurship and Employment, Start-up Case Studies

Textbooks/References:

1. Zero to One: Notes on Startups, or How they Build the Future by Peter Thiel.
2. The Lean Startup: How Today ‘s Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses by Eric Ries.
3. India as Global Start-up Hub: Mission with Passion by C B Rao.
4. Elon Musk: Tesla, Space X, and the Quest for a Fantastic Future by Ashlee Vance.
5. Steve Jobs by Walter Isaacson.
6. Innovation and Entrepreneurship: Practice and Principles by Peter F Drucker.
7. The Innovator ‘s Solution: Creating and Sustaining Successful Growth by Clayton M Christensen.

NPTEL Platform:

NPTEL Course	Name of Instructor	Host Institute	Link
Entrepreneurship	Prof. C Bhakta Vatsala Rao	IIT Madras	https://onlinecourses.nptel.ac.in/noc20_mg35/preview

OPEN ELECTIVE – II

24AF2294OE301B: ENVIRONMENT AND DEVELOPEMENT

Weekly Teaching Hours	**TH: 03**	**Tu: 1**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

1. To help students comprehend the complex complex interconnections between environmental factors and development processes, highlighting how they can either support or impede each other.
2. To identify and analyze key environmental challenges arising from development activities, such as pollution, resource depletion, deforestation, loss of biodiversity, and climate change.
3. To study the effect of climate change on the environment.
4. To analyze real-world case studies of both successful and unsuccessful attempts to integrate environmental considerations into development projects and policies

Course Outcomes:

1. Demonstrate a deep understanding of the complex interrelationships between environmental factors and socioeconomic development, including how they influence and shape each other.
2. Identify and critically analyze key environmental challenges resulting from development activities, and evaluate their impacts on ecosystems, natural resources, and human well-being.

UNIT I

Environmental movement

Introduction: Development, economic growth and sustainable development, Basic ecosystem ecology, Environmentalism, Environmental Movement, Environmentalism in the global south,

UNIT II

Social ecology

Approaches to environment: Ecofeminism, Feminist political ecology, Marxism and ecology, Debates on environmental ethics: Deep ecology, Gandhi and ecology, social ecology.

UNIT III

Impact of Religion on the environment

Religion, environment, and conservation: Religion, environment and historical roots of ecological crisis, Biodiversity conservation ethics in Buddhism and Hinduism, Christian religion in the age of ecological crisis

UNIT IV

Natural Resources & development

Natural resource management, Common property vs. private property, Livelihoods, forests, and conservation, Displacement, dispossession, and development: Conservation-induced displacement, Environment impact assessment and national rehabilitation & resettlement policy, Dispossession, and land acquisition.

UNIT V

Gender & Development, Climate change

Development theory and gendered approach to development, Gender, environment & sustainable development.

Environment and climate change: Climate change interventions and policy framework, Eastern Himalayas, and climate change.

Belief and local knowledge of environment

Belief and knowledge systems, biodiversity conservation and sustainability: Ecological knowledge, biodiversity conservation and sustainability, Traditional religion and conservation of nature in Northeast India: Case study

Local knowledge in the environment-development discourse: Indigenous knowledge, environment and development, Relevance of indigenous knowledge: case study

Textbooks/References:

1. Arnold, David, and Guha, Ramchandra, (eds.), 1997. Nature, Culture and Imperialism, New Delhi: Oxford University Press.
2. Baviskar, Amita. 1997. In the Belly of the River: Tribal Conflicts over Development in the Narmada Valley, OUP, Delhi.
3. Barnhill, David Landis & Roger S. Gottlieb. (eds.) 2001. Deep Ecology and World Religions: New Essays on Sacred Grounds. State Univ. of New York Press, Albany.
4. Bicker, Alan, Paul Sillitoe and Johan Pottier. 2004. Development and Local Knowledge: New Approaches to Issues in Natural Resources Management, Conservation and Agriculture. Routledge, London & New York.
5. Esteva, G. 1997. Development ‘in W. Sachs, ed., The Development Dictionary, Orient Longman, pp. 8-34.
6. Gadgil, Madhav and Guha, Ramchandra. 1995. Ecology and Equity: The use and Abuse of Nature in Contemporary India, New Delhi: Oxford University.
7. Gottlieb, Roger S. 2004. This Sacred Earth: Religion, Nature, Environment. Routledge, New York, and London.
8. Merchant, Carolyn. 1994. Ecology: Key Concepts in Critical Theory, Humanities Press, New Jersey.
9. Ramakrishnan, P.S. 1992. Shifting Agriculture and Sustainable Development: An Interdisciplinary Study from North-Eastern India, Man and the Biosphere Series, Volume 10, UNESCO.

NPTEL Platform

NPTEL Course	Name of Instructor	Host Institute	Link
Environment and Development	Prof. Ngamjahao Kipgen	IIT Guwahati	https://onlinecourses.nptel.ac.in/noc21_hs83/preview

OPEN ELECTIVE – II

24AF2294OE301C: STUDENT PSYCHOLOGY

Weekly Teaching Hours	**TH: 03**	**Tu: 1**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

1. Gain an understanding of prominent learning theories and models, enabling you to grasp the foundational concepts that influence effective teaching and learning.
2. Acquire skills to assess and appreciate diverse student characteristics, including learning styles, cultural backgrounds, and individual differences that impact learning.
3. Gain proficiency in understanding, administering, and interpreting psychological tests and inventories to assess cognitive abilities, personality traits, and emotional development in learners
4. Examine psychological theories of motivation and cultivate the skills needed to apply motivational strategies that enhance student engagement, commitment, and achievement.
5. Investigate the stages of physical, cognitive, emotional, and social development in individuals, equipping you to design instructional methods that support comprehensive growth.
6. Acquire an understanding of NLP concepts and techniques that can be used to improve communication, establish rapport, and optimize teaching and learning experiences.

Course Outcomes:

1. Understanding of Psychological Factors: Gain a comprehensive understanding of the psychological factors that influence students' learning, behavior, and overall well- being in educational settings.
2. Recognition of Diverse Student Needs: Develop the ability to recognize and appreciate the diverse cognitive, emotional, and social needs of students, enabling tailored support and fostering inclusive learning environments.
3. Application of Psychological Strategies: Apply psychological theories and principles to address various challenges in student development, including motivation, learning difficulties, and behavioural issues.
4. Competence in Student Assessment: Acquire skills in utilizing psychological assessment tools to evaluate students' cognitive abilities, emotional states, and learning styles, informing instructional strategies and support plans.
5. Promotion of Positive Learning Experiences: Learn to create positive and conducive learning experiences by integrating insights from student psychology, fostering engagement, motivation, and holistic growth among learners.

UNIT I

Teaching Learning Process

UNIT II

Student Characteristics, Types and Problems

UNIT III

Psychological Tests and Inventories, Student Motivation

UNIT IV

Physical and Cognitive Development

UNIT V

Emotional and Social Development, Neuro-Linguistic Programming, Counselling Skills, and Summary

Textbooks/References:

1. Sharma, R. A. (2007). Training Technology. Meerut: Surya Publications.
2. Sharma, R. A. (2007). Psychology of Teaching-Learning Process. Meerut: Surya Publications.
3. B. Mukhopadhyay (1997). Motivation in Educational Management. New Delhi: Sterling Publishers.
4. Barki &Mukhopadhyay. (1995). Guidance and Counselling. New Delhi: Sterling Publishers.
5. Agochya, D. (2010). Life competencies for adolescents. New Delhi: Sage Publications.
6. Davies, I. K. (1971). Management of Learning. Berkshire: McGraw Hill.
7. Dusay. (1980). Ego grams. New York: Harper & Row.
8. Goleman, D. (1996). Emotional Intelligence. New York: Bantam Books.
9. Anastasi (2016). Psychological Testing. New Delhi: Pearson Education. Psychological Tests.

NPTEL Platform

NPTEL Course	Name of Instructor	Host Institute	Link
Student Psychology	Dr. S. Renuka devi	NITTTR, Chennai	https://onlinecourses.swayam2.ac.in/ntr19_ed23/preview

OPEN ELECTIVE – II

24AF2294OE301D: PRINCIPLES OF ECONOMICS

Weekly Teaching Hours	**TH: 03**	**Tu: 1**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

1. Introduce essential economic terms and concepts for analyzing real-world situations.
2. Understand market dynamics, supply and demand, and resource allocation.
3. Study national indicators, inflation, unemployment, and government policies' effects.
4. Learn to make informed choices using opportunity cost, utility, and cost analysis.
5. Explore global interdependencies, trade, exchange rates, and policy impacts.

Course Outcomes:

1. Grasp key economic principles, like supply and demand, opportunity cost, and marginal analysis, forming a foundation for economic understanding.
2. Gain insights into market structures, pricing mechanisms, and factors influencing consumer and producer behavior.
3. Understand the role of government interventions, regulations, and fiscal/monetary policies in shaping economic outcomes.
4. Learn how societies allocate scarce resources efficiently, exploring topics like production, distribution, and factors of production.
5. Develop analytical thinking by applying economic principles to real-world scenarios and making informed personal and business decisions.

UNIT I

Principles of Economics, Thinking like an Economist; Interdependence and the gains from Trade.

UNIT II

Market forces of supply and Elasticity, Application of elasticity; supply, demand, and government policies

UNIT III

Consumer and producer surplus; cost of taxation and international trade, Externalities, and cost of production

UNIT IV

Competitive market and monopoly market, Game theory and oligopoly measure national income, measuring the cost of living

UNIT V

Production and growth; Saving, Investment and the financial system, the monetary system, Money growth and inflation

Textbooks/References:

1. N. Gregory Mankiw, Principles of Economics.

NPTER Platform

NPTEL Course	Name of Instructor	Host Institute	Link
Principles Of Economics	Prof. Sabuj Kumar Mandal	IIT Madras	Principles Of Economics– Course (nptel.ac.in)

OPEN ELECTIVE–II

24AF2294OE301E: BUSINESS TO BUSINESS MARKETING (B2B)

Weekly Teaching Hours	**TH: 03**	**Tu: 1**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

1. Develop a comprehensive understanding of the unique characteristics, dynamics, and complexities that define business-to-business (B2B) marketing, including the role of intermediaries, supply chains, and collaborative relationships.
2. Learn how to segment B2B markets based on factors such as industry, company size, and purchasing behavior. Understand the significance of effective market segmentation in tailoring marketing strategies to specific B2B customer segments.
3. Explore the elements of the B2B marketing mix, including product/service offerings, pricing strategies, distribution channels, and promotional approaches. Develop the ability to design marketing strategies that align with the unique needs and preferences of B2B customers.
4. Gain insights into relationship-building strategies in B2B contexts. Learn how to nurture long-term, mutually beneficial partnerships with B2B clients through effective communication, trust-building, and value delivery.
5. Acquire skills in B2B sales processes, negotiations, and contract management. Understand the intricacies of negotiation dynamics, procurement processes, and key decision-making factors in B2B transactions.

Course Outcomes:

1. Foundational Knowledge: Gain a strong grasp of the core concepts and theories that form the basis of B2B marketing, enabling practical application.
2. Market Analysis Expertise: Develop skills to analyse B2B markets, segment customers effectively, and make informed marketing decisions.
3. Strategic Implementation: Acquire the ability to design and execute B2B marketing strategies tailored to the unique needs of business customers.
4. Relationship Management: Learn how to build and nurture enduring relationships with B2B clients through effective communication and collaboration.
5. Sales and Negotiation Proficiency: Master the art of B2B sales, negotiation strategies, and contract management for successful transactions.

UNIT I

Introduction to B2B Marketing: Business marketing, Classifying goods for the business market, Business market customers, Market structure, Environment and Characteristics of Business Marketing, Strategic role of marketing, Commercial enterprises, Commercial and institutional customers, B2B vs B2C Marketing.

Organizational Buying and Buyer Behavior: Organizational buyers‘ decision process - A Stepwise Model and A Process Flow Model, Organizational and business markets - Government as a customer

- Commercial enterprises - Commercial and institutional customers, Value analysis, Buy-grid framework, Strategic procurement.

UNIT II

B2B Marketing Strategy: Strategy making and strategy management process, Industrial products strategy– Managing Products for Business Markets-Managing Services for Business Markets-Managing Business Market Channels the Growth-Share Matrix, Multifactor Portfolio Matrix, The Balanced Scorecard.

B2B Marketing STP: Market Segmentation, bases for segmenting business markets, basic framework of segmentation, choosing target segments and positioning.

UNIT III

Business Marketing Communications- B2B Advertising, Digital marketing, - Trade shows, exhibitions, and business meets - Managing the sales force - Deployment analysis, direct marketing. Demand forecasting: industrial market, Forecasting- meaning, importance and relevance, issues related to forecasting, forecasting measurement models, sales force forecasting, estimating segment demand, Collaborative approach to estimate demand, qualitative and quantitative forecasting methods.

UNIT IV

Product management: (existing and new) in industrial market, role of product in the industrial market, new product development, industrial product life cycle, product evaluation matrix, techniques for identifying new products QFD, perceptual mapping, reverse engineering, fish bone diagram, role of service and maintenance in industrial markets, customer experience life cycle, service quality. Pricing: Pricing strategies; the pricing policy; Price on the Internet; Financial marketing, competitive bidding, commercial terms and conditions, role of leasing.

UNIT V

Buyer seller relationships, types of relationships, transactional and collaborative relationships, influencing industrial customers, role of service in industrial markets. CRM.

B2B marketing research, challenges in B2B research, developing a marketing information system, role of qualitative research techniques in B2B research.

Business marketing channels and participants - Channel design and management decisions - B2B logistics management, types of industrial middlemen and intermediaries, marketing logistics and physical distribution.

Strategic decision making in industrial markets, strategic planning at corporate levels, allocation of resources, portfolio analysis, developing SBU‘S objectives and goals, implementing and controlling marketing plan. Marketing through electronic commerce.

Textbooks/References:

1. Business Market Management Understanding, Creating and Delivering Value by James C. Anderson, Das Narayan das, James A. Narus and D.V. R. Seshadri Pearson, 2010 3rd edition
2. Business Marketing Management b2b By Hutt and Speh South-Western CENGAGE Learning www.cengagebrain.com 2013
3. B2BBrandManagementbyKotlerandPfoertschSpringerwww.springer.com2006
4. Business Marketing: Text and Cases by Krishna K Havaldar, McGraw hill Publications, 2014 4th edition.

NPTEL Platform:

NPTEL Course	Name of Instructor	Host Institute	Link
Business To Business Marketing (B2B)	Prof. J. K. Nayak	IIT Roorkee	Business To Business Marketing (B2B) – Course (nptel.ac.in)

MULTIDISCIPLINARY MINOR

24AF2294MD302A: STOCHASTIC CONTROL

Weekly Teaching Hours	**TH: 03**	**Tu: 1**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

1. To develop skills in building stochastic models using Markov chains.
2. To better understand inventory/production control in light of stochastic models.
3. To develop an understanding of queuing systems under different configurations.
4. To develop skills in analyzing and interpreting the results.

Course Outcomes:

1. To develop skills in analyzing and interpreting the results.
2. Master essential stochastic modeling tools including Markov chains and queuing theory.
3. Be able to formulate and solve problems which involve setting up stochastic models

UNIT I: Random Variables and Stochastic Processes

Random Variables, Probabilistic Concepts Applied to Random Variables, Special Stochastic Process, Covariance Function, Concept of Spectral Density and analysis of Stochastic Process, Gauss–Markov Processes, Gauss–Markov Processes.

UNIT II: Stochastic State Models

Discrete Time Systems, solutions to differential Equations, Continues time systems, Stochastic Integrals, Linear and nonlinear Stochastic Differential Equations, Stochastic Calculus.

UNIT III: Dynamical Systems with Stochastic Process Input

Discrete Time Systems, Spectral Factorization of Discrete Time Processes, Analysis of Continuous Time Systems whose Input Signals Are Stochastic Processes, Spectral Factorization of Continuous Time Processes.

UNIT IV: Parametric Optimization

Evaluation of Loss Functions for Discrete Time Systems, Evaluation of Loss Functions for Continuous Time Systems, Reconstruction of State Variables for Discrete Time Systems, Reconstruction of State Variables for Continuous Time Systems

UNIT V: Stochastic Control and the Linear Quadratic Gaussian Control Problem

Filtering and Estimation, Stochastic Control Problem with Perfect Observation, Stochastic LQ Problems with Perfect Information, Continuous and discrete time LQG Problems

Textbooks/References:

1. Stochastic Processes, Estimation, and Control, - George N. Saridis Wiley, 03-Apr-1995.
2. Introduction to Stochastic Control Theory, Karl J. Åström, Dover Publications

MULTIDISCIPLINARY MINOR

24AF2294MD302B: INDUSTRIAL LOAD MODELLING AND CONTROL

Weekly Teaching Hours	**TH: 03**	**Tu: 1**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

1. To understand Industrial Load Management

Course Outcomes:

1. Understands the Demand Side Management of Electrical Energy.
2. Understand the classification of electricity pricing.
3. Understands Reactive power management in industries.
4. Understands Industrial load profiling.
5. Understands Selection of Schemes Optimal Operating Strategies, Peak load saving, Constraints Problem formulation.

UNIT I

Electric Energy Scenario-Demand Side Management-Industrial Load Management, Load Curves-Load Shaping Objectives, Methodologies-Barriers, Classification of Industrial Loads Continuous and Batch Processes-Load Modelling.

UNIT II

Electricity pricing –Dynamic and spot pricing –Models, Direct load control-Interruptible Load control, Bottom-up approach-Scheduling- Formulation of load Models, Optimization and control algorithms-Case studies.

UNIT III

Reactive power management in industries, controls-power quality impacts, application of filters Energy saving in industries.

UNIT IV

Cooling and heating loads, load profiling, Modelling- Cool storage, Types-Control strategies, Optimal operation, Problem Formulation-Case studies.

UNIT V

Captive power units, Operating and control strategies, Power Pooling- Operation models, Energy banking, Industrial Cogeneration, Selection of Schemes Optimal Operating Strategies, Peak load saving, Constraints Problem formulation-Case study, Integrated Load management for Industries.

Textbooks/References:

1. C.O. Bjork "Industrial Load Management-Theory, Practice and Simulations", Elsevier, the Netherlands,1989

2. C.W. Gellings and S.N. Talukdar. Load management concepts. IEEE Press, New York, 1986, pp. 3-28

3. Y. Manichaikul and F.C. Schweppe, "Physically based Industrial load", IEEE Trans. on PAS, April1981

4. H. G. Stoll, "Leastcost Electricity Utility Planning", Wiley Inter science Publication, USA, 1989.

5. I. J. Nagarath and D. P. Kothari, Modern Power System Engineering., Tata Mc Graw Hill publishers, New Delhi, 1995

6. IEEE Bronze Book "Recommended Practice for Energy Conservation and cost-effective planning in Industrial facilities", IEEE Inc, USA

MULTIDISCIPLINARY MINOR

24AF2294MD302C: ETHICAL HACKING

Weekly Teaching Hours	**TH: 03**	**Tu: 1**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

1. Introduce students to the concept of ethical hacking, its importance in cyber security, and the role of ethical hackers in identifying vulnerabilities.
2. Provide an overview of cyber security principles, threats, and attacks, highlighting the need for ethical hacking to strengthen defences.
3. Teach students a structured approach to hacking, including reconnaissance, scanning, gaining access, maintaining access, and covering tracks.
4. Cover essential network concepts to help students understand how networks function, including protocols, IP addressing, and network architecture.

Course Outcomes:

1. Gain a comprehensive understanding of ethical hacking concepts, methodologies, and its role in enhancing cyber security.
2. Acquire a solid grasp of cyber security principles, types of threats, and the importance of proactive defence strategies.
3. Develop proficiency in various hacking techniques, including reconnaissance, scanning, exploitation, and post-exploitation activities.
4. Perform effective vulnerability assessments on systems and networks, identifying potential security weaknesses and exposures.
5. Demonstrate the ability to conduct penetration tests, simulating real-world attacks to evaluate the strength of security measures.

UNIT I

Introduction to ethical hacking. Fundamentals of computer networking. TCP/IP protocol stack. IP addressing and routing. TCP and UDP. IP subnets. Routing protocols. IP version 6.

UNIT II

Installation of attacker and victim system. Information gathering using advanced google search, archive.org, net craft, who is, host, dig, dnsenum and NMAP tool.

UNIT III

Vulnerability scanning using NMAP and Nessus. Creating a secure hacking environment. System Hacking: password cracking, privilege escalation, application execution. Malware and Virus. ARP spoofing and MAC attack.

UNIT IV

Introduction to cryptography, private-key encryption, public-key encryption. Cryptographic hash

functions, digital signature and certificate, applications. Steganography, biometric authentication, network-based attacks, DNS, and Email security.

UNIT V

Packet sniffing using Wireshark and Burpsuite, password attack using burp suite. Social engineering attacks and Denial of service attacks. Elements of hardware security: side-channel attacks, physical inclinable functions, hardware trojans.

Different types of attacks using the Metasploit framework: password cracking, privilege escalation, remote code execution, etc. Attack on web servers: password attack, SQL injection, cross-site scripting**.**

Textbooks/References:

1. Data and Computer Communications -- W. Stallings.
2. Data Communication and Networking -- B. A. Forouzan
3. TCP/IP Protocol Suite -- B. A. Forouzan
4. UNIX Network Programming -- W. R. Stallings
5. Introduction to Computer Networks and Cyber security -- C-H. Wu and J. D. Irwin
6. Cryptography and Network Security: Principles and Practice -- W. Stalling

NPTEL Platform

NPTEL Course	Name of Instructor	Host Institute	Link
Ethical Hacking	Prof. Indranil Sengupta	IIT Kharagpur	Ethical Hacking Course(nptel.ac.in)

MULTIDISCIPLINARY MINOR

24AF2294MD302D: ARTIFICIAL INTELLIGENCE AND MACHIN LEARNING

Weekly Teaching Hours	**TH: 03**	**Tu: 1**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

1. Apply AI techniques to solve the given problems.
2. Implement trivial AI techniques on relatively large system
3. Explain uncertainty and Problem-solving techniques.
4. Compare various learning techniques.

Course Outcomes:

This course will enable students to

1. Identify the AI-based problems.
2. Apply techniques to solve AI problems.
3. Define learning and explain various logic inferences.
4. Discuss different learning techniques.

UNIT I

Introduction to AI and State space search, Introduction to unguided and guided search

UNIT II

Problems in search and solutions, Genetic algorithms, Neural Networks, BPNN, learning process in BPNN

UNIT III

Some other search methods and Admissibility, Planning, Game Playing

UNIT IV

Mini-max and other game-playing algorithms, using predicate logic for Knowledge Representation

UNIT V

Resolution and non-monotonic reasoning, Strong methods for Knowledge Representation; Fuzzy logic and CD, Scripts and Introduction to Expert systems, Developing expert systems and Machine learning

Text/Reference Books:

1. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach. III Edition
2. E. Rich, K. Knight & S.B. Nair -ArtificialIntelligence,3/e, Mc Graw Hill.
3. Dan W. Patterson, Introduction to Artificial Intelligence and Expert Systems, Prentice Hal of India.
4. G. Luger, ―Artificial Intelligence: Structures and Strategies for Complex Problem Solving‖,

Fourth Edition, Pearson Education, 2002.

5. N. P. Padhy—Artificial Intelligence and Intelligent Systems, Oxford University Press- 2015.

NPTEL Platform

NPTEL Course	Name of Instructor	Host Institute	Link
Artificial Intelligence and Machine Learning	Prof. Bhushan Trivedi	GLS University	https://onlinecourses.swayam2.ac.in/cec21_cs08/preview

MULTIDISCIPLINARY MINOR
24AF2294MD302E: COMPONENTS AND APPLICATIONS OF INTERNET OF THINGS

Weekly Teaching Hours	**TH: 03**	**Tu: 1**		**Credit: 3**
Scheme of Marking	**TH: 60**	**MSE: 20**	**CA: 20**	**Total: 100**

Course Objectives:

1. The objective of this course is to learn about the Basics of IoT, Components of IoT including Sensors and actuators, computing, and communication systems.
2. It will also cover IoT Protocols, Security of IoT, Cloud-based design and AI/Deep learning-based analytics.

Course Outcomes:

1. Identify IoT Components: Recognize and classify key components of IoT systems, including sensors, actuators, communication protocols, and data processing units.
2. Explore IoT Communication: Understand various wireless and wired communication technologies used in IoT networks and their suitability for different application scenarios.
3. Design IoT Applications: Create IoT solutions by integrating hardware and software components, demonstrating proficiency in prototyping, programming, and data handling.
4. Analyse Data from IoT Devices: Collect, analyse, and interpret data generated by IoT devices to extract meaningful insights and support informed decision-making.

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UNIT I: Basics of IoT

Introduction to the Internet of Things, various sensors, and sensing techniques. Technological trends in IoT. Impact of IoT on society. Review of various IoT application domains including agriculture, healthcare, manufacturing, device management, and vehicle-to-vehicle communication and wearable computing devices.

UNIT II: Microcontroller and Interfacing Techniques for IoT Devices

Introduction to IoT and architecture layers, IoT smart devices, Typical embedded computing systems, Introduction to ARM architecture and programming method, Embedded system development: a case study, Introduction to interfacing techniques.

UNIT III: IoT Protocols & Security

Networking and basic networking hardware. Networking protocols, Interaction between software and hardware in an IoT device. IoT components and technologies to secure systems and devices.

Various security issues related to the IoT and security architectures. Hardware security threats and security vulnerabilities; protecting physical hardware

UNIT IV: Location Tracking

Introduction to device localization and tracking; different types of localization techniques: time-of-arrival (TOA) based, time-difference-of-arrival (TDOA) based, angle-of-arrival (AOA) based,

received signal strength (RSS) based, Radio-Frequency Identification (RFID) based and fingerprinting based; Monte-Carlo tracking; Kalman filter based tracking; Cramer- Rao lower bound (CRLB) for device location estimator; Device diversity/heterogeneity issue in IoT networks.

UNIT V: Deep learning for IoT

This topic will focus on how to build a good model from past data to predict correctly when the system is provided with a data point. In this course, mostly, supervised learning will be considered. The basics of neural networks, activation functions, back-propagation, etc. will be covered. At the end, some of the challenges in the context of IoT will be mentioned.

IoT Applications

Smart grid: Introduction to smart grid, Integration of IoT into smart grid, Standardization activities for IoT aided smart grid, Applications of IoT aided smart grid, Architectures for IoT sided smart grid, Prototypes, Applications of big data and cloud computing, Open Issues, and Challenges. IoT-based Smart Home and Nano-grid Monitoring System

Sensor-Controller Coordination of a DC Microgrid in IoT Platform, Cyber-physical system, dc microgrid, DC-DC power converter, distributed energy generator, sensor control and controller design. Low-cost DC Nano-grid with Smart Remote Monitoring Unit, DC-DC converter modelling, closed-loop control, placement of IoT devices, sensors, microgrid, solar energy, and low-cost communication system design. Introduction, objective, components of the home monitoring system, control, and management, Zigbee, Wireless Sensor Network (WSN), Internet of Things (IoT).

Internet of Robotic Things (IoRT): Introduction to stationary and mobile robots; Brief introduction to localization, mapping, planning, and control of robotic systems; Introduction to cloud-enabled robotics; Applications of IoT in robotics; Architectures for IoRT; Examples and case studies; Open issues and challenges.

Textbooks/References:

It will be provided in each of the lecture sessions. (Refer NPTEL platform)

NPTEL Course	Name of Instructor	Host Institute	Link
Components And Applications of Internet of Things	Dr. Sanjoy Kumar Parida	Indian Institute of Technology Patna	https://onlinecourses.swayam2.ac.in/arp20_ap03/preview

24AF2294SE303: INTERNSHIP

Weekly Teaching Hours	**TH: --**			**Credit: 6**
Scheme of Marking	**TH: --**	**IA: 50**	**OR/PR: 50**	**Total: 100**

Course Outcomes:

1. Able to develop a sound theoretical and practical knowledge of new technologies.
2. Able to develop domain-specific problem-solving and critical-thinking skills
3. Able to develop individual responsibility towards their internship goal as well as participate as an effective team member
4. Gain exposure to professional work culture & practices
5. Able to develop effective presentation & communication skills and create proper documentation of the work.

24AF2294SE304: SEMINAR-II

Weekly Teaching Hours	**TH: --**			**Credit: 2**
Scheme of Marking	**TH: --**	**IA: 50**	**OR/PR: 50**	**Total: 100**

The seminar shall be on the state of the art in the area of the advanced communication of student ‘s choice approved by an authority. The student shall submit the duly certified seminar report in standard format, for satisfactory completion of the work duly signed by the guide and head of the Department/Institute concerned.

24AF2294PR305: PROJECT-I

Weekly Teaching Hours	**TH: --**	**PR: 4Hr**		**Credit: 6**
Scheme of Marking	**TH: --**	**IA: 50**	**OR/PR: 50**	**Total: 100**

Project I is an integral part of the final project work. In this, the student shall complete the partial work of the project which will consist of a problem statement, literature review, project overview, scheme of implementation that may include mathematical model/SRS/UML/ERD/block diagram/ PERT chart, and layout and design of the proposed system/work. As a part of the progress report of project-I work; the candidate shall deliver a presentation on the progress of the work on the selected dissertation topic.

It is desired to publish the paper on the state of the art on the chosen topic in an international conference/ journal.

The student shall submit the duly certified progress report of project-I in standard format for satisfactory completion of the work duly signed by the concerned guide and head of the department/institute.

24AF2294PR401: PROJECT- II

Weekly Teaching Hours	**TH: --**	**PR: --**		**Credit: 20**
Scheme of Marking	**TH: --**	**IA: 100**	**OR/PR: 100**	**Total: 200**

In Project - II, the student shall complete the remaining part of the project which will consist of the simulation/ analysis/ synthesis/implementation/fabrication of the proposed project work, workstation, conducting experiments and taking results, analysis and validation of results and concluding.

It is mandatory to publish the paper on the state of the art on the chosen topic in an international conference/ journal.

The student shall prepare the duly certified final report of project work in standard format for satisfactory completion of the work duly signed by the concerned guide and head of the department/institute.