

# **6<sup>th</sup> Semester**

## **B.Tech.(Electrical and Electronics Engineering)**

### **Detailed SYLLABUS:**

Sixth Semester (Electrical and Electronics Engineering)					
Theory					
Sl. No.	Category	Course Code	Course Title	L-T-P	Credit
1	PCC	19EEE6PC01T	PCC-9: Microprocessor and Microcontroller	3-0-0	3
2	PCC	19EEE6PC02T	PCC-10 :Power System Operation and Control	3-0-0	3
3	BSC	19CM6BS01T	Optimization Engineering	3-1-0	4
4	PEC			3-0-0	3
		19EEE6PE01T	Modeling and Control of Power Electronic Systems		
		19EEE6PE02T	High Voltage Engineering and HVDC Transmission		
		19EEE6PE03T	Utilization of Electrical Energy		
		19EEE6PE04T	Advance Control System Engineering		
5	PEC			3-0-0	3
		19EEE6PE05T	Electric Drives		
		19EEE6PE06T	Robotics and Autonomous Vehicles		
		19EEE6PE07T	Industrial Automation and Control		
		19EEE6PE08T	Electric and Hybrid Vehicle		
6	OEC	<b>Open Electrive-1(Other Branch)</b>		3-0-0	3
		19EEE6OE01T	Electrical EnergyUtilization		
		19EEE6OE02T	Introduction toRobotics and Autonomous Vehicles		
		<b>Open Electrive-1(for Electrical Engineering)</b>			
		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
<b>Practical</b>					
1	PCC	19EEE6PC01L	Microprocessor and Microcontroller Lab	0-0-2	1
2	PCC	19EEE6PC02L	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 :
19EEE6PC01T	Microprocessor and Microcontroller	3-0-0	3

### COURSE OBJECTIVES:

1. Understand the main components and working principle of the Intel 8086 microprocessor.
2. Understand the Memory organization, interfacing and the interrupt concept of 16-bit microprocessor
3. Program and debug in assembly language program
4. Understand the properties and interfacing of the I/O devices using programmable interfacing devices.
5. Understand the main components and working principle of the Intel 8051 microcontroller.

### SYLLABUS:

#### Module-1 (10 Hours)

##### 8086 Microprocessor

Introduction: Overview of Microcomputer organization Intel 8086 Microprocessor: Introduction, 8086 Programmer's model: Register organization, Hardware Architecture: Bus interface unit (BIU), Execution unit (EU), Pipelined operation, physical address generation and Memory segmentation. 8086 Pin description: Common, Minimum and maximum mode Pin and Signals, Bus cycle and System configuration.

#### Module-2 (6 Hours)

**8086 Memory Interfacing and Interrupt technique** 8086 Memory Interfacing: External Memory addressing, EPROM and RAM interface with 8086. 8086 Interrupt: Interrupt Processing, sources of interrupt in 8086, Interrupt Instructions, Interrupt types, IVT, Hardware Interrupts and Interrupt priorities.

#### Module-3 (6 Hours)

##### 8086 Instruction set and programming

8086 Addressing modes, Instruction sets, Assembler directives and programming

#### **Module-4**

**(10 Hours)**

##### **Peripheral interfacing**

Introduction to basic I/O interface, I/O interfacing techniques in 8086 Interfacing devices:8255 PPI, 8251 USART,ADC-0808/0809,DAC-0800interfacing using PPI.

#### **Module-5**

**(8 Hours)**

##### **8051 Microcontroller**

Introduction to 8051 Micro-Controllers, Architecture, pin and signals,list of Special Function registers, Description of basic registers (A, B, SP, PC, DPTR, PSW), Memory Organization;External Memory Interfacing, I/O port programming; Interrupts operation and its programming; Programmer's model of 8051; Operand types, Operand addressing; Data transfer instructions, Arithmetic instructions, Logic instructions, Control transfer instructions; Programming.

#### **COURSE OUTCOMES:**

On Completion of this Subject/ Course the students should be able to:

1. Gain knowledge on 8086 microprocessor architecture and its memory interfacing.
2. Identify the addressing modes and apply the knowledge in assembly language programming.
3. Illustrate the design aspect of programmable peripheral devices with the 8086 microprocessor.

#### **TEXT BOOKS:**

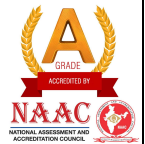
1. A.K.Ray and K.M.Bhurchandi, "Advanced Microprocessors and Peripherals",Tata McGrawHill,2000.
2. Walter A Triebel and AvtarSingh,The 8088 and 8086 Microprocessors, Programming, Interfacing, Software, Hardware and Applications4e, Pearson Education
3. The 8051 Microcontroller and Embedded Systems using assembly and C by M.A. Mazidi, J.G. Mazidi, Pearson.

#### **REFERENCE BOOKS:**

1. Barry B. Brey, The Intel Microprocessors, Architecture, Programming and Interfacing-, 8e, 2009, Pearson Education, ISBN 0-13-502645-8



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2. Douglas.V.Hall, “ Microprocessor and Interfacing : Programming and Hardware”, 2nd edition, McGraw Hill, 1991
3. Yu-chengliu and Glenn a.Gibson, Microcomputer Systems: The 8086/8088 Family Architecture, Programming & Design-, 2nd Edition, Prentice Hall of India, 2007.

**ONLINE LEARNING RESOURCES:**

Course Name	Microprocessor and Microcontroller
Course Link	<a href="https://nptel.ac.in/courses/108/105/108105102/">https://nptel.ac.in/courses/108/105/108105102/</a>
Course Instructor	Prof. Santanu Chattopadhyay, Indian Institute of Technology Kharagpur

<b>Course Code:</b>	<b>Course Name:</b>	<b>L-T-P</b>	<b>Credit :</b>
19EEE6PC02T	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	<a href="https://nptel.ac.in/courses/108/104/108104052/">https://nptel.ac.in/courses/108/104/108104052/</a>
Course Instructor	Prof. S.N. Singh, Indian Institute of Technology Kanpur

<b>Course Code:</b>	<b>Course Name:</b>	<b>L-T-P</b>	<b>Credit :</b>
19EEE6PE01T	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 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  $2 \times n$  and  $m \times 2$  games by graphical approach.

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

**Module-5: (8Hours)**

**Queuing models:** General characteristics, Markovian queuing model, M/M/1 model, 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. Analyse and appreciate variety of performance measures for various optimization problems

**TEXT BOOKS:**

1. S. S. Rao, *Engineering Optimization*, New Age International Publications.
2. 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.



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**ONLINE LEARNING RESOURCES:**

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

Course Code:	Course Name:	L-T-P	Credit :
19EEE6PE01T	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:

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

**TEXT BOOKS:**

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

**REFERENCE BOOKS:**

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

**ONLINE LEARNING RESOURCES:**



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Course Name	Fundamentals of Power Electronics
Course Link	<a href="https://onlinecourses.nptel.ac.in/noc21_ee01/preview">https://onlinecourses.nptel.ac.in/noc21_ee01/preview</a>
Course Instructor	Prof. L Umanand, Indian Institute of Science Bangalore

<b>Course Code:</b>	<b>Course Name:</b>	<b>L-T-P</b>	<b>Credit :</b>
19EEE6PE02T	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, Converter 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



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**REFERENCE BOOKS:**

3. J. Kuffel and W. S. Zaengl, *High Voltage Engineering: Fundamentals*, Newnes , 2000
4. J. Arrillaga, *HVDC Transmission*, IET, peter pereginver Ltd., London, U.K , 1998

**ONLINE LEARNING RESOURCES:**

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

Course Code:	Course Name:	L-T-P	Credit :
19EEE6PE03T	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-1 Illumination:(8Hours)**

Production of light - lighting calculations - determination of MHCP and MSCP - Polar curves of different types of sources - Rouseau'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	<a href="https://nptel.ac.in/courses/108/105/108105060/">https://nptel.ac.in/courses/108/105/108105060/</a>
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



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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	<a href="https://nptel.ac.in/courses/108/103/108103007/">https://nptel.ac.in/courses/108/103/108103007/</a>
Course Instructor	Prof. SomanathMajhi, Indian Institute of Technology Guwahati

<b>Course Code:</b>	<b>Course Name:</b>	<b>L-T-P</b>	<b>Credit</b>
19EEE6PE05T	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



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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	<a href="https://nptel.ac.in/courses/108/104/108104140/">https://nptel.ac.in/courses/108/104/108104140/</a>
Course Instructor	Prof. Shyama Prasad Das, Indian Institute of Technology Kanpur



<b>Course Code:</b>	<b>Course Name:</b>	<b>L-T-P</b>	<b>Credit :</b>
19EEE6PE06T	Robotics and Autonomous Vehicles	3- 0- 0	<b>3</b>

**COURSE OBJECTIVES:**

1. Gain basic knowledge on control and design of robotic system and its applications to solve common human society problems
2. Will be 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 be 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 kinematic structures. Applications, Non-servo robots, motion planning. Feedback systems, encoders Kinematics, homogeneous coordinates solution of the inverse kinematic problem, multiple solutions, jacobian, work envelopes.

Trajectory planning. Joint Interpolated Trajectory, Link joints and their Manipulator dynamics 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.



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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	<a href="https://nptel.ac.in/courses/107/106/107106090/">https://nptel.ac.in/courses/107/106/107106090/</a>
Course Instructor	Prof. Asokan T, Indian Institute of Technology Madras

Course Code:	Course Name:	L-T-P	Credit :
19EEE6PE07T	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 programming.
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, Cenegage Learning 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	<a href="https://nptel.ac.in/courses/108/105/108105062/">https://nptel.ac.in/courses/108/105/108105062/</a>
Course Instructor	Prof. S. Sen, Prof. S. Mukhopadhyay, Indian Institute of Technology Kharagpur

Course Code:	Course Name:	L-T-P	Credit :
19EEE6PE08T	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:**

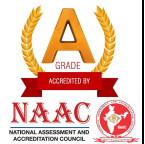
1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
2. MehrdadEhsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.

#### **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	Introduction to Hybrid and Electric Vehicle
Course Link	<a href="https://nptel.ac.in/courses/108/103/108103009/">https://nptel.ac.in/courses/108/103/108103009/</a>
Course Instructor	Dr. Praveen Kumar, Prof. S. Majhi, Indian Institute of Technology Guwahati



<b>Course Code:</b> 19EEE6OE01T	<b>Course Name:</b> Electrical Energy Utilization	<b>L-T-P</b> 3-0-0	<b>Credit : 3</b>
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### 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	<a href="https://nptel.ac.in/courses/108/105/108105060/">https://nptel.ac.in/courses/108/105/108105060/</a>
Course Instructor	Prof. N.K.Kishore, Indian Institute of Technology Kharagpur



Course Code:	Course Name:	L-T-P	Credit :
19EEE6OE02T	Introduction to Robotics and Autonomous Vehicles	3- 0- 0	3

**COURSE OBJECTIVE:**

1. Gain basic knowledge on control and design of robotic system and its applications to solve common human society problems
2. Will be 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 be 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 kinematic structures. Applications, Non-servo robots, motion planning. Feedback systems, encoders Kinematics, homogeneous coordinates solution of the inverse kinematic problem, multiple solutions, jacobian, work envelopes.

Trajectory planning. Joint Interpolated Trajectory, Link joints and their Manipulator dynamics 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.



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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	<a href="https://nptel.ac.in/courses/107/106/107106090/">https://nptel.ac.in/courses/107/106/107106090/</a>
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

5. Make the students understand the basic concept in the field of Satellite Communication.
6. Understand the design of satellite links
7. Gain knowledge about the Satellite Access schemes.
8. Comprehend the details of earth stations design and 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 Launch 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

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

**TEXT BOOKS:**

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

**REFERENCE BOOKS:**

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



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**DIGITAL LEARNING RESOURCES:**

Course Name	Satellite Communication Systems
Course Link	<a href="https://nptel.ac.in/courses/117/105/117105131/">https://nptel.ac.in/courses/117/105/117105131/</a>
Course Instructor	<b>Prof. KalyankumarBandyopadhyay</b>



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

5. Gain an insight into the various analytical methods used in image processing.
6. Familiarize with image enhancement and restoration techniques.
7. Mathematical modeling of different image compression techniques and their applications.
8. 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:

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

#### **TEXT BOOKS:**

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

#### **REFERENCE BOOKS:**

5. Rafael C. Gonzalez, Richard E. Woods Digital Image Processing using MATLAB, Seventh Edition , Pearson Education, Inc, 2004, New Delhi.
6. William K. Pratt, Digital Image Processing, 4<sup>th</sup> Edition, Wiley, 2002, New York.



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7. Anil K. Jain, 'Fundamentals of Digital Image Processing', 1<sup>st</sup> Edition, Pearson 2019, New Delhi.
8. B. Chanda, Dutta D. Majumder, Digital Image Processing And Analysis, 2<sup>nd</sup> Edition, PHI, 2011, New Delhi.

**DIGITAL LEARNING RESOURCES:**

Course Name	Digital Image Processing
Course Link	<a href="https://nptel.ac.in/courses/117/105/117105135/">https://nptel.ac.in/courses/117/105/117105135/</a>
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:

6. To know the sources of plastics
7. To know plastic waste management system
8. To know the recycling of waste plastic.
9. To know the plastic waste management practices.
10. 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 Context, 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, tertiary 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 lumbars, chemical recycling/feed Stockrecycling 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

6. Students will able to explain the sources of plastics.
7. Students will be able to explain the plastic waste management.
8. Students will be able to explain the recycling process of plastic.
9. Students will able to explain waste management practices.
10. Students will able to explain biodegradable plastics.

**TEXT BOOKS:**

4. R.J. Brandrup, *Recycling and recovery of plastics*, First Edition, Hanser Publishers, 1996 New York
5. 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.
6. *Technologies in Plastics Recycling*, American Chemical Society, Washington, DC 1992.

**DIGITAL LEARNING RESOURCES**

Course Name	Plastic Waste Management
Course Link	<a href="https://nptel.ac.in/courses/105/105/105105184/">https://nptel.ac.in/courses/105/105/105105184/</a>



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Course Instructor

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

<b>Course Code:</b>	<b>Course Name:</b>	<b>L-T-P</b>	<b>Credit :</b>
19CS6OE01T	Data Analytics	3- 0- 0	3

**Course Objective:**

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

5. To explore the concepts regression and classification.
6. To learn to analyze the complexity of different techniques.
7. To understand the various additive models and boosting techniques.
8. 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:**

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

**REFERENCES**

3. C.M.Bishop –Pattern Recognition and Machine Learning,Springer,2006
4. 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:**

5. Identify basic components of operating system.
6. Conceptualize synchronization amongst various components of a typical operating system.
7. Understand and simulate activities of various operating system components.
8. Correlate basic concepts of operating system with an existing operating system.

### **TEXT BOOK:**

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

### **DIGITAL LEARNING RESOURCES**

Course Name	Operating System Fundamentals
Course Link	<a href="https://nptel.ac.in/courses/106/105/106105214/">https://nptel.ac.in/courses/106/105/106105214/</a>
Course Instructor	Prof. Santanu Chattopadhyay IIT Kharagpur



Course Code:	Course Name:	L-T-P	Credit :
19EEE6PC01L	Microprocessor and Microcontroller Lab	3- 0- 0	3

### COURSE OBJECTIVES:

1. To introduce the basic concept and become familiar with the Instruction set of 8086 processor and 8051 Microcontroller.
2. To provide practical hands on experience with Assembly language programming using 8086 and 8051.
3. To develop the I/O interfacing skill with 8086 processor like DAC 0800, 8255PPI, 8279 Keyboard and Display, DC Motor
4. To provide the knowledge regarding real time applications of Microprocessors and Microcontrollers.

### LIST OF EXPERIMENTS

#### (Perform any 10 Experiments)

1. Programs for 16-bit arithmetic operations (using 8086).
2. Programs for Sorting and Searching (Using 8086).
3. Programs for Block Transfer using String manipulation operations (Using 8086).
4. Programs for Counter (Using 8086).
5. Interfacing DAC and generate Square Wave, Saw Tooth Wave, Triangular Waveforms (Using 8086)
6. Square Wave generation using Mode-0 and BSR mode of 8255 (Using 8086)
7. Interfacing and Programming 8279.
8. Serial Communication between two Microprocessor Kits using 8251.
9. Interfacing and Programming of Stepper Motor or DC Motor Speed control (Using 8086)
10. Programming of clearing 10 memory locations using different addressing modes using 8051 Microcontroller
11. Programming using Arithmetic, Logical and Bit Manipulation instructions of 8051 microcontroller.
12. Programming and verifying Timer, Interrupts and UART operations in 8051

13. Communication between 8051 Microcontroller kit and PC.
14. A design problem using 8086 for testing of Logic gate IC like AND gate or OR gate
15. 8051 port programming for generating square wave

### **COURSE OUTCOMES:**

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

1. Understand and apply the fundamentals of assembly language programming on Microprocessor and Microcontroller.
2. Familiarize with 8086 microprocessor real time interfaces like DAC, ADC, PPI, DC motor.
3. Design the real world interfacing applications using microprocessor and microcontrollers which can be used for their projects.
4. Troubleshoot interactions between software and hardware

### **DIGITAL LEARNING RESOURCES:**

Virtual Lab Link: <a href="http://vlabs.iitb.ac.in/vlabs-dev/labs_local/microprocessor/labs/explist.php">http://vlabs.iitb.ac.in/vlabs-dev/labs_local/microprocessor/labs/explist.php</a>
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Course Code:	Course Name:	L-T-P	Credit :
19EEE6PC02L	Power System Operation and Control Lab	3- 0- 0	3

### **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 axis synchronous 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 an alternator 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 differential 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 an Alternator.
2. To formulate the Y-Bus matrix and perform load flow analysis.
3. To compute voltage, current, power factor, regulation and efficiency at the receiving end of a three phase Transmission line when the voltage and power at the sending end are given. Use  $\Pi$  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 and neglect transmission loss.