6th Semester B.Tech.

(Electrical Engineering)

Detailed SYLLABUS:

Sixth Semester (Electrical Engineering)					
Theory					
Sl. No.	**Category**	**Course Code**	**Course Title**	**L-T-P**	**Credit**
1	PCC	19EE6PC01T	PCC-9: Electric Drives	3-0-0	3
2	PCC	19EE6PC02T	PCC-10 :Power System Operation and Control	3-0-0	3
3	BSC	19CM6BS01T	Optimization Engineering	3-1-0	4
4	PEC	**Professional Electives-2**			
		19EE6PE01T	Modeling and Control of Power Electronic Systems	3-0-0	3
		19EE6PE02T	High Voltage Engineering and HVDC Transmission		
		19EE6PE03T	Utilization of Electrical Energy		
		19EE6PE04T	Advance Control System Engineering/		
5	PEC	**Professional Electives-3**		3-0-0	3
		19EE6PE05T	Electrical Machine Design		
		19EE6PE06T	Robotics and Autonomous Vehicles		
		19EE6PE07T	Industrial Automation and Control		
		19EE6PE08T	Electric and Hybrid Vehicle		
6	OEC	**Open Electrive-1(Other Branch)**		3-0-0	3
		19EE6OE01T	Electrical Energy Utilization		
		19EE6OE02T	Introduction to Robotics and Autonomous Vehicles		
		Open Electrive-1(for Electrical Engineering)			
		19EC6OE01T	Fundamentals of Satellite Communication		
		19EC6OE02T	Image Processing Technique		
		19CE6OE01T	Plastic Waste Management		
		19ME6OE1T	Applied Mechanics		
		19ME6OE3T	Numerical Methods for Engineers		
		19CS6OE01T	Data Analytics		
		19EE6PE07T	Introduction to Operating Systems		

Total Credit (Theory)					**19**
Practical					
1	PCC	19EE6PC01L	Electric Drives Lab	0-0-2	1
2	PCC	19EE6PC02L	Power System Operation and Control Lab	0-0-2	1
3	PSI	19CM6PS01L	Research/Lab based Project	0-0-3	2
4	HS	19CM6HS01L	Business Communication & Interview Skills	0-0-3	2
Total Credit (Practical)					**6**
Total Semester Credit					**25**

Course Code:	Course Name:	L-T-P	Credit
19EE6PC01T	Electric Drives	3- 0- 0	3

COURSE OBJECTIVES:

1. To study the fundamentals & background on Electrical Drives, and control of electrical drives their power ratings.
2. Equip the student with the basic knowledge on Induction motor drives, its control and use in industrial applications.
3. Provide a foundation in the theory and applications of Synchronous Motor Drives with respect to their control.
4. Understand the applicability of Ac drives, DC drives in the field of electrical Traction and on the specific applications.

SYLLABUS:

Module- I Fundamental of Electric Drives (8 Hours)

Electrical Drives Introduction, block diagram, parts of the electrical drives, Choice of electrical Drives, Nature and Classification of Load Torques, Advantages of Electrical Drives. Fundamentals of Torque Equations, Speed Torque Conventions and Multi-quadrant Operation, Equivalent Values of Drive Parameters, Components of Load Torques, Calculation of Time and Energy Loss in Transient Operations, Steady State Stability, Load Equalization, Control of Electrical Drives. Thermal Model of Motor for Heating and Cooling, Classes of Motor Duty, Determination of Motor Rating.

Module- II Controlled Fed DC Drives (6Hours)

DC Motors and their Performances, Starting, Braking, Transient Analysis, Speed Control, Methods of Armature Voltage Control,Single – phase fully controlled rectifier control of DC separately excited Motor, Single – phase semi controlled rectifier control of DC separately excited Motor, Three – phase fully controlled rectifier control of DC separately excited Motor, Three – phase semi controlled rectifier control of DC separately excited Motor, Rectifier control of dc Series Motor. Supply Harmonics, Power Factor and Ripple in Motor Current. Multi Quadrant operation of dc separately excited Motor fed from Fully- controlled rectifier.

Module- III **(4Hours)**

Chopper Control of Separately Excited dc Motors, Chopper Control of Series Motor, Multi Quadrant operation of dc separately excited Motor fed from Fully- controlled rectifier.

Module- IV Induction Motor Drives and Synchronous Motor Drives: (10 Hours)

Speed Control, Pole Changing, Pole Amplitude Modulation, Stator Voltage Control, Variable Frequency Control from Voltage Source, Voltage Source Inverter Control, Variable Frequency Control from Current Source, Current Source Inverter Control, Current Regulated Voltage Source Inverter Control, Rotor Resistance Control, Slip Power Recovery.

Synchronous Motor Variable Speed Drives, Variable Frequency Control of Multiple Synchronous Motors, BLDC motor and switch reluctance motor.

Module- V Electrical Traction and Drives for specific Application (8 Hours)

System of electric traction Mechanics of Train Movement: Speed- time, distance- time and simplified speed-time curves, Attractive effort for acceleration and propulsion, effective weight, train resistance, adhesive weight, specific energy output and consumption.

Textile Mills, Steel Rolling Mills, Cranes and Hoist Drives, Cement Mills. Application Areas and Functions of Microprocessors in Drive Technology.

COURSE OUTCOMES:

After completion of this course the students will be able to:

1. Calculate the Drive parameter, their steady state stability, determination of motor power rating, design of thermal model of the electrical drive.
2. Articulate power electronics applications in control of Dc motors with their transient analysis by dc converters.
3. Understand the speed control methods of Induction motors, and able to calculate the various parameters of Induction motor drives with respect to their control strategy
4. Understand importance of electric drives in electrical traction and other applications

TEXT BOOKS:

1. G. K. Dubey, *Fundamentals of Electrical Drives*, Narosa Publishing House, New Delhi , 2001

2. N. K. De and P. K. Sen, *Electric Drives*, PHI Learning Pvt. Ltd., New Delhi , 1999
3. V. Subrahmanyam, *Electric Drives: Concepts and Applications*, New Age International, New Delhi , 2005

REFERENCE BOOKS:

1. Power Electronics-Md.H.Rashid –Pearson Education Third Edition- First IndianReprint- 2008
2. Power Electronics- Ned Mohan, Tore M.Undelan and William P.Robbins –John Wiley& Sons -2nd Edition.
3. Power Converter Circuits – William Shepherd & Li Zhang-Yes Dee Publishing Pvt. Ltd.

ONLINE LEARNING RESOURCES:

Course Name	Fundamentals of Electric Drives
Course Link	https://nptel.ac.in/courses/108/104/108104140/
Course Instructor	Prof. Shyama Prasad Das, Indian Institute of Technology Kanpur

Course Code:	Course Name:	L-T-P	Credit :
19EE6PC02T	Power System Operation and Control	3-0-0	3

COURSE OBJECTIVES:

1. Understand the basic operating states of electrical power system and complex power in single-phase and three-phase AC circuits.
2. Provide a solid foundation in per-unit representation of power system variables and to develop computer programs to perform load flow analysis on a power system of any size.
3. Learn basic knowledge in the area of economic dispatch of power, unit commitment and various generation dispatching schemes.
4. Develop the mathematical and engineering fundamentals required to model single area and two area load frequency control schemes on a power system and analyse their steady state and dynamic response using simulation tools.
5. Comprehend power system stability problem, understand the solution methods of swing equation, and recognize various applications of equal-area criterion.

SYLLABUS:

Module- I **(6 Hours)**

Fundamentals of Power Systems: Historical development of electric power system, structure of power system, operating states of power system, subscript notation, power in single-phase AC circuit, complex power, power triangle, voltage, current and power in balanced three-phase circuits, single-line diagram, impedance and reactance diagrams.

Module-2:(8 Hours)

Steady-State Analysis: Load flow problem, primitive network model, network matrices, bus admittance matrix (Y_{BUS}), sparsity, properties of Y_{BUS}, step-by-step and singular transformation method for the development of Y_{BUS}, effect of mutually coupled branches on Y_{BUS}, modeling of regulating transformer, steady-state load flow equation, classification of buses, Gauss-Seidal method, Newton-Raphson method, fast decoupled method, comparison of load flow methods.

Module-3:(8 Hours)Economic Load Dispatch and Unit Commitment: Economic dispatch

problem and its constraints, performance curves, generation cost, economic dispatch (i) neglecting losses as well as generator limit and (ii) neglecting losses and including generator limit, transmission loss equation in terms of plant generation, economic dispatch considering transmission loss, need for unit commitment, dynamic programming method for the solution of unit commitment.

Module-4:(9 Hours)

Automatic Generation Control: Automatic voltage regulator and automatic load frequency control (ALFC) loops, governor characteristics, adjustment of governor characteristics of parallel operating alternators, modeling of speed governing and its steady-state performance, generator-load model, closing the ALFC loop, response of primary ALFC loop, secondary ALFC loop, block diagram representation of two-area system, modeling of tie-line, response of two-area system, Reactive Power and voltage control, Automatic voltage Regulator

Module-5:(8 Hours)

Power System Stability: The stability problem- Steady state stability, transient stability and Dynamic stability-Swing equation. Equal area criterion of stability-Applications of Equal area criterion, Step-by-step solution of swing equation-Factors affecting transient stability, Methods to improve steady state and Transient stability, Introduction to voltage stability.

COURSE OUTCOMES:

After completion of this course the students will be able to:

1. Recall the fundamental concepts such as subscript notation, complex power in single-phase as well as balanced three-phase AC circuit and the concepts of per-unit impedance diagram representation of three-phase power system components.
2. Formulate bus admittance matrix to compute the load flow solution using different iterative methods.
3. Appreciate the theory for the economic operation of thermal power stations and compute optimal solution through unit commitment and economic load dispatch considering transmission losses.

4. Design the mathematical models of the various components involved in power system operation and understand the open loop and closed loop control practices associated with the frequency control of the single area as well as two-area power systems.
5. Recognize the concepts of power system stability analysis using equal area criterion method and apply numerical solutions to swing equations.

TEXT BOOKS:

1. Power System Analysis, HadiSaadat, TMH, 2002 Edition, Eighth Reprint.
2. An Introduction to Electric Energy System Theory, O. I. Elgard, TMH, Second Edition.
3. Power System Analysis, John. J. Grainger and W. D. Stevenson, Jr. – TMH, 2003 Edition, Fifteenth Reprint.

REFERENCE BOOKS:

1. Power System Analysis Operation and Control, A. Chakrabarti and S. Haldar, Third Edition, PHI Publications, Sixth Reprint, 2010.
2. Power Generation, Operation, And Control, Allen J Wood Bruce F. Wollenberg, Gerald B. Sheble Third Edition, WILEY Publication.

ONLINE LEARNING RESOURCES:

Course Name	Power system Operation and Control
Course Link	https://nptel.ac.in/courses/108/104/108104052/
Course Instructor	Prof. S.N. Singh, Indian Institute of Technology Kanpur

Course Code:	Course Name:	L-T-P	Credit :
19EE6BS01T	Optimization Engineering	3-0-0	3

COURSE OBJECTIVES:

1. To understand the theory of optimization methods and algorithms developed for solving various types of optimization problems.
2. To develop and promote research interest in applying optimization techniques in problems of Engineering and Technology.
3. To apply the mathematical results and numerical of optimization theory to different Engineering problems.

SYLLABUS:

Module-1:Introduction: (8Hours)

Idea of Engineering optimization, Classification of optimization Problems, Optimization Problem and Model Formulation.Linear programming: Formulation of LPP, Simplex method, Big-M method, Two-phase Method, Dual Simplex method, Sensitivity analysis in linear programming.

Module-2: (8Hours)

Transportation problems: Finding an initial basic feasible solution by Northwest Corner rule, Vogel's approximation method, Degeneracy, Optimality test, MODI method, Stepping stone method.

Assignment problems: Hungarian method for solution of Assignment Problems

Integer Programming: Integer Programming, Mixed Integer Programming, Branch and Bound method.

Module-3: (10 Hours)

Non-linear programming: Introduction to non-linear programming. Constrained optimization, Multivariable optimization: Method of Lagrange Multipliers, Kuhn-Tucker condition.

Unconstraint optimization: Powell's Method, Steepest Descent (Cauchy) Method, Conjugate Gradient (Fletcher-Reeves) Method, Newton's Method.

Module-4: (8Hours)

Game Theory: Concept, Game models, two persons zero sum games and their solution, Pure & Mixed Strategy, solution of 2Xn and mX2 games by graphical approach.

Dexcision Theory: Concept, Decision under risk (EMV) & uncertainty**.**

Module-5: (8Hours)

Queuing models: General characteristics, Markovian queuing model, M/M/1model, Limited queue capacity, multiple server, Finite sources, Queue discipline.

COURSE OUTCOMES:

After completion of this course the students will be able to:

1. Understand importance of optimization of industrial process management.
2. Apply basic concepts of mathematics to formulate an optimization problem.
3. Analyses and appreciate variety of performance measures for various optimization problems

TEXT BOOKS:

1. S. S. Rao, *Engineering Optimization*, New Age International Publications.
2. A. Ravindran, D. T. Philips, J. Solberg, *Operations Research- Principle and Practice*, Second edition, Wiley India Pvt Ltd.
3. H.A.Taha, A.M.Natarajan, P.Balasubramanie, A.Tamilarasi, *Operations Research*, Pearson Education, Eighth Edition.

REFERENCE BOOKS:

1. S.D.Sharma, *Operations Research*, Kedarnath Publications.
2. F.S.Hiller, G.J.Lieberman, *Operations Research*, Tata McGraw Hill.
3. P.C.Biswal,*Optimization Engineering*, Scitech Publications
4. Prem Kumar Gupta, D.S.Hira, *Operations Research*, S.Chand Publications.

ONLINE LEARNING RESOURCES:

Course Name	Optimization Engineering
Course Link	https://nptel.ac.in/courses/111/105/111105039/
Course Instructor	Prof. A. Goswami, Indian Institute of Technology Kharagpur

Course Code:	Course Name:	L-T-P	Credit :
19EE6PE01T	Modelling and Control of Power Electronics Systems	3-0-0	3

COURSE OBJECTIVES:

1. Understand various methods to analyze power electronics circuits and Systems.
2. Understand the concept of Modeling of switching power converters for nonlinear dynamical analysis.
3. To develop the concept of Nonlinear control of dc/dc Converters

SYLLABUS:

Module-1: Modeling:(8Hours)

Steady state analysis of dc/dc and dc/ac converters, dynamic analysis of converters, state space average modeling, PWM switch modeling and discrete time modeling, modeling of dc/dc converters operating in discontinuous conduction mode, dc/dc and dc/ac converters transfer functions.

Module-2: Overview of dc/dc power electronics circuits:(8Hours)

Voltage-mode control, current-mode control, complexity of operation, complex behavior in power electronics computer and laboratory techniques for studying nonlinear behavior in switching power converters.

Module-3:(10 Hours)

Modeling of switching power converters for nonlinear dynamical analysis: Discrete-time modeling, general procedure for derivation of discrete-time iterative maps, method of averaging analysis of period-doubling bifurcation – CCM and DCM operations, smooth versus non-Smooth bifurcations, nonlinear dynamics of free-running converter systems, fast-scale analysis of power-factor-correction boost converters, intermittent chaotic operation in switching power converters.

Module-4: Nonlinear control of dc/dc Converters:(9 Hours)

Practical design of conventional hysteresis modulation-based sliding mode controllers for power converters, General approach of deriving fixed-frequency PWM-based sliding mode controller for power converters in discontinuous conduction mode, Design and implementation of fixed-frequency PWM-based sliding mode controller for power converters, Model predictive control of

converters and inverters systems

Module-5: Control of power inverters:(9 Hours)

Power Quality Control - Current H8 repetitive control, voltage and current h8 repetitive control, Voltage H8 repetitive control with a frequency-adaptive mechanism, Voltage H8 repetitive control with a frequency-adaptive mechanism, Control of inverter output impedance, Power Flow Control-Current proportional–integral control, Current proportional-resonant control, Robust droop control with improved voltage quality, Synchronisation Conventional synchronisation techniques, Sinusoid-locked loops.

COURSE OUTCOMES:

After completion of this course the students will be able to:

1. Gain skills to understand operational issues and limitations of practical converters in industrial applications.
2. Acquired knowledge on practical design of nonlinear controller of dc-dc converters.
3. Gain knowledge on the control of power inverters.

TEXT BOOKS:

1. John G. Kassakian, Martin F. Schlecht, George C. Verghese, *Principles of Power Electronics*, Addison-Wesley Series
2. Qing-Chang Zhong, Tomas Hornik, *Control of Power Inverters in Renewable Energy and Smart Grid Integration*, Wiley-IEEE Press

REFERENCE BOOKS:

1. S.C. Tan, Y.M. Lai and C.K. Tse, *Sliding Mode Control of Switching Power Converters: Techniques and Implementation*, Boca Raton: CRC Press
2. Soumitro Banerjee and George C. Verghese, *Nonlinear Phenomena in Power Electronics: Bifurcations, Chaos, Control, and Applications*, Wiley-IEEE Press.

ONLINE LEARNING RESOURCES:

Course Name	Fundamentals of Power Electronics

Course Link	https://onlinecourses.nptel.ac.in/noc21_ee01/preview
Course Instructor	Prof. L Umanand, Indian Institute of Science Bangalore

Course Code:	Course Name:	L-T-P	Credit :
19EE6PE02T	High Voltage Engineering and HVDC Transmission	3-0-0	3

COURSE OBJECTIVES:

1. To understand the basic concepts and properties of Solid, Liquid and Gaseous insulation.
2. To understand the basic concept of High Voltage and Current generation and their measurements and testing.
3. To understand the operation of HVDC conversion technology and power control techniques
4. To identify factors affecting AC-DC transmission

SYLLABUS:

Module-1: Introduction:(9 Hours)

Design, planning and layout of H.V. laboratories Conduction and breakdown in Gaseous Dielectrics: Townsend's current growth equation, current growth in the presence of secondary processes, and streamer theory of breakdown in gases. Breakdown in non-uniform fields and corona. Conduction and Breakdown in Liquid dielectrics: Pure liquids and commercial liquids, conduction and breakdown in commercial liquids. Breakdown and pre-breakdown phenomena in solid Dielectrics: Intrinsic breakdown, electromechanical breakdown, thermal breakdown.

Module-2: Generation of High voltages:(10 Hours)

Generation of high D.C. voltage, high A.C. voltage, impulse voltage, impulse current, tripping and control of impulse generators. Measurement of high voltages and current: Measurement of high D.C., A.C. and impulse. Measurement of D.C. resistivity, dielectric constant and loss factor, partial discharge and Condition monitoring. H.V. Testing of Electrical Apparatus: Testing of insulators, bushings, isolators, circuit breakers, cables, transformers, and surge diverters.

Module-3: HVDC Transmission System:(7 Hours)

DC Power Transmission Technology: Introduction, Comparison of AC and DC Transmission, Application. Analysis of HVDC Converters: Choice of converter configuration, Graetz circuit, Convertor bridge characteristics, Characteristics of a twelve pulse converters, Converter

Module-4: HVDC system Control:(9 Hours)

Principles of DC Link control, Converter control characteristics, System control hierarchy Firing angle control, current and extinction angle control, Starting and stopping of DC link, Power Control. Smoothing Reactor and DC Line: Smoothing reactors, DC Line, transient over voltages in DC Line, Protection of DC line, DC breakers, Monopolar operation, Effects of proximity of AC and DC Transmission lines. Reactive Power Control: Reactive power requirements in steady state, Sources of reactive power, Static var systems, Reactive power control during transients.

Module-5: Harmonics and Filters:(8Hours)

Generation of Harmonics, Design of AC Filters, DC Filters, Carrier frequency and RI noise.Multiterminal DC systems: Potential applications of MTDC systems, Types of MTDC systems, control and protection of MTDC systems, Control and protection of MTDC Systems study of MTDC systems.

COURSE OUTCOMES:

After completion of this course the students will be able to:

1. Students will be able to understand the basic concepts and properties of Solid, Liquid and Gaseous insulation
2. Students will be able to understand the High Voltage and Current generation and measurements and high voltage testing techniques.
3. Students will be able to assess the degree of adequacy level in HVDC transmission.
4. Students can analyze problem related to HVAC and HVDC transmission system.
5. Students will understand the operation of HVDC conversion technology and power control techniques.

TEXT BOOKS:

1. M. S. Naidu and V. Kamaraju, *High Voltage Engineering*, Tata McGraw Hill , 1995
2. E.W. Kimbark, *Direct Current Transmission-vol.1*, Wiley Inter science, New York , 1971

REFERENCE BOOKS:

1. J. Kuffel and W. S. Zaengl, *High Voltage Engineering: Fundamentals*, Newnes , 2000

2. J. Arrillaga, *HVDC Transmission*, IET, peter pereginver Ltd., London, U.K , 1998

ONLINE LEARNING RESOURCES:

Course Name	High Voltage DC Transmission
Course Link	https://nptel.ac.in/courses/108/104/108104013/
Course Instructor	Prof. S.N. Singh, Indian Institute of Technology Kanpur
Course Name	High Voltage Engineering
Course Link	https://nptel.ac.in/courses/108/104/108104048/
Course Instructor	Prof. RavindraArora,Indian Institute of Technology Kanpur

Course Code:	Course Name:	L-T-P	Credit :
19EE6PE03T	Utilization of Electrical Energy	3-0-0	3

COURSE OBJECTIVES:

1. To understand the basic concepts of illumination systems
2. To understand the basic concept of design of lighting schemes
3. To understand the fundamental requirements of railway electrification
4. To understand the operation of refrigeration and air-conditioning control technique

SYLLABUS:

Module-1Illumination:(8Hours)

Production of light - lighting calculations - determination of MHCP and MSCP - Polar curves of different types of sources - Rousseau's construction - photometers - interior and exterior illumination systems - lighting schemes - Design of lighting schemes - factory lighting - flood lighting - electric lamps - gaseous discharge lamps - high pressure and low pressure neon signs - high frequency, low pressure discharge tubes.

Module-1 Electric furnaces and welding:(7 Hours)

Resistance, inductance and Arc Furnaces - Construction and fields of application - control equipment, high frequency dielectric heating, resistance - welding equipment - characteristics of carbon and metallic arc welding - butt welding - spot welding.

Module-3 Electro-chemical processes:(4 Hours)

Electrolysis – Electroplating – Electro deposition – Extraction of metals Current, Efficiency - Batteries – types – Charging Methods.

Module-4 Electric traction:(8Hours)

Railway electrification – definition and analysis of traction effort – speed – time curve – traction motors - battery driven vehicles - energy efficiency drives – advanced speed control measures-tractive effort calculations - electric braking - control wire - A.C. traction - recent trend in electric traction.

Module-5 Refrigeration and air-conditioning: (7 Hours)

Control of temperature - basic wiring diagram - simple heat load and motor calculations. Air-

conditioning - function of complete air conditioning system - type of compressor motor and fan motor-wiring diagram for a typical air conditioning unit.

COURSE OUTCOMES:

After completion of this course the students will be able to:

1. Understand the basic concepts of illumination systems and concept of design of lighting schemes.
2. Understand the construction and fields of application of resistance, inductance and arc furnaces.
3. Assess the degree of adequacy level in electro-chemical processes in Industry.
4. Analyze problem related to railway electrification.
5. Understand the operation of refrigeration and air-conditioning control techniques.

TEXT BOOKS:

1. S. C. Tripathy, *Electric Energy Utilisation and Conservation*, Tata McGraw Hill , 1991
2. W. F. Stocker and J.W. Jones, *Refrigeration & Air Conditioning Refrigeration & Air Conditioning*, McGraw Hill , 1985

REFERENCE BOOKS:

1. C. L. Wadhwa, *Generation, Distribution and Utilization of Electrical Energy*, New Age , 1989
2. N.V. Suryanarayana, *Utilisation of Electric Power*, Wiley Eastern Ltd. , 1993

ONLINE LEARNING RESOURCES:

Course Name	Illumination Engineering
Course Link	https://nptel.ac.in/courses/108/105/108105060/
Course Instructor	Prof. N.K.Kishore, Indian Institute of Technology Kharagpur

Course Code:	Course Name:	L-T-P	Credit :
19EE6PE04T	Advance Control System Engineering	3-0-0	3

COURSE OBJECTIVES:

The objectives of this subject are to

1. Consolidate fundamental knowledge of state space and state feedback
2. How to get the transient response of a system represented in state space form
3. How to design using pole placement technique, state observers
4. Study the stability of Non Linear and Linear systems
5. Equip the students with the basic knowledge of discretization, canonical forms for digital control systems, design the controller and observer for digital control systems
6. Make students understand the optimal control problems and their types, liner regulator and tracking systems

SYLLABUS:

Module-1:State Space Representation: (8 Hours)

Introduction, State-space representations of discrete-time systems, Solving discrete-time state-space equations, Pulse transfer function matrix, Discretization of continuous time state space equations, Linearization of non-linear system.

Module-2:State Space approach to Control System Design:(8 Hours)

Eigenvalues and Eigenvectors, Different methods of calculations the state transition matrix, Controllability and Observability, state feedback control, pole placement through state feedback, State feedback with integral control, Observer design, Reduced order observer.

Module-3: Digital Control: (8 Hours)

Introduction to discrete time systems, Introduction, Stability analysis of closed-loop systems in the z-plane, Sample and Hold, Z-transform, State variable analysis of digital control systems

Module-4: Nonlinear Control and Stability Analysis:(10 Hours)

Introduction to Nonlinear systems and their properties, Common Non-linearities, Describing functions, Phase plane method, Basic concepts, stability theorems, Lyapunov functions for LTI systems Nonlinear Control System Characteristics of nonlinear systems, common nonlinearities,

phase plane, describing function, Concept of limit Cycles.

Module-5: Optimal Control:(8 Hours)

Introduction, Optimal control problems, Mathematical procedures for optimal control design: Continuous time linear quadratic regulator (LQR),Pontryagin's optimum policy, Bang-Bang Control, Hamilton-Jacobi Principle.

COURSE OUTCOMES:

At the end of the course, students will be able to

1. Construct the state space model for the given linear and nonlinear dynamical systems and apply linearization techniques when appropriate
2. Solve the state space dynamical systems to get the transient response with different inputs.
3. Define and explain the basic properties of linear systems such as controllability, observability.
4. Design pole placement controller and/or observer for the given system to achieve desired specifications, design the full order and reduced order observer
5. Check the stability of the dynamical systems using Lyapunov method
6. Understand mathematical models of linear discrete-time control systems using transfer functions and state-space models
7. Design controllers and observers for linear discrete-time control systems so that their performance meet specified design criteria
8. Identify various optimal control problems with performance measure with minimum time, minimum fuel, minimum energy, terminal cost and general problems.
9. Derive linear quadratic optimal controllers for scalar systems, and evaluate how design parameters influence the closed-loop system properties
10. Study the nonlinear system behaviour by phase plane and describing function methods

TEXT BOOKS:

1. K.Ogata, *Modern Control Engineering*, Pearson

2. G. F. Franklin, J.G. Powell and M.L. Workman, , *Feedback Control of Dynamic Systems*, Pearson Higher Education

REFERENCE BOOKS:

1. M. Gopal, *Digital Control and State Variable Methods*, Tata McGraw-Hill
2. S.H. Zak, *Systems and Control*, Oxford Univ. Press
3. D.S.Naidu, Optimal control systems, CRC press, 2002.

ONLINE LEARNING RESOURCES:

Course Name	Advance Control System Engineering
Course Link	https://nptel.ac.in/courses/108/103/108103007/
Course Instructor	Prof. SomanathMajhi, Indian Institute of Technology Guwahati

Course Code:	**Course Name:**	**L-T-P**	**Credit :**
19EE6PE05T	Electrical Machine Design	3-0-0	3

COURSE OBJECTIVES:

1. To impart knowledge on the materials used for the designing the electrical machines like transformers, induction machines and DC machine
2. To impart knowledge on the principle of design of electrical machines like transformers.
3. To understand the basic design of induction machines and DC machine

SYLLABUS:

Module-1: Materials used in electrical equipment (8 Hours)

Review of electrical conducting materials, Various characteristics and comparison between conducting materials, Materials of high conductivity and high resistivity Magnetic materials:Classification ,characteristics and application of magnetic materials, Materials for steady flux (solid core materials), materials for pulsating fluxes (laminated core materials sheet), Special purpose alloys ,hot rolled and cold rolled steel sheets, sintered power core, Magnetic materials used in transformers, dc machines and ac machines, Insulating materials,Classification ,characteristics ,application, Insulating materials for transformers, dc machines and ac machines, ceramics, Heating and cooling of electric machine.

Module-2:DC Machine Design (9 Hours)

Armature Winding, Lap and wave winding, Design Approach: Output equation, choice of average gap density, choice of ampere conductors per meter, Choice of no of poles in DC machine, pole proportions, Selection of length of air gap, Choice of armature windings, no of armature conductors, no of coils, no of armature slots, armature conductor selection, Design of commutator, design of brushes, design of compensating winding, Evaluation of operating characteristics from design data.

Module-3:Transformer Design (13 Hours)

Review of transformer theory, Types of transformer : Power transformer, distribution transformer, core type and shell type, Design approach, Output equations (single and three phase), Volt per turn, Design of core(square core, stepped and cruciform core), Choice of flux

density, Design of winding and choice of current density, Design of insulation, Design of window and window space factor, Design of yoke, Calculation of operating characteristics from design data, Resistance of winding, leakage reactance of winding in core type transformer, iron loss, copper loss, efficiency, regulation., Design of cooling system, Temperature rise in plain walled tank, design of tank and tubes.

Module-4:Three phase induction motor design (10 Hour)

Review of three phase induction motor theory, Construction and principle of three phase induction motor, Various types of three phase stator winding, Design approach:, Output equation, choice of magnetic and electric loading, Choice of stator winding. stator slots and insulation, stator teeth , stator teeth, stator core and stator stamping dimension, Air gap length, rotor design (squirrel cage and slip ring type), Leakage inductance, evaluation of equivalent circuit parameters and operating characteristics from design data.

Module-5: Design of Three Phase Synchronous Machines: (6Hour)

Output Equation, Choice of Specific Loadings, Short Circuit Ratio, Main Dimensions of Stator. Design of stator slots and Winding.Design of Salient and non- salient Pole Rotors.Magnetic Circuit and Field Winding. Revised Bloom's Taxonomy Level L3 – Applying, L4 – Analysing. L2 – Understanding, L4 – Analysing.

COURSE OUTCOME:

After completion of this course the students will be able to:

1. Student will understand the detail design of core type power and distribution transformer.
2. Student will understand thedetail design of three phase induction motor.

TEXT BOOKS:

1. K. Sawhney, A course in Electrical Machine Design, DhanpatRai& Co. New Delhi. 6thEdition, 2013.
2. M.G.Say, Performance and Design of Ac Machines, Pitman Pub.
3. M.G. Say "Performance and design of DC Machines", Pitman Pub.

REFERENCE BOOKS:

1. M. V. Deshpande, “Design and Testing of Electrical Machines”, Wheeler Publishing.
2. R. K. Agarwal, “Principles of Electrical Machine Design”, Essakay Publications, Delhi.
3. Ramamoorthy M, “Computer Aided Design of Electrical Equipment”, East-West Press.
4. M. N. O. Sadiku, “Numerical techniques in Electromagnetics”, CRC Press Edition-2001.

ONLINE LEARNING RESOURCES:

Course Name	Modeling and Analysis of Electrical Machines
Course Link	https://nptel.ac.in/courses/108/106/108106023/
Course Instructor	Prof. Krishna Basudevan, Indian Institute of Technology Madras

Course Code:	**Course Name:**	**L-T-P**	**Credit :**
19EE6PE06T	Robotics and Autonomous Vehicles	3- 0- 0	3

COURSE OBJECTIVE:

1. Gain basic knowledge on control and designof robotic system and it applications to solve common human society problems
2. Will able to gain knowledge on sensor technology and computer vision
3. Knowledge on autonomous vehicle technology
4. Will generate fundamental knowledge needed for the future technological advances that will able to drive the economic engines of the society.

SYLLABUS:

Module-1:

Introduction and Overview of Robotic Systems and their Dynamics (12Hours)

Introduction.Construction of manipulators, advantages and disadvantages of various kinematicstructures. Applications, Nonservo robots, motion planning. Feedback systems, encoders Kinematics,homogeneous coordinates solution of the inverse kinematic problem, multiple solutions, jacobian, workenvelopes.

Trajectory planning. Joint Interpolated Trajectory, Link joints and their Manipulatordynamics and force control. Sensors: Vision, ranging, laser, acoustic, tactile.

Module-2: Evolution of Automotive Electronics (8 Hours)

Basic Control System Theory applied to Automobiles -Overview of the Operation of ECUs - Infotainment, Body, Chassis, and Powertrain Electronics-Advanced Driver Assistance Systems-Autonomous Vehicles

Module-3: Sensor Technology for Autonomous Vehicles (8 Hours)

Basics of Radar Technology and Systems -Ultrasonic Sonar Systems -LIDAR Sensor Technology and Systems -Camera Technology -Night Vision Technology -Use of Sensor Data Fusion -Kalman Filters.

Module IV: Computer Vision and Deep Learning for Autonomous Vehicles (7 Hours)

Computer Vision Fundamentals -Advanced Computer Vision -Neural Networks for Image Processing –TensorFlow -Overview of Deep Neural Networks -Convolutional Neural Networks

Module V: Autonomous Vehicle Technology (7 Hours)

Driverless Car Technology-Different Levels of Automation -Localization, Unmanned Aerial Vehicle (UAV) Technology, Navigation, Path Planning, Path Following, Obstacle avoidance technology. Controllers to Actuate a Vehicle:PID Controllers -Model Predictive Controllers.

COURSE OUTCOMES:

After completion of this course the students will be able to:

1. Gain the knowledge on robotics and its applications to operate autonomous vehicles
2. Explain the applications of controllers in the field of robotics
3. Gain depth knowledge Sensor Technology and computer vision
4. Gain knowledge in different types of motor drives
5. Explain different applications of Deep Learning for Autonomous Vehicles
6. Describe the Technology of Autonomous Vehicle including the design and path planning

TEXT BOOKS:

1. K.S Fu, R.C. Gonzalez, C.S.G. Lee, Robotics, McGraw Hill, 1987.
2. R Kelly, D. Santibanez, LP Victor and Julio Antonio, “Control of Robot Manipulators in Joint Space”, Springer, 2005.
3. Hong Cheng, “Autonomous Intelligent Vehicles: Theory, Algorithms and Implementation”, Springer, 2011.
4. Williams. B. Ribbens: “Understanding Automotive Electronics”, 7th Edition, Elsevier Inc, 2012.

REFERENCE BOOKS:

1. Shaoshan Liu, Liyun Li, “Creating Autonomous Vehicle Systems”, Morgan and Claypool Publishers, 2017.
2. Marcus Maurer, J.ChristianGerdes, “Autonomous Driving: Technical, Legal and Social Aspects” Springer, 2016.
3. Ronald.K.Jurgen, “Autonomous Vehicles for Safer Driving”, SAE International, 2013.

4. James Anderson, KalraNidhi, Karlyn Stanly, "Autonomous Vehicle Technology: A Guide for Policymakers", Rand Co, 2014.
5. Lawrence. D. Burns, ChrostopherShulgan, "Autonomy – The quest to build the driverless car and how it will reshape our world", Harper Collins Publishers, 2018.

ONLINE LEARNING RESOURCES:

Course Name	Introduction to Robotics
Course Link	https://nptel.ac.in/courses/107/106/107106090/
Course Instructor	Prof. Asokan T, Indian Institute of Technology Madras

Course Code:	Course Name:	L-T-P	Credit :
19EE6PE07T	Industrial Automation and Control	3- 0- 0	3

COURSE OBJECTIVES:

1. To study the architecture of industrial automation systems and different measuring systems used in industries.
2. To study and understand the process control and to design the controllers using PLC programing.
3. To study and understand the operation and control of CNC Machine with different actuator circuits.
4. To study the operational characteristics of basic electrical machine drives.
5. To study the working of industrial embedded and communication systems.

SYLLABUS:

Module-1: (9 Hours)

Introduction to Industrial Automation and Control

Introduction to Industrial Automation and Control, Architecture of Industrial Automation Systems.

Measurement Systems

Measurement Systems Specifications, Temperature Measurement, Pressure and Force Measurement, Displacement and Speed Measurement, Flow Measurement, Measurement of Level, Humidity and pH, Signal Conditioning Circuits, Errors and Calibration.

Module-2 (9 Hours)

Process Control

Introduction to Process Control, P-I-D Control, Controller Tuning, Implementation of P-I-D Controllers, Special Control Structures – Feedforward and Ratio Control, Predictive Control, Control Systems with Inverse Response, Cascade, Override and Split Range Control

Programmable Logic Control Systems

Introduction to Sequence/Logic Control and Programmable Logic Controllers, Software Environment and Programming of PLCs, Formal Modelling of Sequence Control Specifications

and Structured RLL Programming, Programming of PLCs – Sequential Function Charts, PLC Hardware Environment.

Module-3 **(8 Hours)**

CNC Machines

Introduction to Computer Numerically Controlled (CNC) Machines, Interpolation, Control and Drive.

Actuators

Control Valves, Hydraulic Actuation Systems – Principles and Components, Directional Control Valves, Switches and Gauges, Industrial Hydraulic Circuits, Pneumatic Control Components, Pneumatic Control Systems.

Module-4 **(4 Hours)**

Electrical Machine Drives

Energy Savings with Variable Speed Drives, Step Motors – Principles, Construction and Drives, Electrical Actuators – DC Motor Drives, Induction Motor Drives, BLDC Motor Drives.

Module-5: **(4 Hours)**

Industrial Embedded and Communication Systems

Introduction to Real Time Embedded Systems, Real-Time Operating Systems and Process Management, Networking of Field Devices via Fieldbus.

Next Level Automation Systems

Higher levels of automation systems, applications, future aspects

COURSE OUTCOMES:

After completion of this course the students would gain enough knowledge.

1. Acquire knowledge about fundamental concepts and techniques used in industrial automation systems and measurements
2. Ability to analyze various controllers including but not restricted to PID and understand their applications.
3. Foster ability to identify the operation of CNC and other actuator based design applications.
4. To develop skills to build, and troubleshoot power electronics circuits.

5. Foster ability to understand the machine drives in commercial and industrial applications in real-time.

TEXT BOOKS:

1. Principles of Industrial Instrumentation and Control Systems by Chennakesava R Alavala, CenegageLearing Publishers, 2009.
2. Industrial Automation: Circuit Design and Components by Pessen and David W, John Wiley & Sons, 1989.Curtis D. Johnson, “Process Control and Industrial Technology”, Pearson India, 8th ed., 2012.

REFERENCE BOOKS:

1. Norman A Anderson, “Instrumentation for Process Measurement and Control”, CRC Press, 2018.
2. B. Wayne Bequette, “Process Control – Modeling, Design, and Simulation”, Pearson India, 2015.
3. John W. Webbs, “Programmable Logic Controllers – Principals and Applications”, fifth Edition, Pearson India /PHI (Old edition), 2012.

ONLINE LEARNING RESOURCES:

Course Name	Industrial Automation and Control
Course Link	https://nptel.ac.in/courses/108/105/108105062/
Course Instructor	Prof. S. Sen, Prof. S. Mukhopadhyay, Indian Institute of Technology Kharagpur

Course Code:	Course Name:	L-T-P	Credit :
19EE6PE08T	Electric and Hybrid Vehicles	3- 0- 0	3

COURSE OBJECTIVES:

1. Students will understand the concept of hybrid electric vehicle.
2. Understand the idea of hybrid electric drive trains.
3. Finds application of power electronics devices in hybrid electric vehicles.

SYLLABUS:

Module-1:Introduction to Hybrid Electric Vehicles:(7 Hours)

History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance. Architectures of HEVs, series and parallel HEVs, complex HEVs.

Module-2:Hybrid Electric Drive-trains:(10 Hours)

Basic concept of hybrid traction, introduction to various hybrid drivetrain topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

Module-3:Electric Propulsion unit:(10 Hours)

Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives. Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices.

Module-4:Power Electronics in HEVs: (7 Hours)

Rectifiers used in HEVs, voltage ripples; Buck converter used in HEVs, non-isolated bidirectional DC-DC converter, regenerative braking, voltage source inverter, current source inverter, isolated bidirectional DC-DC converter, PWM rectifier in HEVs, EV and PHEV battery

chargers. Electric Machines and Drives in HEVs: Induction motor drives, Field oriented control of induction machines; Permanent magnet motor drives; Switched reluctance motors; Doubly salient permanent magnet machines, Case studies.

Module-5:(7 Hours)

Communications, supporting subsystems: In vehicle networks- CAN, Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies.

COURSE OUTCOMES:

Upon completion of the course, the students will demonstrate the ability to:

1. Describe the requirements and architecture of EVs and HEVs.
2. Describe drive trains used in EVs and HEVs.
3. Design electric propulsion unit and storage systems for EVs and HEVs.
4. Design drives systems for EVs and HEVs. CO5 Describe different communication systems used in EVs and HEVs.

TEXT BOOKS:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
2. MehrdadEhsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.

REFERENCE BOOKS:

1. Mi Chris, Masrur A., and Gao D.W., “Hybrid Electric Vehicle: Principles and Applications with Practical Perspectives”.

ONLINE LEARNING RESOURCES:

Course Name	Introdution to Hybrid and Electric Vehicle
Course Link	https://nptel.ac.in/courses/108/103/108103009/
Course Instructor	Dr. Praveen Kumar, Prof. S. Majhi, Indian Institute of Technology Guwahati

Course Code:	Course Name:	L-T-P	Credit :
19EE6OE01T	Electrical Energy Utilization	3-0-0	3

COURSE OBJECTIVES:

1. To understand the basic concepts of illumination systems
2. To understand the basic concept of design of lighting schemes
3. To understand the fundamental requirements of railway electrification
4. To understand the operation of refrigeration and air-conditioning control technique

SYLLABUS:

Module-1:Illumination:(8 Hours)

Production of light - lighting calculations - determination of MHCP and MSCP - Polar curves of different types of sources - Rousseau's construction - photometers - interior and exterior illumination systems - lighting schemes - Design of lighting schemes - factory lighting - flood lighting - electric lamps - gaseous discharge lamps - high pressure and low pressure neon signs - high frequency, low pressure discharge tubes.

Module-2: Electric furnaces and welding:(7 Hours)

Resistance, inductance and Arc Furnaces - Construction and fields of application - control equipment, high frequency dielectric heating, resistance - welding equipment - characteristics of carbon and metallic arc welding - butt welding - spot welding.

Module-3: Electro-chemical processes:(5 Hours)

Electrolysis – Electroplating – Electro deposition – Extraction of metals Current, Efficiency - Batteries – types – Charging Methods.

Module-4: Electric traction:(8 Hours)

Railway electrification – definition and analysis of traction effort – speed – time curve – traction motors - battery driven vehicles - energy efficiency drives – advanced speed control measures-tractive effort calculations - electric braking - control wire - A.C. traction - recent trend in electric traction.

Module-5: Refrigeration and air-conditioning: (7 Hours)

Control of temperature - basic wiring diagram - simple heat load and motor calculations. Air-

conditioning - function of complete air conditioning system - type of compressor motor and fan motor-wiring diagram for a typical air conditioning unit.

COURSE OUTCOMES:

After completion of this course the students will be able to:

1. Students will be able to understand the basic concepts of illumination systems and concept of design of lighting schemes.
2. Students will be able to understand the construction and fields of application of resistance, inductance and arc furnaces.
3. Students will be able to assess the degree of adequacy level in electro-chemical processes in Industry.
4. Students can analyze problem related to railway electrification.
5. Students will understand the operation of refrigeration and air-conditioning control techniques.

TEXT BOOKS:

1. S. C. Tripathy, *Electric Energy Utilisation and Conservation,* Tata McGraw Hill , 1991
2. W. F. Stocker and J.W. Jones, *Refrigeration & Air Conditioning Refrigeration & Air Conditioning*, McGraw Hill , 1985

REFERENCE BOOKS:

1. L. Wadhwa, *Generation, Distribution and Utilization of Electrical Energy*, New Age,1989
2. N.V. Suryanarayana, *Utilisation of Electric Power*, Wiley Eastern Ltd. , 1993

ONLINE LEARNING RESOURCES:

Course Name	Illumination Engineering
Course Link	https://nptel.ac.in/courses/108/105/108105060/
Course Instructor	Prof. N.K.Kishore, Indian Institute of Technology Kharagpur

Course Code:	Course Name:	L-T-P	Credit :
19EE6OE02T	Introduction to Robotics and Autonomous Vehicles	3- 0- 0	3

COURSE OBJECTIVE:

1. Gain basic knowledge on control and designof robotic system and it applications to solve common human society problems
2. Will able to gain knowledge on sensor technology and computer vision
3. Knowledge on autonomous vehicle technology
4. Will generate fundamental knowledge needed for the future technological advances that will able to drive the economic engines of the society.

SYLLABUS:

Module-1: Introduction and Overview of Robotic Systems and their Dynamics (12Hours)

Introduction.Construction of manipulators, advantages and disadvantages of various kinematicstructures. Applications, Nonservo robots, motion planning. Feedback systems, encoders Kinematics,homogeneous coordinates solution of the inverse kinematic problem, multiple solutions, jacobian, workenvelopes.

Trajectory planning. Joint Interpolated Trajectory, Link joints and their Manipulatordynamics and force control. Sensors: Vision, ranging, laser, acoustic, tactile.

Module-2: Evolution of Automotive Electronics (8 Hours)

Basic Control System Theory applied to Automobiles -Overview of the Operation of ECUs - Infotainment, Body, Chassis, and Powertrain Electronics-Advanced Driver Assistance Systems-Autonomous Vehicles

Module-3:Sensor Technology for Autonomous Vehicles (8 Hours)

Basics of Radar Technology and Systems -Ultrasonic Sonar Systems -LIDAR Sensor Technology and Systems -Camera Technology -Night Vision Technology -Use of Sensor Data Fusion -Kalman Filters

Module-4: Computer Vision and Deep Learning for Autonomous Vehicles (7 Hours)

Computer Vision Fundamentals -Advanced Computer Vision -Neural Networks for Image Processing –TensorFlow -Overview of Deep Neural Networks -Convolutional Neural Networks

Module-5: Autonomous Vehicle Technology **(7 Hours)**

Driverless Car Technology-Different Levels of Automation -Localization, Unmanned Aerial Vehicle (UAV) Technology, Navigation, Path Planning, Path Following, Obstacle avoidance technology. Controllers to Actuate a Vehicle:PID Controllers -Model Predictive Controllers.

COURSE OUTCOMES:

After completion of this course the students will be able to:

1. Gain the knowledge on robotics and its applications to operate autonomous vehicles
2. Explain the applications of controllers in the field of robotics
3. Gain depth knowledge Sensor Technology and computer vision
4. Gain knowledge in different types of motor drives
5. Explain different applications of Deep Learning for Autonomous Vehicles
6. Describe the Technology of Autonomous Vehicle including the design and path planning

TEXT BOOKS:

1. K.S Fu, R.C. Gonzalez, C.S.G. Lee, Robotics, McGraw Hill, 1987.
2. R Kelly, D. Santibanez, LP Victor and Julio Antonio, “Control of Robot Manipulators in Joint Space”, Springer, 2005.
3. Hong Cheng, “Autonomous Intelligent Vehicles: Theory, Algorithms and Implementation”, Springer, 2011.
4. Williams. B. Ribbens: “Understanding Automotive Electronics”, 7th Edition, Elsevier Inc, 2012.

REFERENCE BOOKS:

1. Shaoshan Liu, Liyun Li, “Creating Autonomous Vehicle Systems”, Morgan and Claypool Publishers, 2017.
2. Marcus Maurer, J.ChristianGerdes, “Autonomous Driving: Technical, Legal and Social Aspects” Springer, 2016.
3. Ronald.K.Jurgen, “Autonomous Vehicles for Safer Driving”, SAE International, 2013.

4. James Anderson, KalraNidhi, Karlyn Stanly, "Autonomous Vehicle Technology: A Guide for Policymakers", Rand Co, 2014.
5. Lawrence. D. Burns, ChrostopherShulgan, "Autonomy – The quest to build the driverless car and how it will reshape our world", Harper Collins Publishers, 2018.

ONLINE LEARNING RESOURCES:

Course Name	Introduction to Robotics
Course Link	https://nptel.ac.in/courses/107/106/107106090/
Course Instructor	Prof. Asokan T, Indian Institute of Technology Madras

Subject Code:	Subject Name:	L-T-P:	Credit:
19EC6OE01T	Fundamental Of Satellite Communication	3-0-0	3

COURSE OBJECTIVE:

The purpose of this course is to introduce students to

1. Make the students understand the basic concept in the field of Satellite Communication.
2. Understand the design of satellite links
3. Gain knowledge about the Satellite Access schemes.
4. Comprehend the details of earth stations designand various useful satellite applications

SYLLABUS

Module-1 **(10 Hours)**

Introduction to satellite communication: Overview of satellite communications, General structure of satellite communication, Satellite frequency allocation and band spectrum, Satellite orbits – Performance characteristics of different altitude satellites (GEO, MEO and LEO satellite systems)

Orbital mechanics: Introduction, Kepler's laws of planetary motion, Orbital parameters, look angle determination, Launches and Lunch vehicle, Orbital effects in communication system performance.

Satellite subsystem: Attitude and Orbit Control System(AOCS), Telemetry, Tracking and Command System(TT&C), Power System, Satellite antennas, Communications subsystem, Transponders

Module-2: **(8 Hours)**

Satellite Link Design: Basics of transmission theory, system noise temperature and G/T ratio, Uplink and Downlink design, design of satellite links for specified (C/N) performance.

Module-3 **(8 Hours)**

Multiple Accesses: Multiplexing techniques for satellite links, Comprehensive study on FDMA, TDMA and CDMA; Spread Spectrum Transmission and Reception.

Propagation on satellite: Earth paths and influence on link design; Quantifying attenuation and depolarization, hydrometric & non hydrometric effects, ionosphere effects, rain and ice effects.

Module-4 **(6 Hours)**

Satellite Antennas: Types of antenna and relationships; Basic Antennas Theory – linear, rectangular & circular aperture; Gain, pointing loss.

Earth station Technology: Earth station design; Design of large antennas – Cassegrain antennas

Module-5 **(6 Hours)**

Application of Satellite communication: Overview of VSAT systems, Network architectures, direct broad casting TV.

Other Satellite services: Fundamentals of mobile communication satellite.

COURSE OUTCOME:

After completion of the course, the student will be able to

1. Explain the basic concepts of orbit mechanics and satellite Launching.
2. Analyze the design of satellite links for specified C/N with system design examples.
3. Understand the various multiple access schemes for satellite communication systems, as well as the satellite link propagation impairments.
4. Explain the fundamentals of earth station technology and the role of satellites in various applications.

TEXT BOOKS:

1. T. Pratt, C. Bostian, *Satellite Communication,* 2nd Edition John Wiley Co.,2003,India
2. R.N.Mutagi, *Satellite Communication: Principles & Applications*, 1st Edition, Oxford University Press, 2016,India

REFERENCE BOOKS:

1. Dennis Roddy, *Satellite Communications*, 2nd Edition, McGraw Hill, 1996,India
2. M. Richcharia, *Satellite Communications: Design Principles*, 2nd Edition, BSP, 2003,India
3. Tri T. Ha, *Digital Satellite Communication*, Special Indian Edition, Tata McGraw- Hill, 2009, India

DIGITAL LEARNING RESOURCES:

Course Name	Satellite Communication Systems
Course Link	https://nptel.ac.in/courses/117/105/117105131/
Course Instructor	**Prof. KalyankumarBandyopadhyay**

Subject Code:	Subject Name:	L-T-P	Credits
19EC6OE02T	Image Processing Techniques	3-0-0	3

COURSE OBJECTIVE:

The program is expected to enable the students to

1. Gain an insight into the various analytical methods used in image processing.
2. Familiarize with image enhancement and restoration techniques.
3. Mathematical modeling of different image compression techniques and their applications.
4. Understand the Concept of color image processing and morphological operations on gray image.

SYLLABUS

Module- 01 **(8 Hours)**

Introduction: Background of image processing, Fundamental steps in image processing, Elements of digital image processing systems. Digital image representation, Sampling and quantization, Relationship between pixels: Neighbours, adjacency, connectivity, regions, boundaries and distance measure, Image geometry: translation, rotation, perspective transformation.

Module-02 **(8 Hours)**

Image Enhancement: Enhancement in spatial domain: Point Processing: Log, Power law, Image Negatives, Piecewise linear transformation, Spatial correlation and convolution Histogram processing. Smoothing and Sharpening of Spatial Filters.

Enhancement in frequency domain: Introduction to filtering in frequency domain, Smoothing and Sharpening of frequency domain filters.

Module-3 **(8 Hours)**

Image Restoration and Reconstruction: Image Restoration: Degradation model, Restoration in presence of noise only – spatial filtering, Linear position invariant degradations, Estimating degradation functions, Inverse filtering, Wiener filtering.

Color Image Processing: Color fundamentals, Conversion of color image to gray scale image, Color model (RGB, HSI, HSV, HLS, CMK, CMYK).

Module- 4 **(6 Hours)**

Image compression: Introduction and motivation, Fundamental concepts: Data redundancy (coding redundancy, inter pixel redundancy and psycho visual redundancy), Fidelity criteria, Image compression models, Image compression standards, Elements of information theory. Image compression methods: Huffman coding, Arithmetic coding, LZW coding, Run-Length Coding, Bit plane coding.

Module-5 **(6 Hours)**

Morphological Image Processing: Morphological Image Processing: Preliminaries, Erosion, Dilation, Opening and Closing, hit or Miss transformation, Boundary extraction, Hole filling, Extraction of connected components, Thinning, Thickening.

COURSE OUTCOMES:

On Completion of this course, the students should be able to:

1. Understand the need for different types of image transforms and their properties for processing of gray and color image data.
2. Implement the signal processing algorithms and techniques in image enhancement, image restoration, Morphology and Image Compression.
3. Implement basic image processing algorithms in MATLAB.
4. Understand practical scope of digital image processing for most of the work currently underway in this field.

TEXT BOOKS:

1. R.C. Gonzalez, R.E. Woods, Digital Image Processing, 3rd Edition, Pearson Education, 2007, New Delhi.
2. S. Sridhar, Digital Image Processing, 2nd Edition, Oxford University Press, 2016, New Delhi.

REFERENCE BOOKS:

1. Rafael C. Gonzalez, Richard E. Woods Digital Image Processing using MATLAB, Seventh Edition , Pearson Education, Inc, 2004, New Delhi.
2. William K. Pratt, Digital Image Processing, 4th Edition, Wiley, 2002, New York.

3. Anil K. Jain, 'Fundamentals of Digital Image Processing', 1st Edition, Pearson 2019, New Delhi.
4. B. Chanda, Dutta D. Majumder, Digital Image Processing And Analysis, 2nd Edition ,PHI, 2011 , New Delhi.

DIGITAL LEARNING RESOURCES:

Course Name	Digital Image Processing
Course Link	https://nptel.ac.in/courses/117/105/117105135/
Course Instructor	Prof. P.K. Biswas , Department of Electronics & Electrical Communication Engineering, I.I.T, Kharagpur

Course Code:	Course Name:	L-T-P	Credit :
19CE6OE01T	Plastic Waste Management	3- 0- 0	3

COURSE OBJECTIVE:

1. To know the sources of plastics
2. To know plastic waste management system
3. To know the recycling of waste plastic.
4. To know the plastic waste management practices.
5. To know about the biodegradable plastics.

SYLLABUS

Module: 01(08 hours)

Plastics –What it is? Types, Uses and Global Statistics, Plastic Waste –Sources, Production, Global and Indian Contex, Plastic Waste Management Rules 2016 (India) and Global Rules and Regulations

Module: 02(08 hours)

Plastics waste management-4 R & I approach viz. Source reduction, Reuse, Repair, Recycling, and Incineration with examples. Plastics recycling, Classification Code of practice-Primary, secondary, territory and quaternary recycling with examples-Coextrusion and co-injection moulding-Waste plastics as fillers.

Module: 03 (08 hours)

Mechanical recycling of commonly used plastics, such as PP, PE. PET, etc. mixed waste recycling-co-extruded films waste, commingled waste extrusion flow moulding for production of plastics lumbers, chemical recycling/feed Stochrecycling processes for recovery of oil, monomer and energy-thermolytic processes. Solvolysis-process outline for PMMA, PET, etc.

Module: 04 (08 hours)

Plastic Waste Management Practices –Use of Plastic waste in roads, issues and challenges, Possible Alternate Materials to Plastics –Greener Alternatives, Plastics Resource Recovery and Circular Economy, Plastic Bans including China Sword Policy implication on global plastic

waste management, Impact of Plastics on Marine Life, Effect on Wildlife, Human Health and Environment.

Module: 05 (08 hours)

Biodegradable plastics-an overview. Environmental issues, policies and legislation in India. Plastics-Energy saving, Eco-Friendly-Case studies.Life cycle analysis-a model.

COURSE OUTCOME:

After completion of the course the student can

1. Students will able to explain the sources of plastics.
2. Students will be able to explain the plastic waste management.
3. Students will be able to explain the recycling process of plastic.
4. Students will able to explain waste management practices.
5. Students will able to explain biodegradable plastics.

TEXT BOOKS:

1. R.J. Brandrup, *Recycling and recovery of plastics*, First Edition, Hanser Publishers, 1996 New York
2. N. Mustafa, *Plastics Waste Management*, Disposal Recyding and Reuse, First Edition, Marcel Dekker, Inc. 1993, New York.

REFERENCE BOOKS:

1. A. L. Andrady, *Plastics and the Environment*, First Edition Wiley Inter science, 2003, New York.
2. R.J. Ehrig, *Plastics Recycling, Products and Processes*, First Edition Hanser Publishers, 1992, New York.
3. *Technologies in Plastics Recycling*, American Chemical Society, Washington, DC 1992.

DIGITAL LEARNING RESOURCES

Course Name	Plastic Waste Management
Course Link	https://nptel.ac.in/courses/105/105/105105184/

Course Instructor	Prof. B. K. Dubey, Department of Civil Engineering, IIT Kharagpur

Course Code:	**Course Name:**	**L-T-P**	**Credit :**
19CS6OE01T	Data Analytics	3- 0- 0	3

Course Objective:

To optimize business decisions and create competitive advantage with Big Data analytics

1. To explore the concepts regression and classification.
2. To learn to analyze the complexity of different techniques.
3. To understand the various additive models and boosting techniques.
4. To understand the Neural Networks, Support Vector Machines, and K-nearest Neighbor.

SYLLABUS

Module: 01 **(8 Hours)**

Linear Methods for Regression and Classification: Overview of supervised learning, Linear regression models and least squares, Multiple regression, Multiple outputs, Subset selection , Ridge regression, Lasso regression , Linear Discriminant Analysis , Logistic regression , Perceptron learning algorithm.

Module: 02 **(8 Hours)**

Model Assesment and Selection : Bias, Variance, and model complexity, Bias-variance trade off, Optimisim of the training error rate ,Esimate of In-sample prediction error, Effective number of parameters, Bayesian approach and BIC, Cross- validation ,Boot strap methods, conditional or expected test error.

Module: 03 **(8 Hours)**

Additive Models, Trees, and Boosting: Generalized additive models, Regression and classification trees , Boosting methods-exponential loss and AdaBoost, Numerical Optimization via gradient boosting ,Examples (Spam data, California housing , NewZealand fish, Demographic data).

Module: 04 **(8 Hours)**

Neural Networks(NN) , Support Vector Machines(SVM),and K-nearest Neighbor: Fitting neural networks, Back propagation, Issues in training NN, SVM for classification, Reproducing

Kernels, SVM for regression, K-nearest –Neighbour classifiers(Image Scene Classification)

Module: 05 **(8 Hours)**

Unsupervised Learning and Random forests: Association rules, Cluster analysis, Principal Components, Random forests and analysis. (II) Inferential Statistics and Prescriptive analytics.

TEXT BOOKS:

1. Trevor Hastie, Robert Tibshirani, Jerome Friedman , The Elements of Statistical Learning Data
2. Mining, Inference, and Prediction ,Second Edition , Springer Verlag, 2009.
3. G.James,D.Witten,T.Hastie,R.Tibshirani-An introduction to statistical learning with applications in R,Springer,2013.
4. E.Alpaydin, Introduction to Machine Learning, Prentice Hall Of India,2010,(Chapter-19)

REFERENCES

1. C.M.Bishop –Pattern Recognition and Machine Learning,Springer,2006
2. L.Wasserman-All of statistics.

DIGITAL LEARNING RESOURCES

Course Name	Data Analytics with Python
Course Link	Computer Science and Engineering - NOC:Data Analytics with Python
Course Instructor	Prof. A. Ramesh, IIT Roorkee

Course Code:	Course Name:	L-T-P	Credit :
19IT6OE01T	Introduction to Operating System	3- 0- 0	3

COURSE OBJECTIVES:

1. Recognize the concepts and principles of operating systems.
2. Provide comprehensive introduction to understand the underlying principles, techniques and approaches which constitute a coherent body of knowledge in operating systems.
3. To teach understanding how the various elements that underlie operating system interact and provides services for execution of application software.

SYLLABUS:

Module-01: **(8 Hours)**

Overview of operating systems: computer system organization, computer system architecture, operating system operations, Need of Process/Memory/Storage Management, Protection and security, Distributed systems, Real-Time Embedded Systems. Operating systems services, User Operating System Interface, Systems calls and its types, operating system structure.

Module-02: **(8 Hours)**

Process Concept; Process Scheduling; Operations on Processes; Interprocess Communication; Thread; Multithreading models;

Module-03: **(8 Hours)**

Scheduling Criteria, Algorithms (FCFS, SJF, SRTF, Round Robin, Priority, Multi-level Queue and Feedback Queue), Thread scheduling. The Critical- section problem, Peterson's Solution, Synchronization Hardware, Semaphores, Classical problems of synchronization, monitors

Module-04: **(8 Hours)**

System model; Deadlock Characterization; Methods for Handling Deadlock (Deadlock prevention, detection and Avoidance, recovery); Swapping; Contiguous memory allocation; Paging; Structure of the page table; Segmentation; Virtual memory, demand paging, Copy on write, page-Replacement algorithms (FIFO, LRU, LFU, Optimal Page Replacement)

Module-05: **(8 Hours)**

File Concept, Access Methods, Directory Structure, File System Mounting, File Sharing and Protection, File system structure, File System Implementation, Directory Implementation, Allocation Methods. Overview of Mass-storage structure, disk structure, disk attachment, disk scheduling, swap-space management

COURSE OUTCOME:

1. Identify basic components of operating system.
2. Conceptualize synchronization amongst various components of a typical operating system.
3. Understand and simulate activities of various operating system components.
4. Correlate basic concepts of operating system with an existing operating system.

TEXT BOOK:

1. Abraham Silberschatz, Peter Baer Galvin & Greg Gagne “Operating System Concepts”, 8th edition.
2. John Wiley &SonsWilliam Stallings, “Operating Systems – Internals and Design Principles”, 5/e, Pearson.
3. Charles Crowley, “Operating Systems: A Design□Oriented Approach”, Tata McGraw Hill Co.,1998 edition.
4. Andrew S.Tanenbaum, “Modern Operating Systems”, 2nd edition, 1995, PHI.

DIGITAL LEARNING RESOURCES

Course Name	Operating System Fundamentals
Course Link	https://nptel.ac.in/courses/106/105/106105214/
Course Instructor	Prof. SantanuChattopadhyay IIT Kharagpur

Course Code:	Course Name:	L-T-P	Credit
19EE6PC01L	Electric Drives Lab	0- 0- 3	1

COURSE OBJECTIVES:

1. Enhance understanding of Concept of speed control of DC Electrical Motors, through AC to DC, DC to DC converter and to get adequate knowledge to design the suitable converter for the required application.
2. Determine the mechanical losses and momentum of inertia of a dc separately excited motor for the load equalization and no energy loss in transient operation.
3. Understand the concept of one of the speed control method - Rotor Rheostatic control for three phase Slipring Induction motor.
4. To get more confident to apply suitable speed control of 3-phase induction motor through DC to AC converter and to overcome the difficulties and problems faced in conventional speed control methods.

SYLLABUS:

Select any 8 experiments from the list of 12 experiments (Using Hardware)

1. Speed control of separately excited dc motor by varying armature voltage usingsingle-phase fully controlled bridge converter.
2. Speed control of separately excited dc motor by varying armature voltage usingsingle phase half controlled bridge converter.
3. Speed control of separately excited dc motor using single phase dual converter(Static Ward-Leonard Control)
4. Speed control of separately excited dc motor using MOSFET/IGBT chopper
5. Closed loop control of separately excited dc motor.
6. Speed control of single phase induction motor using single phase ac voltagecontroller.
7. Speed control of three phase induction motor using three phase ac voltage controller
8. Speed control of three phase induction motor using three phase current sourceInverter.
9. Speed control of three phase induction motor using three phase voltage sourceInverter.

10. Speed control of three phase slip ring induction motor using static rotor resistance control using rectifier and chopper
11. Determinations of transfer function of DC shunt motor.
12. Determination of Moment of Inertia of DC Shunt Motor Drive System by Retardation Test.

COURSE OUTCOMES:

After successful completion of lab, Student can be able to

1. Determine the Power factor, average votage, current and also plot the speed torque characteristics to improve the design of the converter.
2. Determine the momentum of inertia, mechanical losses for DC motor by retardation test and sucessfully validate with the simulation.
3. Plot the speed torque characteristics by varying the rotor resistance of an induction motor and able to design the software model of it.
4. Plot the speed charcteristics of inductionmotor and give proper conclusion for convention method speed control of induction motor and with the PWM Inverter.

Course Code:	Course Name:	L-T-P	Credit :
19EE6PC02L	Power System Operation and Control Lab	3- 0- 0	1

COURSE OBJECTIVES:

1. Enhance understanding of Concept of zero sequence, positive and negative sequence reactance of a 3-phase alternator.
2. Determine the faults current for various types faults at the terminals of an alternator..
3. Understand the concept of operating characteristics of different types of relay such as over current relay differential relay.

(Perform any 05 Experiments from Group-A and any 03 Experiments from Group-B)

Group-A (Hardware Based)

1. To determine negative and zero sequence synchronous reactance of an alternator.
2. To determine sub-transient direct axis and sub-transient quadrature axissynchronous reactance of a 3-ph salient pole alternator.
3. To determine fault current for L-G, L-L, L-L-G and L-L-L faults at the terminals of analternator at very low excitation.
4. To study the IDMT over-current relay and with different plug setting and timesetting multipliers and plot its time – current characteristics.
5. To determine the operating characteristics of biased different relay with different% of biasing
6. To study the MHO and reactance type distance relays.
7. To determine location of fault in a cable using cable fault locator.

Group-B (Simulation Based)

1. To obtain steady-state, transient and sub-transient short-circuit currents in anAlternator.
2. To formulate the Y-Bus matrix and perform load flow analysis.
3. To compute voltage, current, power factor, regulation and efficiency at the receivingend of a three phase Transmission line when the voltage and power at the sendingend are given. Use Π model.
4. To perform symmetrical fault analysis in a power system.

5. To perform unsymmetrical fault analysis in a power system.
6. Write a program in ‘C’ language to solve economic dispatch problem of a powersystem with only thermal units. Take production cost function as quadratic andneglect transmission loss.