Bachelor of Technology

(B Tech)

7th Semester

Detailed Syllabus

2022 Batch

Department of

Electrical and Electronics Engineering

NIST Institute of Science and Technology,
Pallur Hills, Berhampur, 761008, Odisha
www.nist.edu

Seventh Semester (Electrical and Electronics Engineering)					
Theory					
Sl. No.	**Category**	**Course Code**	**Course Title**	**L-T-P**	**Credit**
1	PCC	22EEE7PC01T	PCC-11: Communication Engineering	3-0-0	3
2	PCC	22EEE7PC02T	PCC-12:Power System Protection	3-0-0	3
3	PEC	**Professional Elective-5:**			
		22EEE7PE01T	Energy Audit and Sustainable Management	3-0-0	3
		22EEE7PE02T	Smart Grid Technology		
		22EEE7PE03T	Artificial Intelligence and Machine Learning		
		22EEE7PE04T	Optical and Satellite Communication		
4	PEC	**Professional Elective-6:**			
		22EEE7PE05T	Flexible AC Transmission System	3-0-0	3
		22EEE7PE06T	Soft computing Techniques and Applications		
		22EEE7PE07T	Energy Storage Systems and Applications		
		22EEE7PE08T	Biomedical Instrumentation		
5	OEC	**Open Elective-4 (To Other Branch Students)**		3-0-0	3
		22EEE7OE01T	Energy Audit and Management		
		22EEE7OE02T	Introduction to Biomedical Instrumentation		
		Open Elective-4 (To EE Branch Students)			
		22ELC7OE01T	Internet of Things		
		22ME7OE01T	Robotics(Introduction to Kinematics and Dynamics)		
		22BT7OE01T	Biology For Engineers		
		22CS7OE01T	Introduction to Machine Learning		
Total Credit (Theory)					**15**
Practical					
1	PCC	22EEE7PC01L	Communication Engineering Lab	0-0-2	1

2	PCC	22EEE7PC02L	Power System Protection Lab	0-0-2	1
3	PSI	22CM7PS01L	Minor Project	0-0-6	3
4	PSI	22CM7PS02L	Summer Internship/ Training/MOOC Certification	0-0-2	1
5	HSMC	22CM7HS01L	Entrepreneurship Project	0-0-4	2
Total Credit (Practical)					**8**
Total Semester Credit					**23**

Degree	B. Tech.	
Level	Undergraduate	
Branch	EEE (Electrical & Electronics Engineering)	
Semester	7th	
Subject Name	Communication Engineering	
Course Type	Theory	
Course Code	22EEE7PC01T	
Category	PCC (Professional Core Courses)	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	Nil
	Practice	Nil
	Total	36 Hours
Recommended Background Knowledge		
Subject Description	Communication engineering focuses on the systems and technologies that enable the transmission of information. It involves designing, developing, and maintaining the hardware and software that underpin communication networks, including everything from basic circuits to complex systems like the internet and satellite communication. Essentially, it's about making sure information gets from one place to another reliably and efficiently.	
Objectives and Outcomes	**Objectives:** 1. Concept of time and frequency domain analysis of signals used in communication systems. 2. Understand various analog modulation techniques and their applications in real world scenario. 3. Application of the Sampling theorem in analog-to-digital conversion process and understand the limits of practical sampling techniques. 4. Various modulation techniques used for digital representation of analog signals.	
	Outcomes:	

	1. Analyze frequency response of signals and illustrate the concepts of random variables used in communication systems. 2. Explain the concept of continuous wave modulation techniques and evaluate in terms of Power, bandwidth, etc. 3. Summarize the concept of sampling in various pulse modulation techniques in signal transmission. 4. Explain and analyze techniques used for transmission of analog signal in digital form.

Assessment/ Evaluation		
	Mid-Term Examination	30 %
	Quiz Test-1	2.5 %
	Quiz-Test-2	2.5 %
	Surprise Test	5 %
	Assignment-1	2.5 %
	Assignment-2	2.5 %
	Attendance	5 %
	End-Term Examination	50 %

Prescribed Text Book(s)	[1] H. Taub, D. L Schilling, G. Saha; *Principles of Communication System*, 4th Edition; 2013, McGraw Hill, India. [2] B. P. Lathi, Zhi Ding; *Modern Digital and Analog Communication Systems*, 4th Edition; 2017, Oxford University Press
Reference Book(s)	[1] Masoud Salehi, John G. Proakis; *Communication System Engineering*, 2nd Edition, Pearson, 2015. [2] P Ramakrishna Rao; *Analog Communication*, 1st Edition, Tata McGraw-Hill, 2011.

Digital Learning Resources		
	Course Name	Analog Communication
	Course Link	https://www.nptel.ac.in/courses/117/105/117105143/
	Course Instructor	Prof. Goutam Das, Department of ECE, IIT Kharagpur

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Analyze frequency response of signals and illustrate the concepts of random variables used in communication systems.	PO1, PO2, PO3, PO5
CO2	Explain the concept of continuous wave modulation techniques and evaluate in terms of Power, bandwidth, etc.	PO1, PO2, PO3, PO4,PO5
CO3	Summarize the concept of sampling in various pulse modulation techniques in signal transmission	PO1,PO2, PO3, PO4,PO5, ,PO7
CO4	Explain and analyze techniques used for transmission of analog signal in digital form	PO1, PO2, PO3, PO5, PO7.PO8

DETAILED SYLLABUS:

Module No. 1	**Frequency Domain Analysis of Signals and Systems**	**6 hrs**
Signals and Spectra: Elements of communication System, Communication Channels and their Characteristics, Mathematical Models for Communication Channels. Fourier series, Fourier Transforms, Properties, Power and Energy signal. **(Ref: TB 1, Ch 1)**		

Module No. 2	**Amplitude Modulation Systems**	**10 hrs**
Need of modulation, linear and nonlinear type of modulation, Frequency translation, Amplitude Modulation: Time and frequency analysis of DSB-C, DSB-SC, SSB and VSB Modulation. Modulators and demodulators: Square law modulator, switching modulator, square law detection and envelope detection, Concept of Frequency Division Multiplexing. **(Ref: TB 1, Ch 2)**		

Module No. 3	Angle Modulation:	7 hrs

Angle Modulation, types of angle modulation (FM and PM), Comparison: modulation index, sidebands, power and phasor diagram, Tone Modulated FM Signal, Arbitrary Modulated FM signal, Concept of narrowband and wideband FM(PM), FM Modulators: Direct & Indirect methods, Demodulators: limiter and discriminator. **(Ref: TB 1, Ch 3)**

Radio Transmitter and Receiver: FM and AM Super heterodyne receiver, image frequency and its rejection, FM stereo broadcasting.

Module No. 4	Digital Transmission of Analog Signal and Pulse Modulation:	7 hrs

Concept of sampling, types of sampling, Time and frequency analysis of Sampling Theorem **(Ref: TB 2, Ch 5/TB1. Ch 4)**

Pulse Modulation: Pulse Amplitude Modulation: bandwidth, generation and recovery, Time division multiplexing of PAM signals, Pulse Width Modulation and Pulse Position Modulation. **(Ref: TB 1, Ch 4)**

Module No. 5	Digital Representation of Analog Signal	6 hrs

Quantization of signals, Quantization error, Pulse Code Modulation, Commanding, Line coding techniques, Delta Modulation, Adaptive delta modulation. **(Ref: TB 1, Ch 4)**

Degree	B. Tech.	
Level	Undergraduate	
Branch	EEE (Electrical & Electronics Engineering)	
Semester	7th	
Subject Name	Power System Protection	
Course Type	Theory	
Course Code	22EEE7PC02T	
Category	PCC (Professional Core Courses)	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	Nil
	Practice	Nil
	Total	36 Hours
Recommended Background Knowledge	Basic understanding of Power System	
Subject Description	Power system protection is the science and practice of detecting and isolating faults (like short circuits) in electrical power grids to prevent damage and maintain system stability. It ensures safety and reliability by quickly disconnecting faulty components while minimizing disruption to the rest of the system.	
Objectives and Outcomes	1. To understand the need of protection of electric equipment and their protection schemes. 2. Introduce students to power system protection and switchgear. 3. To understand operations & characteristics of various electromagnetic and static relays. 4. To understand the operations of various types of circuit breakers and their ratings. 5. To understand the unit protection and over voltage protection of different apparatus in power system. 6. To understand the unit protection and over voltage protection of different apparatus in power system. 7. Develop in students an ability and skill to design the feasible protection	

	systems needed for each main part of a power system.	
	1. Understand the fundamental need for power system protection and identify the key components and principles involved in protective systems. 2. Analyze symmetrical and unsymmetrical faults in power systems using sequence components and fault calculation techniques. 3. Evaluate the operation and characteristics of different types of relays and protection schemes used for feeders and transmission lines. 4. Apply protection schemes for major power system apparatus and examine the working and testing of various types of circuit breakers.	
Assessment/ Evaluation	Mid-Term Examination	30 %
	Quiz Test-1	2.5 %
	Quiz-Test-2	2.5 %
	Surprise Test	5 %
	Assignment-1	2.5 %
	Assignment-2	2.5 %
	Attendance	5 %
	End-Term Examination	50 %
Prescribed Text Book(s)	1. Power System Protection and Switchgear – B.Ravindranath & M.Chander–New Age International Publishers (Second Edition). 2. John J Grainger, W. D. Stevenson, “Power System Analysis”, TMH Publication. 3. Van C Warrington, “Protective Relays”, Vol.-I & II. 4. Power System Protection and Switchgear - Badri Ram, Vishwakarma, Tata McGraw hill. 5. Fundamentals of Power System Protection – Y.G.Paithankar and S.R.Bhide, PHI 7th Semester REL6D001 Electric Power System	
Reference Book(s)	1. Electrical Power System - C.L.Wadhwa New Age International Publishers. (Sixth Edition). 2. Protection and Switchgear - B.Bhalja, R.P.Maheshwari, N.G. Chothani, OXFORD University Press. 3. Switchgear and Protection – Sunil S Rao , Khanna Publishers, New Delhi.	

<table>
<tr><td></td><td>Power System relaying by Horwitz, Phadke, Research Press</td></tr>
<tr><td>Digital Learning Resources</td><td>
<table>
<tr><td>Course Name</td><td>Power System Protection</td></tr>
<tr><td>Course Link</td><td>https://nptel.ac.in/courses/108/105/108105167/</td></tr>
<tr><td>Course Instructor</td><td>Prof. Ashok Kumar Pradhan, IIT Kharagpur</td></tr>
<tr><td>Course Name</td><td>Power System Protection and Switchgear</td></tr>
<tr><td>Course Link</td><td>https://nptel.ac.in/courses/108/107/108107167</td></tr>
<tr><td>Course Instructor</td><td>Prof. Bhaveshkumar R. Bhalja, IIT Roorkee</td></tr>
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CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Understand the fundamental need for power system protection and identify the key components and principles involved in protective systems	PO1, PO2,PO10
CO2	Analyze symmetrical and unsymmetrical faults in power systems using sequence components and fault calculation techniques	PO1, PO2, PO3, PO4, PO5, P12
CO3	Evaluate the operation and characteristics of different types of relays and protection schemes used for feeders and transmission lines.	PO1,PO2, PO3, PO4,PO5, PO10, PO12
CO4	Apply protection schemes for major power system apparatus and examine the working and testing of various types of circuit breakers	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO11, PO12

DETAILED SYLLABUS:

Module No. 1	Introduction:	**06 hours**
Need for protective schemes, Nature and causes of faults, Zones of protection, Primary and back-up protection, Essential qualities of protection, Basic principle of operation of protective system, Components of Protection System		

Module No. 2	Sequence Components and Fault Analysis:	**06 Hours**
Significance of positive, negative and zero sequence ,sequence impedance, fault calculations, sequence network equations, Single line to ground fault, Line to ground fault with Zf, Faults in Power systems, and Concept of short circuit capacity of a Bus		

Module No. 3	Operating Principles and Relay Construction:	**08 Hours**
Relay Classification, Types of Electromagnetic Relays, Relay design and construction, Theory of Induction relay torque, General Equations of Comparators and Electromagnetic Relays, Over Current relays, Directional relays, Distance relays, Differential relays. Feeder Protection: Over current, Distance and. Static Relays: Basis for static relay development, Basic elements of a static relay, Over Current Relays, Differential Protection, Static distance Protection.		

Module No. 4	Apparatus Protection:	**08Hours**
Transformer Protection, Generator Protection, Motor Protection, Bus bar protection schemes. Numerical relays: Block Diagram of Numerical Relay, Signal Sampling & Processing, Numerical Over-current protection, Numerical Transformer differential Protection, Numerical distance Protection of Transmission Line		

Module No. 5	Switchgears: Auto reclosing:	**07 Hours**
Theory of Circuit interruption, Circuit constants in relation to Circuit breaking, Re-striking voltage transient, characteristics of Re-striking Voltage, Interaction between breaker and circuit, Current chopping. Circuit Breakers: Types of circuit breakers (air blast, air break, oil, vacuum, SF6, DC circuit breaker), advantages and testing of circuit breaker		

Degree	B. Tech.	
Level	Undergraduate	
Branch	EEE (Electrical & Electronics Engineering)	
Semester	7th	
Subject Name	Energy Auditing and Sustainable Management	
Course Type	Theory	
Course Code	22EEE7PE01T	
Category	PEC (Professional Elective Courses)	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	Nil
	Practice	Nil
	Total	36 Hours
Recommended Background Knowledge		
Subject Description	Energy auditing and sustainable management are processes focused on improving energy efficiency and reducing environmental impact. Energy auditing identifies where and how energy is used, while sustainable management implements strategies to reduce consumption and optimize resource use. Together, they help organizations minimize energy cost and reduce the carbon footprint.	
Objectives and Outcomes	1. To facilitate the students to achieve a clear conceptual understanding of technical and commercial aspects of energy conservation and energy auditing. 2. To enable the students to develop managerial skills to assess feasibility of alternative approaches and drive strategies regarding energy conservation and energy auditing	
	1. Conceptual knowledge of the technology, economics and regulation related issues associated with energy conservation and energy auditing 2. Ability to analyze the viability of energy conservation projects 3. Capability to integrate various options and assess the business and policy environment regarding energy conservation and energy auditing 4. Advocacy of strategic and policy recommendations on energy	

<table>
<tr><td></td><td colspan="2">conservation and energy auditing</td></tr>
<tr><td rowspan="9">Assessment/ Evaluation</td><td>Mid-Term Examination</td><td>30 %</td></tr>
<tr><td>Quiz Test-1</td><td>2.5 %</td></tr>
<tr><td>Quiz-Test-2</td><td>2.5 %</td></tr>
<tr><td>Surprise Test</td><td>5 %</td></tr>
<tr><td>Assignment-1</td><td>2.5 %</td></tr>
<tr><td>Assignment-2</td><td>2.5 %</td></tr>
<tr><td>Attendance</td><td>5 %</td></tr>
<tr><td>End-Term Examination</td><td>50 %</td></tr>
<tr><td>Prescribed Text Book(s)</td><td colspan="2">[1] Energy Management: W. R. Murphy, G. Mckay (Butterworths).
[2] Energy Management Principles: C. B. Smith (Pergamon Press).
[3] Efficient Use of Energy : I. G. C. Dryden (Butterworth Scientific)
[4] Energy Economics - A. V. Desai (Wiley Eastern)
[5] Industrial Energy Conservation : D. A. Reay (Pergammon Press)
[6] Energy Management Handbook – W. C. Turner (John Wiley and Sons, A Wiley Interscience Publication)</td></tr>
<tr><td>Reference Book(s)</td><td colspan="2">[1] Industrial Energy Management and Utilization – L. C. Witte, P. S. Schmidt, D. R. Brown (Hemisphere Publication, Washington)
[2] Industrial Energy Conservation Manuals, MIT Press, Mass, 1982
Energy Conservation guide book Patrick/Patrick/Fardo (Prentice Hall)</td></tr>
<tr><td>Digital Learning Resources</td><td colspan="2"><table><tr><td>Course Name</td><td>Energy management System</td></tr><tr><td>Course Link</td><td>https://nptel.ac.in/courses/108106022</td></tr><tr><td>Course Instructor</td><td>Dr. K. Shanti Swarup, IIT Madras</td></tr></table></td></tr>
</table>

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Conceptual knowledge of the technology, economics and regulation related issues associated with energy conservation and energy auditing	PO1, PO2, PO3, PO4,PO12
CO2	Ability to analyze the viability of energy conservation projects .	PO1, PO2, PO3, PO4
CO3	Capability to integrate various options and assess the business and policy environment regarding energy conservation and energy auditing	PO1,PO2, PO3, PO4,PO5
CO4	Advocacy of strategic and policy recommendations on energy conservation and energy auditing	PO1, PO2, PO3, PO4, PO5, PO12

DETAILED SYLLABUS:

Module No. 1	**General Aspects :**	**06 hours**
General Philosophy and need of Energy Audit and Management: Definition and Objective of Energy Management, General Principles of Energy Management, Energy Management Skills, **Energy Audit:** Need, Types, Methodology and Approach. Energy Management Approach, Understanding Energy Costs, Optimizing the input energy requirements, Fuel and Energy substitution		

Module No. 2	**Procedures and Techniques:**	**09 Hours**

Data gathering: Level of responsibilities, energy sources, control of energy and uses of energy get Facts, figures and impression about energy/fuel and system operations, **Analytical Techniques:** Incremental cost concept, mass and energy balancing techniques, inventory of Energy inputs and rejections, Heat transfer calculations **Evaluation of saving opportunities:** Determining the savings in Rupees, Noneconomic factors, Conservation opportunities, estimating cost of implementation. **Energy Audit Reporting:** The plant energy study report- Importance, contents, effective organization, report writing and presentation.

Module No. 3	**Energy Policy Planning and Implementation:**	**07 Hours**
Key Elements: Force Field Analysis, Energy Policy-Purpose, Perspective, Contents and Formulation. **Format and Ratification Organizing:** Location of Energy Manager, Top Management Support, Managerial functions, Role and responsibilities of Energy Manager, Accountability. Motivating Motivation of employees. **Information Systems:** Designing, Barriers, Strategies, Marketing and Communicating Training and Planning		

Module No. 4	**Energy Balance & MIS**	**06 Hours**
Energy Balance: First law of efficiency and Second law of efficiency, Facility as an Energy system, Methods for preparing process flow, Materials and Energy Balance diagram, Energy Balance sheet and Management Information System (MIS) Energy Modeling and Optimization.		

Module No. 5	**Energy Audit Instruments**	**05 Hours**
Energy Audit Instruments: Instruments for Audit and Monitoring Energy and Energy Savings, Types and Accuracy		

Degree	B. Tech.	
Level	Undergraduate	
Branch	EEE (Electrical & Electronics Engineering)	
Semester	7th	
Subject Name	Smart Grid Technology	
Course Type	Theory	
Course Code	22EEE7PE02T	
Category	PEC (Professional Elective Courses)	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	Nil
	Practice	Nil
	Total	36 Hours
Recommended Background Knowledge		
Subject Description	A smart grid is an advanced electricity network that utilizes digital technologies and two-way communication to improve the efficiency, reliability, and sustainability of electricity delivery. It integrates digital technologies like sensors, smart meters, and automation to monitor, control, and optimize the flow of electricity from generation to consumption	
Objectives and Outcomes	1. Smart electric power grids, including definition, design criteria and technology. Information processing and communications to the power grid. 2. Understanding the development of the smart grid, Smart grid design, implementation, evaluation and management of smart electricity infrastructure. 3. To provide students with a working knowledge of fundamentals and development of Smart Grid, from the basic concepts of power systems.	
	1. Understand features of Smart Grid in the context of Indian Grid. 2. Analyze the role of automation in Transmission/Distribution 3. Apply Evolutionary Algorithms for the Smart Grid/Distribution Generation. 4. Understand operation and importance of PMUs, PDCs, WAMS, Voltage and Frequency control in Micro Grids	

Assessment/ Evaluation	Mid-Term Examination	30 %
	Quiz Test-1	2.5 %
	Quiz-Test-2	2.5 %
	Surprise Test	5 %
	Assignment-1	2.5 %
	Assignment-2	2.5 %
	Attendance	5 %
	End-Term Examination	50 %
Prescribed Text Book(s)	[1] Mani Vadari, Smart Grid Redefined: Transformation of the electric utility, Artech House, 2018. [2] Stuart Borlase, Smart Grids, Infrastructure, Technology and Solutions, CRC Press,2013 [3] A.G. Phadke and J.S. Thorp, "Synchronized Phasor Measurements and their Applications", Springer Edition, 2010	
Reference Book(s)	[1] M. L. Scala, S. Bruno, C. A. Nucci, S. Lamonaca, U. Stecch, "Smart Grids to the Smart Cities: New Paradigms for Future Networks", Vol-II, Wiley publication, 2017 [2] Gil Masters, Renewable and Efficient Electric Power System, Wiley–IEEE Press, 2004. [3] T. Ackermann, Wind Power in Power Systems, Hoboken, NJ, USA, John Wiley,2005 [4] N. Ramesh Babu, Smart Grid Systems: Modeling and Control, 1st ed, CRC Press, 2019	

Digital Learning Resources	

Course Name	Introduction to Smart Grid
Course Link	https://nptel.ac.in/courses/108107113
Course Instructor	Dr. N.P.Padhy and Dr. Premalata Jena, IIT Roorkee

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Understand features of Smart Grid in the context of Indian Grid	PO1, PO2, PO3, PO4,PO12
CO2	Analyze the role of automation in Transmission/Distribution	PO1, PO2, PO3, PO4
CO3	Apply Evolutionary Algorithms for the Smart Grid/Distribution Generation	PO1,PO2, PO3, PO4,PO5
CO4	Understand operation and importance of PMUs, PDCs, WAMS, Voltage and Frequency control in Micro Grids	PO1, PO2, PO3, PO4, PO5, PO12

DETAILED SYLLABUS:

Module No. 1	Introduction to Smart Grid:	**06 hours**
Introduction to Smart Grid - Working definitions of Smart Grid and Associated Concepts – Smart Grid Functions – Traditional Power Grid and Smart Grid – New Technologies for Smart Grid – Advantages – Indian Smart Grid – dimensions of smart grid-Key Challenges for Smart Grid.		

Module No. 2	Smart Grid Architecture:	**09 Hours**
Components and Architecture of Smart Grid Design – Review of the proposed architectures for Smart Grid. The fundamental components of Smart Grid designs – Transmission Automation – Distribution Automation – Renewable and distributed energy Integration Tools and Techniques for Smart Grid: Computational Techniques – Static and Dynamic Optimization Techniques – Computational Intelligence Techniques – Evolutionary Algorithms, Artificial Intelligence techniques.		

Module No. 3	Distribution Generation Technologies	**07 Hours**
:Introduction to Renewable Energy Technologies – Micro grids– Storage Technologies –Electric Vehicles and plug – in hybrids – Environmental impact and Climate Change – Economic Issues		

Module No. 4	Communication Technologies and Smart Grid	**6 Hours**
Introduction to Communication Technology-Synchro-Phasor Measurement Units (PMUs) – Wide Area Measurement Systems (WAMS		

Module No. 5	Control of Smart Power Grid System and Smart Cities:	**05 Hours**
Load Frequency Control (LFC) in Micro Grid System – Voltage Control in Micro Grid System – Reactive Power Control in Smart Grid. Case Studies and Test beds for the Smart Grids, Smart Grids to the Smart Cities: New Paradigms for Future Networks		

Degree	B. Tech.	
Level	Undergraduate	
Branch	EEE (Electrical & Electronics Engineering)	
Semester	7th	
Subject Name	Artificial Intelligence and Machine Learning	
Course Type	Theory	
Course Code	22EEE7PE03T	
Category	PEC (Professional Elective Courses)	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	Nil
	Practice	Nil
	Total	36 Hours
Recommended Background Knowledge		
Subject Description	Artificial intelligence encompasses the idea of a machine that can mimic human intelligence, machine learning does not. Machine learning aims to teach a machine how to perform a specific task and provide accurate results by identifying patterns.	
Objectives and Outcomes	1. Introduce the basic principles, techniques, and applications of Artificial Intelligence. 2. Demonstrate fundamental understanding of the history of artificial intelligence (AI) and its foundations. 3. Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation, and learning. 4. To understand the basic theory underlying machine learning. 5. To be able to formulate machine learning problems corresponding to different applications. 6. To understand a range of machine learning algorithms along with their strengths and weaknesses. 7. To be able to apply machine learning algorithms to solve problems of moderate complexity.	
	1. Analyze AI and searching methods. 2. Plan knowledge management, uncertainty management.	

	3. Apply neural network learning. 4. Construct and implement extended neural network learning methods. And Develop probabilistic and statistical learning	
Assessment/ Evaluation	Mid-Term Examination	30 %
	Quiz Test-1	2.5 %
	Quiz-Test-2	2.5 %
	Surprise Test	5 %
	Assignment-1	2.5 %
	Assignment-2	2.5 %
	Attendance	5 %
	End-Term Examination	50 %
Prescribed Text Book(s)	[1] Applied Machine Learning, M.Gopal, McGraw-Hill. [2] Artificial Intelligence and Soft Computing: Behavioral and Cognitive Modeling of the Human Brain, Amit Konar, CRC Press [3] Artificial Intelligence, Dan W Patterson, Prentice Hall of India [4] S. Russel and P. Norvig, "Artificial Intelligence – A Modern Approach", Second Edition, Pearson Education	
Reference Book(s)	[1] Artificial Intelligence, Nils J.Nilsson, ELSEVIER. [2] E.Rich and K.Knight, Artificial Intelligence, - TMH	

Digital Learning Resources	

Course Name	Machine Learning, ML
Course Link	https://nptel.ac.in/courses/106106202
Course Instructor	Prof. Carl Gustaff Janssan, Prof. Henrik Bostorm, Prof. Fredrik Kilander
Course Name	Artificial Intelligence
Course Link	https://nptel.ac.in/courses/106105077
Course Instructor	Prof. Anupam Basu and Prof. S. Sarkar, IIT Kharagpur

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Analyze AI and searching methods.	PO1, PO2, PO3, PO4,PO12
CO2	Plan knowledge management, uncertainty management	PO1, PO2, PO3, PO4
CO3	Apply neural network learning	PO1,PO2, PO3, PO4,PO5
CO4	Construct and implement extended neural network learning methods. And Develop probabilistic and statistical learning.	PO1, PO2, PO3, PO4, PO5, PO12

DETAILED SYLLABUS:

Module No. 1	Introduction to AI and Search Techniques:	**06 hours**
Introduction to AI, production system, production rules, State-space problem, Problem Solving by Intelligent search: BFS, DFS, Iterative Deepening Search, Hill Climbing, Simulated Annealing, heuristic Search: A*,AO* , Adversary Search: MIN-MAX Algorithm, Alpha-Beta Cut-off algorithm.		

Module No. 2	Knowledge and Reasoning Propositional Logic	**07 Hours**
Theorem Proving by Propositional Logic, Resolution principle, Predicate Logic, wff conversion to clausal form, Dealing with Imprecision and Uncertainty: Probabilistic Reasoning, Dempster-Shafer Theory for Uncertainty Management.		

Module No. 3	Machine Learning:	**06 Hours**
Supervised learning, unsupervised learning, Reinforcement learning, Artificial Neural Net, perceptron model, feed-forward neural network, Back propagation		

Module No. 4	Computational learning	08 Hours
Computational learning tasks for predictions, learning as function approximation, generalization concept. Linear models and Nearest-Neighbors (learning algorithms and properties, regularization). Neural Networks (MLP and deep models, SOM		

Module No. 5		08 Hours
Probabilistic graphical models. Principles of learning processes: elements of statistical learning theory, model validation. Support Vector Machines and kernel-based models. Introduction to applications and advanced models		

Degree	B. Tech.	
Level	Undergraduate	
Branch	EEE (Electrical & Electronics Engineering)	
Semester	7th	
Subject Name	Optical and Satellite Communication	
Course Type	Theory	
Course Code	22EEE7PE04T	
Category	PEC (Professional Elective Courses)	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	Nil
	Practice	Nil
	Total	36 Hours
Recommended Background Knowledge		
Subject Description	Optical communication transmits data using light signals, either through optical fibers or free space, offering high bandwidth and security. Satellite communication uses satellites orbiting the Earth to relay data between different locations, providing global coverage. Both technologies are used for long-distance communication but differ in their medium and specific applications	
Objectives and Outcomes	1. **Global Coverage:** Providing communication services to areas where terrestrial infrastructure is unavailable or impractical. 2. **Remote Area Access:** Connecting remote and underserved regions to the global network. 3. **Disaster Recovery:** Maintaining communication during and after natural disasters. 4. **Mobile Communication:** Enabling communication for mobile users and vehicles	
	1. Express the basic structures of optical fiber and types. 2. Create basic communication system using principles of optical sources and detectors. 3. Analyze the basic principles of the satellite systems. 4. Analyze the principles of the satellite launching and Link Model. And Demonstrate various application of satellite systems.	
Assessment/ Evaluation	Mid-Term Examination	30 %

	Quiz Test-1	2.5 %
	Quiz-Test-2	2.5 %
	Surprise Test	5 %
	Assignment-1	2.5 %
	Assignment-2	2.5 %
	Attendance	5 %
	End-Term Examination	50 %
Prescribed Text Book(s)	[1] Optical Fiber Communications by Gerd Keiser, 4th Edition, Mc Graw-Hill International Editions. [2] Satellite Communications by Timothy Pratt, Charles Bostian and Jeremy Allnutt, 2nd Edition, Wiley Student Edition.	
Reference Book(s)	1. Satellite Communications Systems: Systems, Techniques and Technology" by Gerard Maral and Michel Bousquet 2. Satellite Communications Systems: Systems, Techniques and Technology (Wiley Series in Communication and Distributed Systems)" by Gerard Maral and Michel Bousquet	
Digital Learning Resources		

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Express the basic structures of optical fiber and types	PO1, PO2, PO3, PO4,PO12
CO2	Create basic communication system using principles of optical sources and detectors	PO1, PO2, PO3, PO4
CO3	Analyze the basic principles of the satellite systems	PO1,PO2, PO3, PO4,PO5
CO4	Analyze the principles of the satellite launching and Link Model and demonstrate various application of satellite systems	PO1, PO2, PO3, PO4, PO5, PO12

DETAILED SYLLABUS:

Module No. 1		**08 hours**
Overview of optical fiber communications: Optical spectral bands, Fundamental of data communication concepts, WDM concepts, Key elements of optical fiber systems, Standards for optical fiber communications. Optical fiber modes and configurations: Single-mode fibers, Graded-index fiber structure, Fiber materials		

Module No. 2		**08 Hours**
Signal degradation in optical fibers: Attenuation, Signal distortion of single- mode fibers, Characteristics of single-mode fibers. Optical sources: LED and LASER Diodes, PIN Photo Detector, Avalanche Photo Diode, Optical Fiber System Link Budget		

Module No. 3		**06 Hours**
Orbital mechanics and launchers: Orbital mechanics, Look angle determination, Orbital perturbations, Orbital determination, Launches and launch vehicles, Orbital effects in communications systems performance.		

Module No. 4		**08 Hours**
Satellite Launching, Earth Station, Satellite Subsystems, Satellite System Link Models, Link Equations		

Module No. 5		**06 Hours**
Multiple Access, Direct Broadcast Satellite Services, Application of LEO, MEO and GEO Satellites		

Degree	B. Tech.	
Level	Undergraduate	
Branch	EEE (Electrical & Electronics Engineering)	
Semester	7th	
Subject Name	Flexible AC Transmission Systems	
Course Type	Theory	
Course Code	22EEE7PE05T	
Category	PEC (Professional Elective Courses)	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	Nil
	Practice	Nil
	Total	36 Hours
Recommended Background Knowledge		
Subject Description	A Flexible AC Transmission System (FACTS) is a power electronics-based system designed to enhance the controllability and power transfer capability of AC transmission networks. It utilizes static controllers to improve the dynamic and static transmission capacity of electrical grids, addressing limitations like power flow control, voltage stability, and transient oscillations	
Objectives and Outcomes	1. The students would be able to learn the general concepts of power system, Power Flow and Dynamic Stability Considerations of a Transmission Interconnection, classification of FACTS controller, objective of shunt and series compensation. 2. The students should learn how to represent the variable impedance type shunt compensators system and VSC based shunt compensator. 3. The students should learn how to represent the variable impedance type series compensators system and VSC based series compensator. 4. Students can be able to learn generalized and multifunctional FACTS Controller.	
	1. Describe how FACTS controllers are designed. 2. Explain and analyze the various controllers used in shunt and series	

<table>
<tr><td></td><td colspan="2">compensators.
3. Perform calculations on different control strategies for these shunt and series controllers.
4. Analyze performance characteristics of system using various FACTS controller methods</td></tr>
<tr><td rowspan="9">Assessment/ Evaluation</td><td>Mid-Term Examination</td><td>30 %</td></tr>
<tr><td>Quiz Test-1</td><td>2.5 %</td></tr>
<tr><td>Quiz-Test-2</td><td>2.5 %</td></tr>
<tr><td>Surprise Test</td><td>5 %</td></tr>
<tr><td>Assignment-1</td><td>2.5 %</td></tr>
<tr><td>Assignment-2</td><td>2.5 %</td></tr>
<tr><td>Attendance</td><td>5 %</td></tr>
<tr><td>End-Term Examination</td><td>50 %</td></tr>
<tr><td>Prescribed Text Book(s)</td><td colspan="2">1. Understanding FACTS: Concepts & Technology of Flexible AC Transmission Systems” By N.G.Hingorani & L.Gyugyi, IEEE Press, Standard Publishers Distributors, Delhi</td></tr>
<tr><td>Reference Book(s)</td><td colspan="2">[1] Facts Controllers in Power Transmission & Distribution by K.R.Padiyan, New Age International.
[2] Modeling & Simulation in Power Networks, Enrique Acha, Clandio Esquival & H.A.Perez, CA Camcho, John Wiley & Sons</td></tr>
<tr><td>Digital Learning Resources</td><td colspan="2"><table><tr><td>Course Name</td><td>FACTS</td></tr><tr><td>Course Link</td><td>https://nptel.ac.in/courses/108107114</td></tr><tr><td>Course Instructor</td><td>Prof. Avik Bhattacharya, IIT Roorkee</td></tr></table></td></tr>
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CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Describe how FACTS controllers are designed	PO1, PO2, PO3, PO4,PO12
CO2	Explain and analyze the various controllers used in shunt and series compensators.	PO1, PO2, PO3, PO4
CO3	Perform calculations on different control strategies for these shunt and series controllers	PO1,PO2, PO3, PO4,PO5
CO4	Analyze performance characteristics of system using various FACTS controller methods	PO1, PO2, PO3, PO4, PO5, PO12

DETAILED SYLLABUS:

Module No. 1	**Introduction:**	**08 hours**
FACTS concept and General System Considerations: Transmission Interconnections, Flow of Power in an AC System, Loading Capability, Power Flow and Dynamic Stability Considerations of a Transmission Interconnection, Relative Importance of Controllable Parameters, and FACTS Controllers.		

Module No. 2	**Static Shunt Compensation**:	**08 Hours**
Objectives of shunt compensation, Methods of controllable VAR generation, Static Var Compensator, its characteristics, TCR, TSC, FC-TCR configurations, STATCOM, basic operating principle, control approaches and characteristics		

Module No. 3	**Series Compensation**	**08 Hours**
Objectives of series compensator, variable impedance type of series compensators, TCSC, TSSC-operating principles and control schemes, SSSC, Power Angle characteristics, Control range and VAR rating, Capability to provide reactive power compensation, external control		

Module No. 4	Static Voltage and Phase Angle Regulators:	06 Hours
Objectives of Voltage and Phase Angle Regulators, Approaches to Thyristor-Controlled Voltage and Phase Angle Regulators (TCVRs and TCPARs).		

Module No. 5	Combined Compensators:	06 Hours
Unified Power Flow Controller (UPFC), Interline Power Flow Controller (IPFC), Generalized and Multifunctional FACTS Controllers		

Degree	B. Tech.	
Level	Undergraduate	
Branch	EEE (Electrical & Electronics Engineering)	
Semester	7th	
Subject Name	Soft Computing Techniques and Applications	
Course Type	Theory	
Course Code	22EEE7PE06T	
Category	PEC (Professional Elective Courses)	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	Nil
	Practice	Nil
	Total	36 Hours
Recommended Background Knowledge		
Subject Description	Soft computing techniques are a collection of computational approaches designed to tackle complex problems by mimicking human-like reasoning and decision-making processes. These techniques, including fuzzy logic, neural networks, and genetic algorithms, are particularly useful when dealing with uncertainty, imprecision, and partial truths, offering a more flexible and adaptable approach compared to traditional "hard" computing methods	
Objectives and Outcomes	1. The course will cover the fundamental concepts used in soft computing such as artificial neural network followed by fuzzy logic and genetic algorithm. 2. Neural Networks, architecture, functions and various algorithms involved. 3. Fuzzy Logic, Various fuzzy systems and their functions. 4. Genetic algorithms, its applications and advances. 5. Application of soft computing to power systems	
	1. Differentiate between Algorithmic based methods and knowledge based methods 2. Use the soft computing techniques for power system problems 3. Use appropriate AI framework for solving power system problems Apply GA to power system optimization problems 4. Apply GA to power system optimization problems	

<table>
<tr><td></td><td colspan="2"></td></tr>
<tr><td rowspan="8">Assessment/ Evaluation</td><td>Mid-Term Examination</td><td>30 %</td></tr>
<tr><td>Quiz Test-1</td><td>2.5 %</td></tr>
<tr><td>Quiz-Test-2</td><td>2.5 %</td></tr>
<tr><td>Surprise Test</td><td>5 %</td></tr>
<tr><td>Assignment-1</td><td>2.5 %</td></tr>
<tr><td>Assignment-2</td><td>2.5 %</td></tr>
<tr><td>Attendance</td><td>5 %</td></tr>
<tr><td>End-Term Examination</td><td>50 %</td></tr>
<tr><td>Prescribed Text Book(s)</td><td colspan="2">[1] Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharan and Pai – PHI Publication.
[2] Fuzzy logic with Fuzzy Applications – T.J Ross – Mc Graw Hill Inc, 1997</td></tr>
<tr><td>Reference Book(s)</td><td colspan="2">[1] Neural Networks: A comprehensive Foundation – Simon Haykins, Pearson Edition, 2003.
[2] Yegnanarayana B, “Artificial Neural Networks”, Prentice hall of India Private Ltd., New Delhi, 1999.
[3] Zurada, J.M., “Introduction to Artificial Neural Systems“, Jaico publishing house, Bombay, 1992.
[4] Zimmermann, H.J., “Fuzzy set theory and its applications“, Allied publishers limited, Madras, 2001.</td></tr>
<tr><td>Digital Learning Resources</td><td colspan="2"><table><tr><td>Course Name</td><td>Introduction to Soft Computing</td></tr><tr><td>Course Link</td><td>https://nptel.ac.in/courses/106105173</td></tr><tr><td>Course Instructor</td><td>Prof. Debasis Samanta, IIT Kharagpur</td></tr></table></td></tr>
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CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Differentiate between Algorithmic based methods and knowledge based methods	PO1, PO2, PO3, PO4,PO12
CO2	Use the soft computing techniques for power system problems	PO1, PO2, PO3, PO4
CO3	Use appropriate AI framework for solving power system problems Apply GA to power system optimization problems	PO1,PO2, PO3, PO4,PO5
CO4	Apply GA to power system optimization problems	PO1, PO2, PO3, PO4, PO5, PO12

DETAILED SYLLABUS:

Module No. 1	Artificial Neural Networks (ANN)	10 hours
Definition and fundamental concepts – Biological neural networks – Artificial neuron – activation functions – setting of weights – typical architectures – biases and thresholds – learning/training laws and algorithms. Perceptron – architectures, ADALINE and MADLINE – linear separability- XOR function.		

Module No. 2	ANN Paradigms:	08 Hours
ADALINE – feed forward networks – Back Propagation algorithm- number of hidden layers – gradient decent algorithm – Radial Basis Function (RBF) network. Kohonen‟s self-organizing map (SOM), Learning Vector Quantization (LVQ) and its types – Functional Link Networks (FLN) – Bidirectional Associative Memory (BAM) – Hopfield Neural Networkof hidden layers – gradient decent algorithm – Radial Basis Function (RBF) network. Kohonen‟s self-organizing map (SOM), Learning Vector Quantization (LVQ) and its types – Functional Link Networks (FLN) – Bidirectional Associative Memory (BAM) – Hopfield Neural Network		

Module No. 3	Classical and Fuzzy Sets:	08 Hours
Introduction to classical sets- properties, Operations and relations; Fuzzy sets, Membership, Operations, Properties, Fuzzy relations, Cardinalities, Membership functions.Fuzzy logic controller (flc): Fuzzy logic system components: Fuzzification, Inference engine (development of rule base and decision making system), Defuzzification to crisp sets- Defuzzification methods.		

Module No. 4	Evolutionary Algorithms:	06 Hours
Fundamental of Genetic Algorithm, Creation of off springs, working principle, Encoding, Fitness Function, Reproduction, Roulette-wheel selection, Boltzmann Selection, Tournament Selection, Rank Selection, Steady State Selection, Elitism.		

Module No. 5	Application of ANN and FLC	08 Hours
Applications of ANN- Load flow study in power systems, Economic load dispatch, Load forecasting, Applications of ANN for power system protection, Applications of FLC- Load frequency control- Single area and two area systems- Speed control of DC motor. Unit commitment problem solution using evolutionary algorithms		

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Degree	B. Tech.	
Level	Undergraduate	
Branch	EEE (Electrical & Electronics Engineering)	
Semester	7th	
Subject Name	Energy Storage Systems and Applications	
Course Type	Theory	
Course Code	22EEE7PE07T	
Category	PEC (Professional Elective Courses)	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	Nil
	Practice	Nil
	Total	36 Hours
Recommended Background Knowledge		
Subject Description	Energy storage systems (ESS) are designed to store energy for later use, addressing mismatches between energy supply and demand. They play a crucial role in integrating renewable energy sources like solar and wind into the grid by mitigating intermittency and variability. ESS applications range from personal devices and appliances to large-scale grid support, including power quality, microgrids, and utility-level storage.	
Objectives and Outcomes	1. To energy storage systems and provides a broad understanding and appreciation of the scientific principles that underpin the operation of such systems. 2. To provide a foundation for understanding the general principles and fundamentals of Li-Ion battery technology design and operation. 3. To learn basic electrochemical principles of the hydrogen fuel cells, basic fuel cell design concepts, fuel cell systems concepts. 4. The on grid-scale (or utility-scale) energy storage as a means of addressing the intermittency of renewable energy components (e.g. solar or wind power systems) of modern electricity networks	
	1. Understand various energy storage technologies. 2. Develop an algorithm to estimate the state of charge and state of health of a	

	battery 3. Develop the energy management control of a storage system in a grid connected 4. Develop the control algorithm to a grid-connected storage system to improve the grid reliability	
Assessment/ Evaluation	Mid-Term Examination	30 %
	Quiz Test-1	2.5 %
	Quiz-Test-2	2.5 %
	Surprise Test	5 %
	Assignment-1	2.5 %
	Assignment-2	2.5 %
	Attendance	5 %
	End-Term Examination	50 %
Prescribed Text Book(s)	[1] Grid-scale Energy Storage Systems and Applications, Fu-Bao Wu, Bo Yang, Ji-Lei Ye, Elsevier - Academic Press, 2019, 1st edition. [2] Energy Storage Devices for Renewable Energy-Based Systems, Nihal Kularatna Kosala Gunawardane, Elsevier - Academic Press, 2019, 2nd edition. [3] Ultra-Capacitors in Power Conversion Systems: Applications, Analysis, and Design from Theory to Practice, Petar J. Grbovic, Wiley-IEEE Press, 2013, 1st edition.	
Reference Book(s)	[1] Energy Storage: A New Approach, Ralph Zito, Haleh Ardebili, Wiley, 2019, 2nd Edition. [2] Energy Storage for Power System Planning and Operation, Zechun Hu , Wiley, 2020, 1st edition. [3] Fuel Cell Systems Explained, Andrew L. Dicks, David A. J. Rand, Wiley,	

	2018, 3rd Edition
Digital Learning Resources	Course Name: Electrochemical Energy Storage Course Link: https://nptel.ac.in/courses/113105102 Course Instructor: Prof. Subhasish Basu Majumder, IIT Kharagpur

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Understand various energy storage technologies	PO1, PO2, PO3, PO4,PO12
CO2	Develop an algorithm to estimate the state of charge and state of health of a battery	PO1, PO2, PO3, PO4
CO3	Develop the energy management control of a storage system in a grid connected	PO1,PO2, PO3, PO4,PO5
CO4	Develop the control algorithm to a grid-connected storage system to improve the grid reliability	PO1, PO2, PO3, PO4, PO5, PO12

DETAILED SYLLABUS:

Module No. 1	**Development of energy storage technology**:	**08 hours**
Basic concept, history of energy storage technologies, demand functions of energy storage technology in power system, application outlook and challenges of energy storage technology in power system		

Module No. 2	**Technology of energy storage systems:**	**09 Hours**
Electrochemical energy storage: lead-acid battery, lithium-ion battery, vanadium redox battery, zinc-bromine, sodium sulphur; physical energy storage: pump hydro storage compressed air energy storage, flywheel energy storage; electromagnetic energy storage: super capacitor energy storage, superconducting magnetic energy storage; new type energy storage: advanced lead-acid batter, lithium-sulphur battery, sodium-ion battery, heat pump storage, gravity energy storage; comprehensive comparison of energy storage technologies: technical maturity, performance parameters, applications		

Module No. 3	**Technologies for battery management**:	**08 Hours**
Battery management systems: typical structures, main functions; state of charge (SOC) estimation method: definition, the methods of SOC estimation; state of health (SOH) estimation technology: definition, methods for SOH estimation; balance management technology; protection technology: overvoltage protection, under voltage protection, overcurrent protection, short circuit protection, over temperature protection.		

Module No. 4	Operation control technology of energy storage systems:	06 Hours
grid connected operation control technology: AC/DC converter control, DC/DC converter control, island detection, low voltage ride through; off-grid operation control technology: control of switching from on-grid to off-grid, synchronization control of the switching from off-grid to on-grid		

Module No. 5	Application of energy storage technology	05 Hours
Application of energy storage technology in grid-connected energy power generation: Impact of energy storage system on gird-connected energy storage power generation: smooth power fluctuation		

Degree	B. Tech.	
Level	Undergraduate	
Branch	EEE (Electrical & Electronics Engineering)	
Semester	7th	
Subject Name	Biomedical Instrumentation	
Course Type	Theory	
Course Code	22EEE7PE08T	
Category	PEC (Professional Elective Courses)	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	Nil
	Practice	Nil
	Total	36 Hours
Recommended Background Knowledge		
Subject Description	Biomedical instrumentation is a field that applies engineering principles to medicine and biology, focusing on the design and use of instruments to measure, diagnose, and treat biological systems. It involves using sensors, signal processing, and other techniques to monitor and analyze physiological parameters, aiding in both diagnosis and therapy.	
Objectives and Outcomes	1. Understand the basics of biomedical Instruments. 2. Understand the origination of the bio-potential signals within the human body with some focus in the cardiovascular system. 3. To provide the fundamental knowledge of Bio-medical Instrumentation, the science associated with the measurement of biological variables such as pressure, temperature etc related to human body, the complexities associated with the measurement of the biological parameters and the care that are to be taken for the measurement since it is concerned with human life. 4. Understand the various instruments dealing with the biomedical systems. Predict the safety issues and precautions measures associated with the instruments	
	1. Have knowledge of fundamental medical issues and terminology. **2.** Become master the principles for different types of electrical medical equipment, you are capable of discussing this with medical staff, and you	

	are also able to analyze the effect of different methods, danger potential, possibilities, and potential developments. **3.** Have knowledge of how different types of electrical medical equipment work, advantages, and disadvantages of different methods, as well as sources of error and risks linked to the various methods. **4.** Can explain the physical and medical principles of biomedical instrumentation.	
Assessment/ Evaluation	Mid-Term Examination	30 %
	Quiz Test-1	2.5 %
	Quiz-Test-2	2.5 %
	Surprise Test	5 %
	Assignment-1	2.5 %
	Assignment-2	2.5 %
	Attendance	5 %
	End-Term Examination	50 %
Prescribed Text Book(s)	[1] Hand Book of Biomedical Instrumentation by R.S.Khandpur,-2nd Edition, Tata McGrawHill, 2003	
Reference Book(s)	[1] Introduction to Biomedical Engineering by Michael M.Domach,Pearson Education Inc,-2004. [2] Biomedical Instrumentation and Measurements- by Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, 2ndEdition, PHI learning Pvt. Ltd [3] Introduction to Biomedical equipment technology,4e.ByJOSEPH.J.CAAR &JOHN M.BROWN (Pearson education publication). [4] Medical Instrumentation-application & design. 3e – By JOHN.G.WEBSTER John Wiley & Sons publications.	

Digital Learning Resources	

Course Name	Biomedical Signal Processing
Course Link	https://nptel.ac.in/courses/108/105/108105101/
Course Instructor	Prof.SudiptaMukhopadhyay , IIT Kharagpur

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Have knowledge of fundamental medical issues and terminology	PO1, PO2, PO3, PO4,PO12
CO2	Become master the principles for different types of electrical medical equipment, you are capable of discussing this with medical staff, and you are also able to analyze the effect of different methods, danger potential, possibilities, and potential developments	PO1, PO2, PO3, PO4
CO3	Have knowledge of how different types of electrical medical equipment work, advantages, and disadvantages of different methods, as well as sources of error and risks linked to the various methods	PO1,PO2, PO3, PO4,PO5
CO4	Can explain the physical and medical principles of biomedical instrumentation	PO1, PO2, PO3, PO4, PO5, PO12

DETAILED SYLLABUS:

Module No. 1	: **Introduction to Bioengineering**	**08 hours**
Introduction to Bioengineering, Biochemical Engineering, Biomedical Engineering, Sources of Biomedical Signals, Basic medical Instrumentation systems and their need, use of microprocessors in medical instruments, PC based medical Instruments, general constraints in design of medical Instrumentation system & Regulation of Medical devices. Bioelectrical Signals & Electrodes: Origin of Bioelectric Signals, Electrocardiogram, Electroencephalogram, Electromyogram		

Module No. 2		**09 Hours**
Electrode-Tissue Interface, Polarization, Skin Contact Impedance, Motion Artifacts. Electrodes for ECG: Limb Electrode, Floating Electrodes, Pre-gelled disposable Electrodes, Electrodes for EEG, Electrodes for EMG. Physiological Transducers: Introduction to Transducers, Classification of Transducers, Performance characteristics of Transducers.		

Module No. 3		**08 Hours**
Displacement Transducers, Position and flow and pressure Transducers. Strain gauge pressure transducers, Thermocouples, Electrical Resistance Thermometer, Thermister, Photovoltaic transducers, Photo emissive Cells & Biosensors (Biochemical sensors).		

Module No. 4	**Recording Systems:**	**08 Hours**
ECG Recorder, The ECG Leads, Vector-cardiograph, Phonocardiograph, EEG Recorder, Basic Recording systems, General considerations for Signal conditioners, Preamplifiers, Differential Amplifier, Isolation Amplifier, Electrostatic and Electromagnetic Coupling to AC Signals, Proper Grounding (Common Impedance Coupling)		

Module No. 5	Patient Monitoring System:	08 Hours
System concept, Measurement of Heart rate, Average Heart Rate Meter, Instantaneous heart rate mater, measurement of pulse rate, Blood pressure measurement : Direct measurement and indirect method of blood pressure measurement ,Differential auscultatory technique, The Rheographic Method, Oscillometric Measurement Method, Ultrasonic Dopler shift method		

COURSE DESCRIPTION:

Degree	B. Tech.	
Level	Undergraduate	
Branch	EE (Electrical Engineering)	
Semester	7^{th}	
Subject Name	Communication Engineering Lab	
Course Type	Laboratory	
Course Code	22EE7PC01L	
Category	PCC (Professional Core Courses)	
Credit Point	1	
Time Commitment	Lecture	Nil
	Tutorial	Nil
	Practice	20 Hours
	Total	20 Hours
Recommended Background Knowledge/Course Pre-requisites	Knowledge of basics of Communication Engineering	
Subject Description		
Objectives and Outcomes	1. To understand the types of relays used for generator protection system 2. Study the characteristics of over current relay. 3. Study the characteristics of under voltage and over voltage relay. **4.** Understand the principle of operation of differential relay.	
	1. Design and analyze modulator and demodulator circuits for different analog modulation techniques. 2. Demonstrate transmission of analog signals through pulse modulation techniques. 3. Implement sampling and multiplexing of analog signal. 4. Design and analyze of various analog modulation techniques using computer skills (MATLAB).	
Assessment/ Evaluation	Lab Experiments	20%
	Record Writing	10%
	Behavior/ Attitude	05%
	Quiz	10%
	Attendance	05%
	Final Lab Test	30%

	Final Viva/ Final Lab Quiz Test	20%
Prescribed Text Book(s)		
Digital 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	

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Design and analyze modulator and demodulator circuits for different analog modulation techniques	PO1, PO2, PO3, PO4, PO5
CO2	Demonstrate transmission of analog signals through pulse modulation techniques	PO1, PO2, PO3, PO5
CO3	Implement sampling and multiplexing of analog signal	PO1, PO2, PO3, PO4, PO5, PO6
CO4	Design and analyze of various analog modulation techniques using computer skills (MATLAB).	PO1, PO2, PO3, PO4, PO5, PO6

DETAILED SYLLABUS (EXPERIMENTS):

Sl. No.	Name of Experiments (7 Experiments out of 8 Hardware Experiments)	Duration in Hrs
1	Design and analysis of Amplitude modulation and demodulation technique.	2
2	Generation and reception of DSB-SC signal and analyze its various parameters.	2
3	Design, analysis and comparison of NBFM and WBFM.	2
4	Spectrum analysis of various modulated signal with spectrum analyzer	2
5	Implement and analyze Frequency division multiplexing and demultiplexing.	2
6	Verify Sampling theorem by performing sampling and reconstruction of signals	2
7	Examine the process of pulse modulation in PAM, PPM and PWM signals.	2
8	Analyze the process of quantization and encoding in PCM.	2
9	Design and analysis of Pre-emphasis and De-emphasis circuits if FM system to increase SNR	2
10	Along with the above experiments which are going to be conducted with experimental kits, the following should also be performed by the students (in/out of the Lab)	2
11	*Using MATLAB simulate modulation and demodulation techniques mentioned in Ex-1, Ex-2, Ex-3, Ex-4, Ex-8, and Ex-9. Verify the process of modulation and demodulation and analyze frequency spectrum of the signal after modulation and demodulation*	2
12	*Circuit design of (i) AM modulator(Transistor based Modulator and Bridge modulator for DSB-C and DSB-SC) (ii) FM receiver*	2

Degree	B. Tech.	
Level	Undergraduate	
Branch	EE (Electrical Engineering)	
Semester	7th	
Subject Name	Power System Protection Lab	
Course Type	Laboratory	
Course Code	22EE7PC02L	
Category	PCC (Professional Core Courses)	
Credit Point	1	
Time Commitment	Lecture	Nil
	Tutorial	Nil
	Practice	20 Hours
	Total	20 Hours
Recommended Background Knowledge/Course Pre-requisites	Knowledge of basics of Power System Protection	
Subject Description	Power system protection is the science and practice of detecting and isolating faults (like short circuits) in electrical power grids to prevent damage and maintain system stability. It ensures safety and reliability by quickly disconnecting faulty components while minimizing disruption to the rest of the system	
Objectives and Outcomes	1. To provide hands-on experience in operating and testing protective relays used for safeguarding generators and motors under abnormal conditions such as over/under voltage and frequency. 2. To familiarize students with fault detection techniques in power systems, such as earth faults and short circuits in underground cables using practical testing methods like the Varley loop test. 3. To introduce students to power system protection simulations using ETAP software, enabling understanding of relay coordination, distance protection, and directional overcurrent protection. 4. To develop analytical and diagnostic skills in evaluating protection	

	schemes for electrical equipment and systems under various fault conditions.	
	1. Demonstrate practical knowledge of relay-based protection for generators and motors against voltage and frequency abnormalities. **2.** Perform and interpret fault location tests on underground cables using conventional test methods like the Varley loop test. **3.** Apply ETAP software tools to model and simulate protection schemes such as relay coordination, distance relays, and directional overcurrent relays. **4.** Design and analyze reliable protection schemes to enhance system stability and prevent damage to electrical equipment under fault conditions.	
Assessment/ Evaluation	Lab Experiments	20%
	Record Writing	10%
	Behavior/ Attitude	05%
	Quiz	10%
	Attendance	05%
	Final Lab Test	30%
	Final Viva/ Final Lab Quiz Test	20%
Prescribed Text Book(s)		
Digital Learning Resources		

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Demonstrate practical knowledge of relay-based protection for generators and motors against voltage and frequency abnormalities.	PO1, PO2, PO3
CO2	Perform and interpret fault location tests on underground cables using conventional test methods like the Varley loop test.	PO1, PO2, PO4
CO3	Apply ETAP software tools to model and simulate protection schemes such as relay coordination, distance relays, and directional overcurrent relays.	PO1, PO5, PO11
CO4	Design and analyze reliable protection schemes to enhance system stability and prevent damage to electrical equipment under fault conditions.	PO1, PO2, PO3, PO12

DETAILED SYLLABUS (EXPERIMENTS):

Sl. No.	Name of Experiments (7 Experiments out of 8 Hardware Experiments)	Duration in Hrs
1	Protection of Generator Using Overvoltage Relay	2
2	Protection of Generator Using Under voltage Relay	2
3	Protection of Generator Using Under frequency Relay	2
4	Protection of Generator Using Over frequency Relay	2
5	Protection of Generator Using Earth fault Relay	2
6	To study the underground cable short circuit test using Varley loop test.	2
7	Relay Coordination Using ETAP	2
8	Distance relay protection using ETAP	2
9	Directional over current relay using ETAP	2
10	Motor protection using ETAP	2

Degree	B. Tech.	
Level	Undergraduate	
Branch	EEE (Electrical & Electronics Engineering)	
Semester	7th	
Subject Name	Energy Auditing and Management	
Course Type	Theory	
Course Code	22EEE7OE01T	
Category	PEC (Professional Elective Courses)	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	Nil
	Practice	Nil
	Total	36 Hours
Recommended Background Knowledge		
Subject Description		
Objectives and Outcomes	1. To facilitate the students to achieve a clear conceptual understanding of technical and commercial aspects of energy conservation and energy auditing. 2. To enable the students to develop managerial skills to assess feasibility of alternative approaches and drive strategies regarding energy conservation and energy auditing	
	1. Conceptual knowledge of the technology, economics and regulation related issues associated with energy conservation and energy auditing 2. Ability to analyze the viability of energy conservation projects 3. Capability to integrate various options and assess the business and policy environment regarding energy conservation and energy auditing	

<table>
<tr><td></td><td colspan="2">4. Advocacy of strategic and policy recommendations on energy conservation and energy auditing</td></tr>
<tr><td rowspan="9">Assessment/ Evaluation</td><td>Mid-Term Examination</td><td>30 %</td></tr>
<tr><td>Quiz Test-1</td><td>2.5 %</td></tr>
<tr><td>Quiz-Test-2</td><td>2.5 %</td></tr>
<tr><td>Surprise Test</td><td>5 %</td></tr>
<tr><td>Assignment-1</td><td>2.5 %</td></tr>
<tr><td>Assignment-2</td><td>2.5 %</td></tr>
<tr><td>Attendance</td><td>5 %</td></tr>
<tr><td>End-Term Examination</td><td>50 %</td></tr>
<tr><td>Prescribed Text Book(s)</td><td colspan="2">[1] Energy Management: W. R. Murphy, G. Mckay (Butterworths).
[2] Energy Management Principles: C. B. Smith (Pergamon Press).
[3] Efficient Use of Energy : I. G. C. Dryden (Butterworth Scientific)
[4] Energy Economics - A. V. Desai (Wiley Eastern)
[5] Industrial Energy Conservation : D. A. Reay (Pergammon Press)
[6] Energy Management Handbook – W. C. Turner (John Wiley and Sons, A Wiley Interscience Publication)</td></tr>
<tr><td>Reference Book(s)</td><td colspan="2">[1] Industrial Energy Management and Utilization – L. C. Witte, P. S. Schmidt, D. R. Brown (Hemisphere Publication, Washington)
[2] Industrial Energy Conservation Manuals, MIT Press, Mass, 1982
[3] Energy Conservation guide book Patrick/Patrick/Fardo (Prentice Hall)</td></tr>
<tr><td>Digital Learning Resources</td><td colspan="2"><table><tr><td>Course Name</td><td>Energy Management System</td></tr><tr><td>Course Link</td><td>https://nptel.ac.in/courses/108106022</td></tr><tr><td>Course Instructor</td><td>Dr. K. Shanti Swarup, IIT Madras</td></tr></table></td></tr>
</table>

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Conceptual knowledge of the technology, economics and regulation related issues associated with energy conservation and energy auditing	PO1, PO2, PO3, PO4,PO12
CO2	Ability to analyze the viability of energy conservation projects	PO1, PO2, PO3, PO4
CO3	Capability to integrate various options and assess the business and policy environment regarding energy conservation and energy auditing	PO1,PO2, PO3, PO4,PO5
CO4	Advocacy of strategic and policy recommendations on energy conservation and energy auditing.	PO1, PO2, PO3, PO4, PO5, PO12

DETAILED SYLLABUS:

Module No. 1	**General Aspects**	**08 hours**
General Philosophy and need of Energy Audit and Management. Definition and Objective of Energy Management, General Principles of Energy Management, Energy Management Skills, Energy Management Strategy. Energy Audit: Need, Types, Methodology and Approach. Energy Management Approach, Understanding Energy Costs, Bench marking, Energy performance, Matching energy usage to requirements, Maximizing system efficiency, Optimizing the input energy requirements, Fuel and Energy substitution		

Module No. 2	Procedures and Techniques	09 Hours
Data gathering: Level of responsibilities, energy sources, control of energy and uses of energy get Facts, figures and impression about energy /fuel and system operations, Past and Present operating data, Special tests, Questionnaire for data gathering. Analytical Techniques: Incremental cost concept, mass and energy balancing techniques, inventory of Energy inputs and rejections, Heat transfer calculations, Evaluation of Electric load characteristics, process and energy system simulation. Evaluation of saving opportunities: Determining the savings in Rs, Noneconomic factors, Conservation opportunities, estimating cost of implementation. Energy Audit Reporting: The plant energy study report- Importance, contents, effective organization, report writing and presentation		

Module No. 3	Energy Policy Planning and Implementation	08 Hours
Key Elements: Force Field Analysis, Energy Policy-Purpose, Perspective, Contents and Formulation. Format and Ratification, Organizing: Location of Energy Manager, Top Management Support, Managerial functions, Role and responsibilities of Energy Manager, Accountability. Motivating Motivation of employees, Requirements for Energy Action Planning. Information Systems: Designing, Barriers, Strategies, Marketing and Communicating Training and Planning		

Module No. 4	Energy Balance & MIS	05 Hours
First law of efficiency and Second law of efficiency, Facility as an Energy system, Methods for preparing process flow, Materials and Energy Balance diagram, Identification of losses, Improvements. Energy Balance sheet and Management Information System (MIS) Energy Modeling and Optimization		

Module No. 5	Energy Audit Instruments	04 Hours
Instruments for Audit and Monitoring Energy and Energy Savings, Types and Accuracy		

Degree	B. Tech.	
Level	Undergraduate	
Branch	EEE (Electrical & Electronics Engineering)	
Semester	7th	
Subject Name	Introduction to Biomedical Instrumentation	
Course Type	Theory	
Course Code	22EEE7OE02T	
Category	PEC (Professional Elective Courses)	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	Nil
	Practice	Nil
	Total	36 Hours
Recommended Background Knowledge		
Subject Description	Biomedical instrumentation is a field that applies engineering principles to medical and biological systems. It focuses on the design, development, and application of instruments and devices used to measure, diagnose, treat, and monitor physiological parameters in living organisms. This includes sensors for detecting various biological signals, signal processing techniques, and the development of medical devices for therapeutic and diagnostic purposes	
Objectives and Outcomes	1. Understand the basics of biomedical Instruments. 2. Understand the origination of the bio-potential signals within the human body with some focus in the cardiovascular system. 3. To provide the fundamental knowledge of Bio-medical Instrumentation, the science associated with the measurement of biological variables such as pressure, temperature etc related to human body, the complexities associated with the measurement of the biological parameters and the care that are to be taken for the measurement since it is concerned with human life. 4. Understand the various instruments dealing with the biomedical systems. Predict the safety issues and precautions measures associated with the instruments	
	1. Have knowledge of fundamental medical issues and terminology.	

<table>
<tr><td></td><td colspan="2">2. Become master the principles for different types of electrical medical equipment, you are capable of discussing this with medical staff, and you are also able to analyze the effect of different methods, danger potential, possibilities, and potential developments.
3. Have knowledge of how different types of electrical medical equipment work, advantages, and disadvantages of different methods, as well as sources of error and risks linked to the various methods.
4. Can explain the physical and medical principles of biomedical instrumentation</td></tr>
<tr><td rowspan="9">Assessment/ Evaluation</td><td>Mid-Term Examination</td><td>30 %</td></tr>
<tr><td>Quiz Test-1</td><td>2.5 %</td></tr>
<tr><td>Quiz-Test-2</td><td>2.5 %</td></tr>
<tr><td>Surprise Test</td><td>5 %</td></tr>
<tr><td>Assignment-1</td><td>2.5 %</td></tr>
<tr><td>Assignment-2</td><td>2.5 %</td></tr>
<tr><td>Attendance</td><td>5 %</td></tr>
<tr><td>End-Term Examination</td><td>50 %</td></tr>
<tr><td>Prescribed Text Book(s)</td><td colspan="2">1. Hand Book of Biomedical Instrumentation by R.S.Khandpur,-2nd Edition, Tata McGrawHill, 2003</td></tr>
<tr><td>Reference Book(s)</td><td colspan="2">1. Introduction to Biomedical Engineering by Michael M.Domach,Pearson Education Inc,-2004.
2. Biomedical Instrumentation and Measurements- by Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, 2ndEdition, PHI learning Pvt. Ltd
3. Introduction to Biomedical equipment technology,4e.ByJOSEPH.J.CAAR &JOHN M.BROWN (Pearson education publication).
4. Medical Instrumentation-application & design. 3e – By</td></tr>
</table>

	JOHN.G.WEBSTER John Wiley & Sons publications.
Digital Learning Resources	

Course Name	Biomedical Signal Processing
Course Link	https://nptel.ac.in/courses/108/105/108105101/
Course Instructor	Prof. Sudipta Mukhopadhyay , IIT Kharagpur

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Have knowledge of fundamental medical issues and terminology	PO1, PO2, PO3, PO4,PO12
CO2	Biomedical Instrumentation and Measurements- by Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, 2ndEdition, PHI learning Pvt. Ltd	PO1, PO2, PO3, PO4
CO3	Have knowledge of how different types of electrical medical equipment work, advantages, and disadvantages of different methods, as well as sources of error and risks linked to the various methods.	PO1,PO2, PO3, PO4,PO5
CO4	Can explain the physical and medical principles of biomedical instrumentation.	PO1, PO2, PO3, PO4, PO5, PO12

DETAILED SYLLABUS:

Module No. 1		**08 hours**
Introduction to Bioengineering, Biochemical Engineering, Biomedical Engineering, Sources of Biomedical Signals, Basic medical Instrumentation systems and their need, use of microprocessors in medical instruments, PC based medical Instruments, general constraints in design of medical Instrumentation system & Regulation of Medical devices. Bioelectrical Signals & Electrodes: Origin of Bioelectric Signals, Electrocardiogram, Electroencephalogram, Electromyogram		

Module No. 2		**09 Hours**
Electrode-Tissue Interface, Polarization, Skin Contact Impedance, Motion Artifacts. Electrodes for ECG: Limb Electrode, Floating Electrodes, Pre-gelled disposable Electrodes, Electrodes for EEG, Electrodes for EMG. Physiological Transducers: Introduction to Transducers, Classification of Transducers, Performance characteristics of Transducers.		

Module No. 3		**08 Hours**
Displacement Transducers, Position and flow and pressure Transducers. Strain gauge pressure transducers, Thermocouples, Electrical Resistance Thermometer, Thermister, Photovoltaic transducers, Photo emissive Cells & Biosensors (Biochemical sensors).		

Module No. 4	Recording Systems:	**05 Hours**
Recording Systems: ECG Recorder, The ECG Leads, Vector-cardiograph, Phonocardiograph, EEG Recorder, Basic Recording systems, General considerations for Signal conditioners, Preamplifiers, Differential Amplifier, Isolation Amplifier, Electrostatic and Electromagnetic Coupling to AC Signals, Proper Grounding (Common Impedance Coupling)		

Module No. 5	Patient Monitoring System	**04 Hours**
Patient Monitoring System: System concept, Measurement of Heart rate, Average Heart Rate Meter, Instantaneous heart rate mater, measurement of pulse rate, Blood pressure measurement : Direct measurement and indirect method of blood pressure measurement ,Differential auscultatory technique, The Rheographic Method, Oscillometric Measurement Method, Ultrasonic Dopler shift method		

Open Elective Course [OEC] offered to EEE students

Open Electives from other Branches:

Degree	B. Tech.	
Level	Undergraduate	
Branch	EE (Electrical Engineering)	
Semester	7th	
Subject Name	INTERNET OF THINGS	
Course Type	Theory	
Course Code	22EC7OE01T	
Category	OEC (Open Elective Courses)	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	Nil
	Practice	Nil
	Total	36 Hours
Recommended Background Knowledge	NA	
Subject Description	The Internet of Things (IoT) refers to a network of physical objects, or "things," that are embedded with sensors, software, and other technologies to connect and exchange data with other devices and systems over the internet. Essentially, it's about connecting previously unconnected devices and objects to the internet, allowing them to communicate and share data	
Objectives and Outcomes	1. To learn the basic issues, policy and challenges in the Internet. 2. To understand the role of IoT in various domains of Industry. 3. To understand the cloud and internet environment and various modes of communications with Internet. 4. To study the basics of IoT Data Analytics and supporting services..	
	1. Able to understand the basics of architecture and characteristics. IoT. 2. Able to understand IOT Applications in Industrial & real world.	

<table>
<tr><td></td><td colspan="2">3. Understand design methodology and hardware platforms involved in IoT.
4. Understand how to analyze and organize the data for IoT and industry 4.0</td></tr>
<tr><td rowspan="9">Assessment/ Evaluation</td><td>Mid-Term Examination</td><td>30 %</td></tr>
<tr><td>Quiz Test-1</td><td>2.5 %</td></tr>
<tr><td>Quiz-Test-2</td><td>2.5 %</td></tr>
<tr><td>Surprise Test</td><td>5 %</td></tr>
<tr><td>Assignment-1</td><td>2.5 %</td></tr>
<tr><td>Assignment-2</td><td>2.5 %</td></tr>
<tr><td>Attendance</td><td>5 %</td></tr>
<tr><td>End-Term Examination</td><td>50 %</td></tr>
<tr><td>Prescribed Text Book(s)</td><td colspan="2">1. VijayMadisetti, Arshdeep Bahga,“Internet of Things-A Hands-On-Approach”, Universities Press, 2015, ISBN:9788 173719547
2. David Hanes Atzor et.al, “IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, Cisco Press, June 2017</td></tr>
<tr><td>Reference Book(s)</td><td colspan="2">1. Honbo Zhou,”The Internet of Things in the Cloud: A Middleware Perspective” — CRC Press, 2012.
2. Luigi Atzor et.al, “The Internet of Things: A survey, “, Journal on Networks, Elsevier Publications, October 2010.
3. Olivier Hersent, David Boswarthick, Omar Elloumi, “The Internet of Things – Key applications and Protocols”, Wiley, 2012.
4. Adrian McEwen, “Designing the Internet of Things”, Wiley Publishers, 2013.</td></tr>
<tr><td>Digital Learning Resources</td><td colspan="2"><table><tr><td>Course Name</td><td>Introduction to internet of things</td></tr><tr><td>Course Link</td><td>NPTEL : Computer Science and Engineering - NOC:Introduction to internet of things</td></tr><tr><td>Course Instructor</td><td>Prof. Sudip Misra, IIT Kharagpur</td></tr></table></td></tr>
</table>

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	To learn the basic issues, policy and challenges in the Internet	PO1, PO3, PO4,PO12
CO2	To understand the role of IoT in various domains of Industry	PO1, PO2, PO3, PO4
CO3	To understand the cloud and internet environment and various modes of communications with Internet	PO1,PO2, PO3
CO4	To study the basics of IoT Data Analytics and supporting services	PO1, PO2, PO3, PO4,

DETAILED SYLLABUS:

Module No. 1	Introduction & Concepts:	08 hours
Definition & Characteristics of IoT, IoT frameworks, Physical Design of IoT- Things in IoT, IoT Protocols, Logical Design of IoT- IoT Functional Blocks, IoT Communication Models, IoT Communication APIs , IoT Enabling Technologies, IoT Levels & Deployment Templates. Domain Specific IOTs: Home Automation, Cities, Environment, Energy, Retail, Logistics, Agriculture, Industry, Health & Life Style, Challenges and Issues.		

Module No. 2	IoT and M2M	09 Hours
Introduction, M2M-Difference between IoT and M2M, SDN and NFV for IoT-Software Defined Networking, Network Function Virtualization IoT Platform Design Methodology: Purpose & Requirements Specification, Process Specification, Domain Model Specification, Information Model Specification, Service Specifications, IoT Level Specification, Functional View Specification, Operational View Specification, Device & Component Integration, Case study on IoT system: smart lightning, weather monitoring system		

Module No. 3	IoT Physical Devices & Endpoints:	08 Hours
What is an IoT Device-Basic building blocks of an IoT Device, Exemplary Device: Raspberry Pi, About the Board, Linux on Raspberry Pi , Raspberry Pi Interfaces – Serial, SPI , I2C , Programming Raspberry Pi with Python-Controlling LED with Raspberry Pi , Interfacing an LED and Switch with Raspberry Pi ,Interfacing a Light Sensor (LDR) with Raspberry Pi.		

Module No. 4	Data and Analytics for IoT	05 Hours
Use of Big Data and Visualization in IoT, IoT Data Analytics Overview and Challenges, Big Data Analytics Tools and Technology.		

Module No. 5	IoT &Beyond Industry 4.0:	04 Hours
Industry 4.0 concepts, The Various Industrial Revolutions, ,Internet of Everything, Overview of RFID, Overview of Android.		

Degree	B. Tech.	
Level	Undergraduate	
Branch	EE (Electrical Engineering)	
Semester	7th	
Subject Name	Robotics	
Course Type	Theory	
Course Code	22EC7OE02T	
Category	OEC (Open Elective Courses)	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	Nil
	Practice	Nil
	Total	36 Hours
Recommended Background Knowledge	NA	
Subject Description	Robotics is an interdisciplinary field drawing from mechanical, electrical, and computer engineering, as well as computer science and artificial intelligence. It focuses on the design, construction, operation, and application of robots, including the computer systems for their control, sensory feedback, and information processing. Essentially, robotics aims to create machines that can perform tasks, often those traditionally done by humans, with greater efficiency and precision.	
Objectives and Outcomes	1. To develop the student's knowledge in various robot structures and their workspace. 2. Acquire knowledge to perform kinematics analysis of robot systems. 3. To provide knowledge on the various robotic systems with the help of mathematical models. 4. Understand the various flexures, actuators and sensor systems. 5. To provide the student with some knowledge and analysis skills associated with trajectory planning	

	1. Differentiate the various types of Industrial Robots, their architecture and robot kinematics. 2. Describe the characteristics of a robotic system from its dynamic model. 3. Specify the characteristics of various actuators and sensor systems 4. Analyze the various path planning techniques by briefing about the robot's environment and Analyze the applications of robots in various industrial application.	
Assessment/ Evaluation	Mid-Term Examination	30 %
	Quiz Test-1	2.5 %
	Quiz-Test-2	2.5 %
	Surprise Test	5 %
	Assignment-1	2.5 %
	Assignment-2	2.5 %
	Attendance	5 %
	End-Term Examination	50 %
Prescribed Text Book(s)	1. Robotics and Control, R. K. Mittal and I. J. Nagrath, Tata McGraw-Hill, 2005 2. Introduction to Robotics: Mechanics and control, John J. Craig, PHI, 3rd edition, 2004 3. Robotics Technology and Flexible Automation, S. R. Deb and S. Deb, TMH, 2nd edition, 2017	
Reference Book(s)	1. Introduction to Robotics, S. K. Saha, Tata McGraw Hill, 1st edition, 2008 2. Robotics: Control, Sensing, Vision and Intelligence, K.S.Fu, R.C.Gonzalez and C.S.G.Lee, McGraw Hill, 2008 3. Industrial Robotics Technology, programming and application, M. P. Groover, TMH, 2nd edition, 2017	
Digital Learning Resources	Video course on "Robotics" by Prof. Dilip Kumar Pratihar, IIT Kharagpur available on NPTEL at Kanpur available on NPTEL at https://onlinecourses.nptel.ac.in/noc21_me76/preview	

	Video course on "Introduction to Robotics" by Prof. Asokan T, Prof. Balaraman Ravindran, Prof. Krishna Vasudevan , IIT Madras available on NPTEL at Kanpur available on NPTEL at https://onlinecourses.nptel.ac.in/noc20_de11/preview

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Differentiate the various types of Industrial Robots, their architecture and robot kinematics	PO1, PO3, PO4,PO12
CO2	Describe the characteristics of a robotic system from its dynamic model	PO1, PO2, PO3, PO4
CO3	Specify the characteristics of various actuators and sensor systems	PO1,PO2, PO3
CO4	Analyze the various path planning techniques by briefing about the robot's environment and Analyze the applications of robots in various industrial application	PO1, PO2, PO3, PO4,

DETAILED SYLLABUS:

Module No. 1	**Fundamentals of Robotics:**	**08 hours**
Evolution of robots and robotics, Definition of industrial robot, Laws of Robotics, Classification, Robot Anatomy, Work volume and work envelope, Human arm characteristics, Design and control issues, Manipulation and control, Resolution; accuracy and repeatability, Robot configuration, Economic and social issues, Present and future application		

Module No. 2	Mathematical modeling of a robot	07 Hours
Mapping between frames, Description of objects in space, Transformation of vectors. Direct Kinematic model: Mechanical Structure and notations, Description of links and joints, Kinematic modeling of the manipulator, Denavit-Hartenberg Notation, Kinematic relationship between adjacent links, Manipulator Transformation matrix		

Module No. 3	Inverse Kinematics & Dynamic modeling::	07 Hours
Manipulator workspace, Solvable of inverse kinematic model, Manipulator Jacobian, Jacobian inverse, Jacobian singularity, Static analysis. Lagrangian mechanics, 2D- Dynamic model, Lagrange-Euler formulation, Newton-Euler formulation		

Module No. 4	Robot Sensors & Robot Actuators:	07 Hours
Internal and external sensors, force sensors, Thermocouples, Performance characteristic of a robot. Hydraulic and pneumatic actuators, Electrical actuators, Brushless permanent magnet DC motor, Servomotor, Stepper motor, Micro actuator, Micro gripper, Micro motor, Drive selection		

Module No. 5	Trajectory Planning and Applications of Robotics:	07 Hours
Definition and planning tasks, Joint space planning, Cartesian space planning. Capabilities of robots, Material handling, Machine loading and unloading, Robot assembly, Inspection, spot and continuous arc welding & spray painting , Obstacle avoidance		

Degree	B. Tech.	
Level	Undergraduate	
Branch	EE (Electrical Engineering)	
Semester	7th	
Subject Name	Numerical Methods for Engineers	
Course Type	Theory	
Course Code	22EC7OE02T	
Category	OEC (Open Elective Courses)	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	Nil
	Practice	Nil
	Total	36 Hours
Recommended Background Knowledge	NA	
Subject Description	The development of fast, efficient and inexpensive computers has significantly increased the range of engineering problems that can be solved reliably. Numerical Methods use computers to solve problems by step-wise, repeated and iterative solution methods, which would otherwise be tedious or unsolvable by hand-calculations. This course is designed to give an overview of numerical methods of interest to scientists and engineers. However, the focus being on the techniques themselves, rather than specific applications, the contents should be relevant to varied fields such as engineering, management, economics, etc.	
Objectives and Outcomes	1. Solve the nonlinear equations and finding the roots of the equation. 2. Realize the power of interpolation, numerical differentiation and integration 3. Solve ordinary differential equations, stability and convergence of numerical methods, 4. Solve elliptic partial differential equations with numerical methods 5. Solve hyperbolic partial differential equations with numerical methods.	
	1. Find the root of the nonlinear equations	

	2. Get experience of using interpolation, numerical differentiation and integration 3. Solve ordinary differential equations numerically and know order, stability and convergence of numerical methods 4. Solve the Laplace and Poisson equations by finite difference approximations. And Solve the hyperbolic differential equations by using simple solvers.	
Assessment/ Evaluation	Mid-Term Examination	30 %
	Quiz Test-1	2.5 %
	Quiz-Test-2	2.5 %
	Surprise Test	5 %
	Assignment-1	2.5 %
	Assignment-2	2.5 %
	Attendance	5 %
	End-Term Examination	50 %
Prescribed Text Book(s)	1. Numerical methods for Engineers, S. C. Chapra and R. P. Canale, McGraw-Hill Higher Education, 5th edition, 2005. 2. Numerical analysis, K.E. Atkinson, John Wiley & Sons, 2nd edition, 2011. 3. Numerical Methods for Engineers and Scientists, Joe D. Hoffmann, CRC Press; 2nd edition, 2001.	
Reference Book(s)	1. Numerical Method for Scientific and Engineering Computation, M. K. Jain, S. R. K. Iyengar and R. K. Jain, New Age International Publishers, 7th edition, 2019. 2. Introductory Methods for Numerical Analysis, S. S. Sastry, PHI learning private limited, 4th edition, 2012	
Digital Learning Resources		

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Find the root of the nonlinear equations	PO1, PO3, PO4,PO12
CO2	Get experience of using interpolation, numerical differentiation and integration	PO1, PO2, PO3, PO4
CO3	Solve ordinary differential equations numerically and know order, stability and convergence of numerical methods	PO1,PO2, PO3
CO4	Solve the Laplace and Poisson equations by finite difference approximations. And the hyperbolic differential equations by using simple solvers	PO1, PO2, PO3, PO4,

DETAILED SYLLABUS:

Module No. 1	**Nonlinear equations:**	**08 hours**
Approximation of numbers, significant figures, accuracy and precision, error definition, round off errors, error propagation, system of non-linear equations: interval halving false-position method, fixed point iteration, newton-raphson method, secant method, convergence and error analysis		

Module No. 2	**Interpolation, Numerical Differentiation and Integration:**	**07 Hours**
Introduction, Newton's divided difference interpolating polynomial, Lagrange interpolating polynomial, spline interpolation, trapezoidal rule, Simpson's rule, Newton-Cotes algorithm for equations, Romberg integration, Gauss quadrature		

Module No. 3	Ordinary differential equation	07 Hours
Introduction, Taylor series method, finite difference grids and finite difference approximations, finite difference equations, consistency, order, stability and convergence, the modified differential equations, stability analysis		

Module No. 4	Elliptic Partial difference equations:	07 Hours
Introduction, finite difference approximations, consistency, order and convergence, finite difference solutions of Laplace equations and Poisson equation		

Module No. 5	Hyperbolic Partial Differential Equations	07 Hours
Introduction, The method of characteristics, the forward-time centered space method, Lax method, upwind methods, the leapfrog method		

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Degree	B. Tech.	
Level	Undergraduate	
Branch	EE (Electrical Engineering)	
Semester	7th	
Subject Name	Biology For Engineers	
Course Type	Theory	
Course Code	22BT7OE01T	
Category	OEC (Open Elective Courses)	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	Nil
	Practice	Nil
	Total	36 Hours
Recommended Background Knowledge	NA	
Subject Description	This course is designed to introduce the fundamental concepts of modern biology to undergraduate engineering students. The curriculum bridges the gap between biology and engineering, highlighting how biological systems can be viewed as complex engineered entities. The course aims to equip students with the necessary biological knowledge to understand and contribute to emerging fields like biotechnology, biomedical engineering, biomimicry, and environmental engineering. It will foster an appreciation for how engineering principles can be applied to solve biological problems and how biological solutions can inspire novel engineering designs	
Objectives and Outcomes	1. To impart fundamental knowledge of cell biology, genetics, and molecular biology. 2. To introduce the concept of biology as a quantitative and engineering science. 3. To convey the principles of biomolecules, enzymes, and metabolic pathways from an engineering perspective (e.g., materials, catalysts, energy systems).	

	4. To motivate students to explore and analyze bio-inspired engineering solutions and modern biotechnological applications	
	1. Describe the fundamentals of cell structure, function, and the hierarchy of life, comparing biological systems to engineered systems. 2. Explain the principles of genetics, information transfer (from DNA to protein), and basic gene regulation 3. Apply the concepts of biomolecules and enzymes to analyze their roles as building blocks, catalysts, and energy sources 4. Analyze various bio-inspired engineering systems and modern biotechnological applications in fields like healthcare, environment, and materials and Assess the role of biology in addressing contemporary engineering challenges related to sustainability and human health	
Assessment/ Evaluation	Mid-Term Examination	30 %
	Quiz Test-1	2.5 %
	Quiz-Test-2	2.5 %
	Surprise Test	5 %
	Assignment-1	2.5 %
	Assignment-2	2.5 %
	Attendance	5 %
	End-Term Examination	50 %
Prescribed Text Book(s)	1. Thyaga Rajan, S., Selvamurugan, N., Rajesh, M. P., Nazeer, R. A., Thilagaraj, W., Barathi, S., &Jaganthan, M. K. (2018). Biology for Engineers. Tata McGraw-Hill Education. 2. Suraishkumar, G. K. (2018). Biology for Engineers and Computer Scientists. Oxford University Press.	

	3. Singh, B. D. (2018). Biotechnology: Expanding Horizons. Kalyani Publishers
Reference Book(s)	1. Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., & Reece, J. B. (2020). Campbell Biology (12th Edition). Pearson. 2. Nelson, D. L., & Cox, M. M. (2021). Lehninger Principles of Biochemistry (8th Edition). W. H. Freeman. 3. Benyus, J. M. (2002). Biomimicry: Innovation Inspired by Nature. William Morrow Paperbacks. 4. Shuler, M. L., & Kargi, F. (2017). Bioprocess Engineering: Basic Concepts (3rd Edition). Prentice Hall
Digital Learning Resources	

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Describe the fundamentals of cell structure, function, and the hierarchy of life, comparing biological systems to engineered systems.	PO1, PO2, PO3, PO6, PO7
CO2	Explain the principles of genetics, information transfer (from DNA to protein), and basic gene regulation	PO1, PO2, PO12
CO3	Apply the concepts of biomolecules and enzymes to analyze their roles as building blocks, catalysts, and energy sources	PO1,PO2, PO4, PO7, PO12
CO4	Analyze various bio-inspired engineering systems and modern biotechnological applications in fields like healthcare, environment, and materials and Assess the role of biology in addressing contemporary engineering challenges related to sustainability and human health	PO1, PO2, PO3, PO4, PO6, PO7,. PO8,PO12

DETAILED SYLLABUS:

Module No. 1	Introduction to Biology & The Cell	07 hours

Why Biology for Engineers: Introduction to the course, highlighting the interface between biology and engineering.
Hierarchy of Life: From atoms to the biosphere.
The Cell as a Basic Unit of Life: Cell theory, prokaryotic vs. eukaryotic cells, animal vs. plant cells.
Cellular Organelles: Structure and function of major organelles (nucleus, mitochondria, chloroplasts, ribosomes, endoplasmic reticulum, Golgi apparatus). Analogy: The cell as a well-designed factory.
Introduction to Biomolecules: Overview of carbohydrates, lipids, proteins, and nucleic acids as the building blocks of life.
Bio-membranes and Transport: Structure of the cell membrane, passive and active transport mechanisms. Analogy: Gates and pumps in an engineered system

Module No. 2	Genetics, Information Transfer, and Control	08 Hours

The Blueprint of Life: Structure of DNA (Watson-Crick model), concept of genes and chromosomes.
The Central Dogma of Molecular Biology: DNA replication, Transcription (DNA to RNA), and Translation (RNA to Protein). Analogy: Information storage, copying, and execution in a computer system.
Introduction to Gene Regulation: Simple models of gene expression control (e.g., Lac Operon) as biological switches.
Heredity and Mendelian Genetics: Basic principles of inheritance.
Introduction to Recombinant DNA Technology: Basic tools and applications (e.g., producing insulin in bacteria).

Module No. 3	Bioenergetics, Enzymes, and Biomaterials	08 Hours

Enzymes as Biocatalysts: Structure, function, and mechanism of enzyme action. Factors affecting enzyme activity. Analogy: Highly specific industrial catalysts.
Enzyme Kinetics: Michaelis-Menten kinetics as a model for catalytic efficiency.
Bioenergetics and Metabolism: Concept of free energy, overview of key metabolic pathways like Glycolysis and the Krebs Cycle for energy harvesting. Analogy: Biological power plants.
Photosynthesis: The process of converting light energy to chemical energy. Analogy: Biological solar cells.
Biomaterials: Introduction to natural polymers (e.g., collagen, cellulose, silk, chitin) and their mechanical and chemical properties for engineering applications

Module No. 4	Applied Biology	07 Hours

Introduction to Biotechnology:

Fermentation Technology & Bioreactors: Design and application in producing antibiotics, enzymes, and biofuels.

Environmental Biotechnology: Role of microbes in bioremediation and waste treatment (e.g., activated sludge process).

Introduction to Biomedical Engineering:

Biosensors: Basic principles and applications (e.g., glucose sensor).

Tissue Engineering: Basic concepts of scaffolds and cell culture

Module No. 5	Bio-inspired Engineering	06 Hours

Biomechanics: Study of biological systems (e.g., human skeleton) from a mechanical perspective (levers, forces, stress, and strain).

Bio mimicry (Bio-inspired Design): Learning from nature to solve engineering problems.

Case Studies: Velcro (burrs), high-speed train design (kingfisher beak), self-cooling buildings (termite mounds), super hydrophobic surfaces (lotus leaf).

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Degree	B. Tech.	
Level	Undergraduate	
Branch	EE (Electrical Engineering)	
Semester	7th	
Subject Name	Introduction to Machine learning	
Course Type	Theory	
Course Code	22CS7OE01T	
Category	OEC (Open Elective Courses)	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	Nil
	Practice	Nil
	Total	36 Hours
Recommended Background Knowledge	NA	
Subject Description	This course provides a foundational understanding of machine learning models (logistic regression, multilayer perceptrons, convolutional neural networks, natural language processing, etc.) and demonstrates how they can solve complex problems in various industries, from medical diagnostics to image recognition to text	
Objectives and Outcomes	1. Develop a concise knowledge of the understanding of the fundamental concept of machine learning. 2. Understand the different learning algorithms and implement them. 3. Gain experience in applying machine learning algorithms to real-world problems.	
	1. Equip students with knowledge of fundamentals concepts in machine learning. 2. Ability to analyse and validate different learning algorithms. 3. Fine tune machine learning algorithms 4. Evaluate models generated from data	

Assessment/ Evaluation	Mid-Term Examination	30 %
	Quiz Test-1	2.5 %
	Quiz-Test-2	2.5 %
	Surprise Test	5 %
	Assignment-1	2.5 %
	Assignment-2	2.5 %
	Attendance	5 %
	End-Term Examination	50 %
Prescribed Text Book(s)	1. Saikat Dutt, Subramanian Chandramouli, Amit Kumar Das, "Machine Learning", Pearson Education2: C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2010	
Reference Book(s)	1. J. Friedman, T. Hastie, and R. Tibshirani.The elements of statistical learning.Vol. 1, no. 10. New York:Springer series in statistics, 2001. 2. S. Shalev-Shwartz, and S. Ben-David. Understanding machine learning: From theory to algorithms. Cambridge university press, 2014	
Digital Learning Resources	Course Name Introduction to Machine Learning Course Link https://nptel.ac.in/courses/106/106/106106139/ Course Instructor Dr. Balaraman Ravindran, IIT Madras	

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Equip students with knowledge of fundamentals concepts in machine learning	PO1,PO2,PO4,PO7
CO2	Ability to analyze and validate different learning algorithms	PO1,PO2,PO4,PO5
CO3	Fine tune machine learning algorithms	PO1,PO3,PO5,PO9
CO4	Evaluate models generated from data	PO1,PO2,PO3,PO4,PO5

DETAILED SYLLABUS:

Module No. 1	**Introduction to Machine Learning,**	**08 hours**
Model Preparation, Modelling and Evaluation, Human learning versus machine learning, types of machine learning, applications of machine learning, tools for machine learning, Machine Learning Activities, Data structures for machine learning, Data Pre-processing, selecting a model, training a model, model representation and interpretability, evaluating the performance of a model, improving the performance of a model, Learning theory, Hypothesis and target class, Hilbert space, Inductive bias and bias-variance trade-off.		

Module No. 2	**Interpolation, Numerical Differentiation and Integration:**	**07 Hours**
Feature Engineering, Bayesian Concept Learning, Introduction to feature engineering, feature transformation, feature subset selection, Importance of Bayesian methods, Bayes' theorem, concept learning through Bayes' theorem, Bayesian Belief Network		

Module No. 3	**Supervised Learning**	**07 Hours**
Classification, Regression, Example of supervised learning, classification model, classification learning steps, common classification algorithms – KNN, Decision trees random forest, SVM, an example of regression, common regression algorithms,		

Module No. 4	Unsupervised learning	07 Hours
Clustering, pattern finding using association rules, Unsupervised learning versus supervised learning, applications of unsupervised learning, clustering and its types, Apriori algorithm for association rule learning		

Module No. 5	Neural Network:	07 Hours
Understanding the biological neuron, exploring artificial neuron, types of activation functions, early implementation of artificial neural network, architectures of neural network, learning process in artificial neural network, back propagation, Overview of Deep Learning		