SNJB's

Late Sau. Kantabai Bhavarlalji Jain

College of Engineering

(An Autonomous Institute Affiliated to Savitribai Phule Pune University, Pune)

Shri Neminath Jain Brahmacharyashram (SNJB) (Jain Gurukul)

Neminagar, Chandwad - 423101, Dist. Nashik (MS, India).

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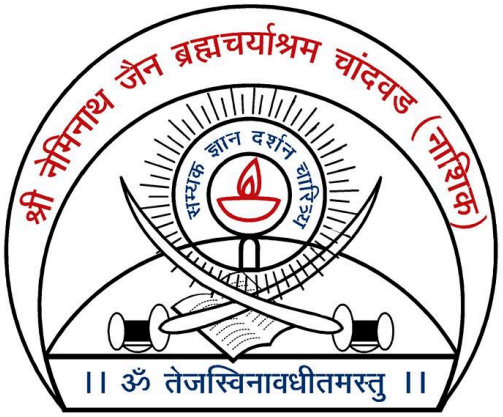

ESTD - 1928

SNJB

Curriculum and Evaluation Scheme for Second Year B. Tech. with Multidisciplinary Minor and Double Minor

To be implemented for 2024-28 Batch

(With Effect from Academic Year 2026-27)

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SNJB's Late Sau. K. B. Jain College of Engineering, Chandwad

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Curriculum and Evaluation Scheme

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Vision of the Institute

Transform young aspirant learners towards creativity and professionalism for societal growth through quality technical education.

Mission of the Institute

1. To transfer the suitable technology, particularly for rural development.
2. To enhance diverse career opportunities among students for building a nation.
3. To acquire the environment of learning to bridge the gap between industry and academics.
4. To share values, ideas, and beliefs by encouraging faculty and students for the welfare of society.

Program Outcomes (POs) for an engineering graduate:

PO1: Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.

PO2: Problem Analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)

PO3: Design/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)

PO4: Conduct Investigations of Complex Problems: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).

PO5: Engineering Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)

PO6: The Engineer and The World: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).

PO7: Ethics: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)

PO8: Individual and Collaborative Team work: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

PO9: Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences

PO10: Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

PO11: Life-Long Learning: Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

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DOUBLE MINORS

- In addition to 172 credits of B. Tech Programmes (Bachelor of Technology) i.e. Major in which the student has taken admission, a student may opt for Specialization Minor in another discipline/branch/emerging areas, not in Major discipline/branch.
- A student is required to earn an additional 18 credits in another discipline/ branch/ emerging areas for Specialization Minor distributed over semesters III to VIII.
- The total number of credits required to complete the Specialization Minor in another discipline/ emerging area is 18 credits, in addition to 172 credits in the Major.
- Minor Courses can be completed through an online platform.

Table 1: Double Minors

Double Minor Basket (UG) (2024-28)						
Double Minor Offered by	**To be Opted By Department**	**Double Minor Basket Name**	**Sr No**	**Course Code**	**Course Name**	**Semester**
Artificial Intelligence & Data Science Engineering	**Students other than the Computer and AIDS department**	**High Performance Computing**	1	24-DMC-AD-2-01	Computer Networks	**III**
			2	24-DMC-AD-2-02	Cloud Computing	**IV**
			3	24-DMC-AD-3-03	Distributed Computing	**V**
			4	24-DMC-AD-3-04	Blockchain Technology	**VI**
			5	24-DMC-AD-4-05	High Performance Computing	**VII**
			6	24-DMC-AD-4-06	Mastering in Cloud Architecture	**VIII**
Civil Engineering	**Students other than Civil department**	**Infrastructure Engineering**	1	24-DMC-CE-2-01	Infrastructure Planning and Management	**III**
			2	24-DMC-CE-2-02	Infrastructure Economics	**IV**
			3	24-DMC-CE-3-03	Project Formulation and Appraisal	**V**
			4	24-DMC-CE-3-04	Advanced and Sustainable Materials in Infrastructure	**VI**
			5	24-DMC-CE-4-05	Management Information Systems	**VII**
			6	24-DMC-CE-4-06	Computational Methods in Infrastructure Engineering	**VIII**
Computer Engineering	**Students other than Computer and AIDS department**	**Data Science**	1	24-DMC-CS-2-01	Foundation of Data Science	**III**
			2	24-DMC-CS-2-02	Principles of Artificial Intelligence and Machine Learning	**IV**
			3	24-DMC-CS-3-03	Data analytics with Python	**V**
			4	24-DMC-CS-3-04	Business Intelligence & Analytics	**VI**

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			5	24-DMC-CS-4-05	Natural Language Processing	**VII**
			6	24-DMC-CS-4-06	Large Language Models	**VIII**
Electronics & Telecommunication Engineering	**Students other than E&TC department**	**Embedded System**	1	24-DMC-ET-2-01	Digital Electronics	**III**
			2	24-DMC-ET-2-02	Microprocessor & Microcontroller	**IV**
			3	24-DMC-ET-3-03	Analog Circuits	**V**
			4	24-DMC-ET-3-04	Mechatronics	**VI**
			5	24-DMC-ET-4-05	Embedded System	**VII**
			6	24-DMC-ET-4-06	Internet of Things	**VIII**
Mechanical Engineering	**Students other than Mechanical department**	**Sustainable Energy Engineering**	1	24-DMC-ME-2-01	Introduction to Sustainable Energy Systems	**III**
			2	24-DMC-ME-2-02	Solar PV Design Optimization & Manufacturing	**IV**
			3	24-DMC-ME-3-03	Future Solar Energy Harnessing Technologies	**V**
			4	24-DMC-ME-3-04	Grid Integration and Smart Grid Technologies	**VI**
			5	24-DMC-ME-4-05	Sustainable Engineering Solutions	**VII**
			6	24-DMC-ME-4-06	Sustainability Assessment and Analysis	**VIII**

#Note for NPTEL/SYAYAM: Approved courses and platforms will be enlisted timely by authorities along with rules and regulations

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Double Minor Syllabus Offered by Artificial Intelligence & Data Science Engineering for Other Branch Students for SEM V and SEM VI

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24-DMC-AD-3-03: Distributed Computing		
Teaching Scheme: Theory: 3 Hours/Week	**Credit:** 03	**Examination Scheme:** **SEE** : 100 Marks

Prerequisites Courses: Computer Networks (24-DMC-AD-2-01), Cloud Computing (24-DMC-AD-2-02)

Companion Course:

Course Objectives:

- **To understand** the fundamentals and knowledge of the architectures of distributed systems
- **To gain knowledge** of working components and fault tolerance of distributed systems
- **To make students aware** about security issues and protection mechanisms for distributed environments

Course Outcomes:
After completion of the course, learners should be able to

CO. No	CO	BL
CO1	**Understand** the features and properties of Distributed computing system with integration of AI	2
CO2	**Analyze** the Concept of data management and storage in distributed computing	3
CO3	**Understand** the algorithm used in distributed computing by applying artificial intelligence.	2
CO4	**Understand** the integration of machine learning algorithm and advanced tools used in distributed computing	2
CO5	**Analyze** how big data is processed in distributed computing	3
CO6	**Identify** Security and privacy issues of distributed computing and apply on specific application	3

Course Contents

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Unit I	**Introduction to Distributed Computing**	**7 Hours**
Fundamentals of distributed computing: Characteristics of Distributed Systems: Issues, Goals, and Types of distributed systems, Distributed System Models **Introduction to Artificial Intelligence and Data Science in distributed computing:** Distributing computational tasks, handling large volumes of data, and leveraging parallel processing capabilities, issues related to data storage and retrieval, data consistency, communication overhead, synchronization, and fault tolerance.		
#Exemplar/Case Studies: Introduction to Distributed Computing in E-commerce		
***Mapping of Course Outcomes**	**CO1**	
Unit II	**Distributed Data Management and Storage**	**7 Hours**
Overview of Distributed Computing Frameworks and Technologies Parallel Computing, Distributed Computing Models, Message Passing, Distributed File Systems: Hadoop Distributed File System (HDFS) and Google File System (GFS), **Cluster Computing: (AWS)**, Microsoft Azure, and Google Cloud Platform (GCP), Message Brokers and Stream Processing, **Edge Computing Data Replication and Consistency Model:** Eager Replication, Lazy Replication, Quorum-Based Replication, Consensus-Based Replication, Selective Replication, Strong Consistency, Eventual Consistency, Read-your-writes Consistency, Consistent Prefix Consistency, Causal Consistency Distributed data indexing and retrieval techniques: Distributed Hash Tables (DHTs), Distributed Inverted Indexing, Range-based Partitioning, Content-based Indexing, Peer-to-Peer (P2P) Indexing, Hybrid Approaches		
#Exemplar/Case Studies: Distributed Data Management and Storage in Healthcare		
***Mapping of Course Outcomes**	**CO2**	
Unit III	**Distributed Computing Algorithms**	**7 Hours**
Distributed Computing Algorithms: Communication and coordination in distributed systems Distributed consensus algorithms (Other consensus algorithms Viewstamped Replication RAFT ,ZAB, Mencius Many variants of Paxos (Fast Paxos, Egalitarian Paxos etc) Fault tolerance and recovery in distributed systems, Load balancing and resource allocation strategies: Weighted Round Robin, Least Connection,Randomized Load Balancing, Dynamic Load Balancing, Centralized Load Balancing, Distributed **Load Balancing, Predictive Load Balancing Applying AI techniques to optimize distributed computing algorithms:** Machine Learning for Resource Allocation, Reinforcement Learning for Dynamic Load Balancing, Genetic Algorithms for Task Scheduling, Swarm Intelligence for Distributed Optimization.		
#Exemplar/Case Studies: Distributed Computing Algorithms in Weather Prediction		
***Mapping of Course Outcomes**	**CO3**	
Unit IV	**Distributed Machine Learning and AI**	**7 Hours**

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Introduction to distributed Machine Learning Algorithms: Types of Distributed Machine Learning:Data Parallelism and Model Parallelism, Distributed Gradient Descent, Federated Learning, All-Reduce, Hogwild, Elastic Averaging SGD **Software to implement Distributed ML:** Spark, GraphLab, Google TensorFlow, Parallel ML System (Formerly Petuum), Systems and Architectures for Distributed **Machine Learning Integration of AI algorithms in distributed systems:** Intelligent Resource Management, Anomaly Detection and Fault Tolerance, Predictive Analytics, Intelligent Task Offloading		
#Exemplar/Case Studies: Distributed Machine Learning and AI in Fraud Detection		
***Mapping of Course Outcomes**	**CO4**	
Unit V	**Big Data Processing in Distributed Systems**	**7 Hours**
Big data processing frameworks in distributed computing: Hadoop, Apache Spark, Apache Storm, Samza, **Flink Parallel and distributed data processing techniques:** Single Instruction Single Data (SISD),Multiple Instruction Single Data (MISD), Single Instruction Multiple Data (SIMD), Multiple Instruction Multiple Data (MIMD), Single program multiple data (SPMD), Massively parallel processing (MPP) **Scalable data ingestion:** types of data ingestion, Benefits, challenges, tools, transformation indistributed systems **Real-time analytics and Streaming analytics:** types of real time analytics, types of streaming analytics, Comparison of real time analytics and streaming analytics, Applying AI and data science for large-scale data processing and analytics.		
#Exemplar/Case Studies: Big Data Processing in Distributed Systems for Social Media Analytics		
***Mapping of Course Outcomes**	**CO5**	
Unit VI	**Distributed Systems Security and Privacy**	**6 Hours**
Security Challenges in Distributed Systems, Insider Threats, Encryption and Secure Communication: TLS/SSL, PKI, VPN, AMQP, **Privacy Preservation Techniques:** Differential Privacy, HomomorphicEncryption, Secure Multi-Party Computation (SMPC), Federated Learning, Anonymization and Pseudonymization, Access Control and Data Minimization. **AI-based Intrusion Detection and Threat Mitigation Techniques:** Anomaly Detection, Behavior-based Detection, Threat Intelligence and Analysis, Real-time Response and Mitigation, Adaptive Security, User and Entity Behavior Analytics (UEBA), Threat Hunting and Visualization.		
#Exemplar/Case Studies: Distributed Systems Security and Privacy in Healthcare		
***Mapping of Course Outcomes**	**CO6**	
Learning Resources		
Text Books		
T1. Attiya Hagit Welch Jennifer; Distributed Computing - Fundamentals & Simulations 2006, ISBN:02322 **T2.** Sunitha Mahajan,Distributed Computing -by ISBN: 10293 **T3.** Hwang K**ai,** Distributed And Cloud Computing, : New Delhi Elsevier Publication ; 2021, ISBN:12927		
Reference Books :		

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R1. G. Coulouris, J. Dollimore, Addison Wesley,Distributed Systems Concepts and Design
R2. Ajay D. Kshemkalyani, Mukesh Singhal, "Distributed Computing: Principles, Algorithms, and Systems"
R3. Pradeep K. Sinha, "Distributed Operating System", PHI

Additional Resources: (Books, e-Resources)

MOOC Courses links :

- nptel.ac.in/courses/106106107?utm_source

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24-DMC-AD-3-04 : Blockchain Technology		
Teaching Scheme: Theory: 3 Hours/Week	**Credit:** 3	**Examination Scheme:** **SEE** : 100 Marks
Prerequisites Courses: Computer Networks (24-DMC-AD-2-01), Cloud Computing (24-DMC-AD-2-02)		
Companion Course:		

Course Objectives:

1. **Explain** the underlying **technology and principles behind Blockchain**
2. **Illustrate** the concepts of cryptocurrency, Bitcoin, and smart contracts and their role in decentralized applications.
3. Compare and Differentiate among various consensus algorithms (e.g., PoW, PoS, PBFT, PoA) used in Blockchain systems.
4. **Examine** and **evaluate real-world applications** of Blockchain across domains such as finance, supply chain, healthcare, and IoT.
5. **Develop and Implement** smart contracts on the **Ethereum platform using Solidity** to build decentralized applications
6. **Analyze and Present case studies** of Blockchain adoption to understand challenges, benefits, and future opportunities.

Course Outcomes:

After completion of the course, learners should be able to

CO. No	CO	BL
CO1	**Explain** the core technology, architecture, and principles of Blockchain, including cryptography and distributed ledgers.	2
CO2	**Illustrate** the functioning of cryptocurrency, Bitcoin, and smart contracts through examples and simple applications..	2
CO3	**Differentiate and Compare** various consensus algorithms used in Blockchain for their efficiency, scalability, and security.	4
CO4	**Analyze and Evaluate** real-world Blockchain applications in domains such as finance, healthcare, supply chain, and IoT.	4
CO5	**Design and Implement** smart contracts using Solidity on the Ethereum platform to develop decentralized applications	3
CO6	**Examine and Present** Blockchain case studies to identify challenges, opportunities, and future	4

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	research directions.	

Course Contents		
Unit I	**Mathematical Foundation for Blockchain**	**7 Hours**
Cryptography: Symmetric Key Cryptography and Asymmetric Key Cryptography, Elliptic Curve Cryptography (ECC), Cryptographic Hash Functions: SHA256, Digital Signature Algorithm (DSA), Merkel Trees.		
#Exemplar/Case Studies: Compare the Symmetric and Asymmetric Cryptography algorithms		
***Mapping of Course Outcomes**	**CO1,CO2**	
Unit II	**Feature Engineering**	**7 Hours**
History, Centralized Vs. Decentralized Systems, Layers of Blockchain: Application Layer, Execution Layer, Semantic Layer, Propagation Layer, Consensus Layer, Why is Block chain important? Limitations of Centralized Systems, Blockchain Adoption So Far.		
#Exemplar/Case Studies: Study of a research paper based on Blockchain.		
***Mapping of Course Outcomes**	**CO3**	
Unit III	**Blockchain Platforms and Consensus in Blockchain**	**7 Hours**
Types of Blockchain Platforms: Public, Private and Consortium, Bitcoin, Ethereum, Hyperledger, IoTA, Corda, R3. Consensus in Blockchain: Consensus Approach, Consensus Elements, Consensus Algorithms, Proof of Work, Byzantine General problem, Proof of Stake, Proof of Elapsed Time, Proof of Activity, Proof of Burn.		
#Exemplar/Case Studies: Compare different consensus algorithms used in Blockchain Technology.		
***Mapping of Course Outcomes**	**CO4**	
Unit IV	**Cryptocurrency – Bitcoin, and Token**	**7 Hours**
Introduction, Bitcoin and the Cryptocurrency, Cryptocurrency Basics Types of Cryptocurrency, Cryptocurrency Usage, Cryptowallets: Metamask, Coinbase, Binance		
#Exemplar/Case Studies: Create your own wallet for crypto currency using any of the Blockchain Platforms.		
***Mapping of Course Outcomes**	**CO1, CO5**	
Unit V	**Blockchain Ethereum Platform using Solidity**	**7 Hours**
What is Ethereum, Types of Ethereum Networks, EVM (Ethereum Virtual Machine), Introduction to smart contracts, Purpose and types of Smart Contracts, Implementing and deploying smart contracts using Solidity, Swarm (Decentralized Storage Platform), Whisper (Decentralized Messaging Platform)		

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#Exemplar/Case Studies: Study Truffle Development Environment.		
***Mapping of Course Outcomes**	**CO5, CO6**	
Unit VI	**Blockchain Case Studies**	**7 Hours**
Prominent Blockchain Applications, Retail, Banking and Financial Services, Government Sector, Healthcare, IOT, Energy and Utilities, Blockchain Integration with other Domains		
#Exemplar/Case Studies: Study 2 uses cases of Blockchain and write a detailed report on every aspect implemented in the same		
***Mapping of Course Outcomes**	**CO5, CO6**	

Learning Resources

Text Books:

T1. Martin Quest, "Blockchain Dynamics: A Quick Beginner's Guide on Understanding the Foundations of Bit coin and Other Crypto currencies", Create Space Independent Publishing Platform, 15-May-2018 2.

T2. Imran Bashir, "Mastering Blockchain: Distributed Ledger Technology, Decentralization and Smart Contracts Explained", Second Edition, Packt Publishing, 2018 3.

T3. Alex Leverington, "Ethereum Programming", Packt Publishing, 2017

Reference Books :

R1. Bikramaditya Singhal, Gautam Dhameja, Priyansu Sekhar Panda, "Beginning Blockchain: A Beginner's Guide to Building Blockchain Solutions",2018 2.

R2. Chris Dannen, "Introducing Ethereum and Solidity", Foundations of Crypto currency and Blockchain Programming for Beginners

R3. Daniel Drescher, "Blockchain Basics", A Non -Technical Introduction in 25Steps.

R4. Ritesh Modi, "Solidity Programming Essentials", Packt Publishing,2018

R5. Chandramouli Subramanian, Asha A George, Abhilash K A and Meena Karthikeyan, "Blockchain Technology", Universities Press, ISBN-9789389211634

MOOC Courses links :

- 1. NPTEL Course on "Introduction to Blockchain Technology & Applications" https://nptel.ac.in/courses/106/104/106104220/
- 2. NPTEL Course on Block Chain: https://nptel.ac.in/courses/106/105/106105184/

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Double Minor Syllabus Offered by Civil Engineering for Other Branch Students for SEM V and SEM VI

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24-DMC-CE-3-03 Project Formulation and Appraisal

Teaching Scheme: Theory: 3 Hours/Week	**Credit:** 3	**Examination Scheme:** **SEE** :- 100 Marks

Prerequisites Courses: - 24-DMC-CE-2-01: Infrastructure Planning and Management

Companion Course: -

Course Objectives:

- Understand the basic concepts and importance of project management in organizations.
- Develop skills to prepare and analyze detailed project reports (DPR).
- Apply risk management techniques to mitigate project uncertainties.
- Apply various estimating guidelines and methods including top-down estimation.
- Understand the key components of and purpose of an RFP in project management.

Course Outcomes:

After completion of the course, learners should be able to

CO No	CO	BL
CO1	**Identify** the key drivers of project management including market, technology and regulatory factors.	2
CO2	**Interpret** bar charts and Gantt charts for effective scheduling and visualization of project activities.	2
CO3	**Apply** Risk identification factors in sample capital project scenarios.	3
CO4	**Analyze** the market, technical, and financial feasibility of a project proposal	4
CO5	**Apply** top–down estimation methods to prepare initial cost estimates for a sample project.	3
CO6	**Apply** a weighted scoring system to assess and rank multiple vendor proposals.	3

Course Contents

Unit I	**Fundamentals of Project Management**	**8 Hours**

Basic Concepts and Introduction, Drivers of Project Management, Linkages between Organization Strategy and Projects, Project Governance and Design of Project Portfolio System.

#Exemplar/Case Studies: Strategic alignment and project portfolio management at Alphatech Solutions.

***Mapping of Course Outcomes**	**CO1**

Unit II	**Project Scheduling and Resource Management**	**8 Hours**

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Work breakdown structure (WBS), Bar chart, Gantt chart, and network diagrams (CPM), Resource allocation and leveling, Project Evaluation, Project progress and Performance Management, Project Closure, and Project Oversight.		
#Exemplar/Case Studies: State of the Art IT Park Construction Project, Pune		
***Mapping of Course Outcomes**	**CO2**	
Unit III	**Risk Management and Scheduling in Capital Projects**	**8 Hours**
Risk Assessment of Capital projects, Managing Risk and Risk Identification,Risk Assessment, Classification of Scheduling Problems: Time-constrained Project, Resource-constrained Project, Time-phased Budget, Critical Chain Project Management.		
#Exemplar/Case Studies: Management and scheduling in mega infrastructure projects-Greenline Expressway.		
***Mapping of Course Outcomes**	**CO3**	
Unit IV	**Market and Technical Appraisal**	**6 Hours**
Market survey and demand forecasting, Technical feasibility analysis, Selection of technology and location, Project capacity and scale of operation.		
#Exemplar/Case Studies: Solar Powered Water Supply Project in Rural Maharashtra, Delhi Metro Rail Project.		
***Mapping of Course Outcomes**	**CO4**	
Unit V	**Project selection, Organizational framework and cost estimation Techniques**	**8 Hours**
Non-Financial and Multi-Criteria Project Selection Models, Organization Structure, Organization Culture, Project Scope of Work and Deliverables, Partnering and Traditional Approaches for Managing Relations, Estimating Guidelines and Methods, Top-down Estimation, Level of Details, Type of Costs and Refining Estimates.		
#Exemplar/Case Studies: Mega Energy plant Development- SunPower Green Energy Ltd.		
***Mapping of Course Outcomes**	**CO5**	
Unit VI	**Preparation and Evaluation Request for Proposal**	**7 Hours**
Preparation and Evaluation of RFP: Best Practices, Project Closure Activities and Post-Implementation Evaluation, Oversight Activities and Levels, Phase Gate System, Project Management Maturity Model.		
#Exemplar/Case Studies: Horizon Smart City - A Government Urban Infrastructure Initiative.		
***Mapping of Course Outcomes**	**CO6**	
Learning Resources		
Text Books		

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T1. Prasanna Chandra, Projects: Planning, Analysis, Selection, Financing, Implementation, and Review, Tata McGraw-Hill, 8th Edition **T2.** Machiraju H.R., Project Finance, Vikas Publishing.
Reference Books :
R1. Goel, B.B., Project Management: Principles and Techniques, Deep & Deep Publications, 6th Edition. **R2.** IS Codes & IRC Manuals (for applicable modules)
Additional Resources: (Books, e-Resources)
MOOC Courses links : ● https://nptel.ac.in/courses/105106149 ● https://nptel.ac.in/courses/110105167

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24-DMC-CE-3-04 : Advanced and Sustainable Materials in Infrastructure

Teaching Scheme: Theory: 3 Hours/Week	**Credit:** 3	**Examination Scheme:** **SEE** : 100 Marks

Prerequisites Courses: 24-ESC-1-04 : Smart Building and Materials

Companion Course: --

Course Objectives:

- To understand the types of building materials, their uses, and their role in making eco-friendly and sustainable buildings.
- To compare alternate materials with traditional construction materials in terms of durability, cost, and environmental impact.
- To explore innovative building materials and their role in sustainability, focusing on permeable concrete, composite bricks, and nanocellulose.
- To apply knowledge of agro-based materials in sustainable construction.
- To explore eco-friendly and alternative materials through real-life case studies.

Course Outcomes:

After completion of the course, learners should be able to

CO No	CO	BL
CO1	**Illustrate** the types and benefits of traditional and natural building materials in creating sustainable eco-friendly buildings.	2
CO2	**Describe** the different types of alternate building materials and their uses in construction.	2
CO3	**Apply** innovative building materials to real-world construction for sustainability.	3
CO4	**Illustrate** the use of environment friendly agro-based materials in sustainable construction projects.	2
CO5	**Apply** the properties of advanced building materials to select suitable alternatives for energy-efficient and eco-friendly construction scenarios.	3
C06	**Apply** sustainable smart materials in building components to enhance energy efficiency and performance.	3

Course Contents

Unit I	**Traditional Sustainable Materials**	**8 Hours**

Introduction: Building materials- classification and their significance in Green Buildings, Traditional Building materials and their characteristics (Carbon Negative Building Materials), Carbon Sequestration by Building Materials, **Traditional Building Materials:** Mud, Stone, Thatch, Bamboo, Binders- Lime, Cowdung, Straw bale, Laterite Quarry waste

#Exemplar/Case Studies: Case Study on Floating Bamboo House by H&P Architects in Vietnam.

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***Mapping of Course Outcomes**	**CO1**	
Unit II	**Sustainable Concrete and Alternative Materials**	**7 Hours**
Alternate Building Materials-Introduction,Classification,Carbon Positive Building Material,Sustainability of alternate building material,Flyash concrete, Phosphogypsum,Furnace Slag,Aerated Concrete, Hempcrete, Papercrete,Alternate aggregates,Milk Paints, Recycled Plastics.		
#Exemplar/Case Studies: Case Study on IPIRTI (Indian Plywood Industries Research and Training Institute) Bamboo Housing.		
***Mapping of Course Outcomes**	**CO2**	
Unit III	**Innovative Building Materials**	**7 Hours**
Introduction –Innovative Building Material,Impact on building materials on Sustainability ,Need & Characteristics for Innovative building materials, Permeable Concrete-Introduction,Properties & Application, Composite Bricks,Nanocellulose-It's Type & Properties,Nanocellulose composite brick		
#Exemplar/Case Studies: Case study on Sustainable TEKITEKI-AN Tiny House in Kamogawa,Japan.		
***Mapping of Course Outcomes**	**CO3**	
Unit IV	**Agro-Based Materials**	**8 Hours**
Environmentally friendly and durable materials,Agro bricks-Introduction,Classification-Rice Husk Ash Bricks, Date Palm Fibres Bricks,Hempcrete Bricks,Sugarcane Bagasse Bricks, Agro Bricks-Environmental Benefits, Limitations,Applications,Fabrick- cotton and textile ash bricks		
#Exemplar/Case Studies: Case study on Interlocking Baggasse Bricks.		
***Mapping of Course Outcomes**	**CO4**	
Unit V	**Sustainable and Green Advanced Building Materials**	**7 Hours**
Introduction -Advanced Building materials,Need,Demand Trends, Light-transmitting bricks, CO_2 absorbing concrete, Geopolymer concrete,Ecobind tile,Mycelium composite brick, Bioluminous paints, Living Bricks for Carbon Sequestration		
#Exemplar/Case Studies: Case study on Carbicrete.		
***Mapping of Course Outcomes**	**CO5**	
Unit VI	**Sustainable Smart Materials**	**8Hours**
Introduction & characteristics of smart materials, Types, Features& Use of Smart Material, Application of smart materials on building components - Facade systems - smart windows,Adhesion Changing Smart Material,Photo adhesive Smart Material,Titanium Dioxide (Tio2),Ceramic Slab with Tio2,Construction Membrane & Glass Panel with Tio2.		
#Exemplar/Case Studies: Case study on Chapel Garden at the Hyatt Regency Hotel in Osaka,Japan		
***Mapping of Course Outcomes**	**CO6**	
Learning Resources		

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Text Books
T1. Jagadish K S,Alternative Building Materials and Technologies,,New Age International P Ltd.Publishers;2007,1st Edition **T2**.Duggal S.K.,Building Materials,New Age International P .Ltd.Publishers;2009, 3rd Edition
Reference Books :
R1. Jagadish K S,Alternative Building Materials and Technologies,,New Age International P .Ltd.Publishers;2007,1st Edition **R2**. Ghose D.N.,Materials of Construction,Tata Mcgraw Hill Publication;2003,11th Edition. **R3.**Sengupta,Materials of construction,Delhi PHI Education of India;2004, 3rd Edition.
Additional Resources: (Books, e-Resources) 1.https://www.academia.edu/79354900/Materials_for_sustainable_sites_a_complete_guide_to_the_evaluation_selection_and_use_of_sustainable_construction_materials 2.https://www.overdrive.com/media/10396255/sustainable-materials-in-civil-infrastructure
NPTEL/Swayam Courses links : 1. https://onlinecourses.nptel.ac.in/noc24_ar20/preview

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24-DMC-CS-3-03: Data analytics with Python

Teaching Scheme: Theory: 3 Hours/Week	**Credit:** 3	**Examination Scheme:** **SEE :** 100

Prerequisites Courses: 24-DMC-CS-2-01 :Foundation of Data Science, 24-DMC-CS-3-03: Data analytics with Python.

Companion Course: NA

Course Objectives:
Students will be able to

- **Understand** basics of data analytics and Python programming.
- **Apply** probability, sampling, and hypothesis testing for data analysis.
- **Analyze** relationships in data using regression and ANOVA.
- **Build and evaluate** predictive models using logistic regression and ROC analysis.
- **Explore** categorical data analysis and clustering techniques.
- **Design** decision trees for classification and prediction.

Course Outcomes:
After completion of the course, learners should be able to

CONo	CO	BL
CO1	**Understand** fundamentals of data analytics, Python, and probability concepts.	2
CO2	**Apply** statistical techniques like sampling, hypothesis testing, and ANOVA.	3
CO3	**IInterpret** regression models to support data-driven decision-making.	3
CO4	**Apply** clustering models for grouping data	3
CO5	**Describe** classification solutions using decision trees	3

Course Contents

Unit I	**Foundations of Data Analytics & Python**	**7 Hours**

Introduction to data analytics, role and applications, fundamentals of Python programming for analytics. Basics of probability theory, concepts of random variables and distributions.

#Exemplar/Case Studies: Analyzing student exam scores with Python to find average, highest, and lowest marks.

***Mapping of Course Outcomes**	**CO1**

Unit II	**Statistical Foundations for Data Analytics**	**7 Hours**

Sampling techniques, sampling distributions, estimation. Hypothesis testing fundamentals, errors in hypothesis testing, one-sample and two-sample tests.

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#Exemplar/Case Studies: Using sampling and hypothesis testing to check if a new teaching method improves student performance		
***Mapping of Course Outcomes**	**CO1,CO2**	
Unit III	**Analysis of Variance and Regression**	**7 Hours**
One-way and two-way ANOVA techniques. Introduction to linear regression, simple linear regression modeling, multiple regression models, assumptions and interpretations.		
#Exemplar/Case Studies: Applying ANOVA and regression to study the effect of advertising spend and product price on sales		
***Mapping of Course Outcomes**	**CO2,CO3**	
Unit IV	**Advanced Regression and Logistic Modeling**	
Concept of Maximum Likelihood Estimation (MLE). Logistic regression modeling, interpretation of logistic regression coefficients, ROC curve analysis, model evaluation and regression analysis model building.		
#Exemplar/Case Studies: Building a logistic regression model to predict whether a bank customer will default on a loan		
***Mapping of Course Outcomes**	**CO3,CO4**	
Unit V	**Categorical Data Analysis & Clustering**	
Chi-square test and its applications in data analytics. Introduction to cluster analysis, K Means Clustering, measures of similarity and distance, hierarchical and non-hierarchical clustering methods.		
#Exemplar/Case Studies: Using clustering to group customers based on their buying patterns in an online store		
***Mapping of Course Outcomes**	**CO4,CO5**	
Unit VI	**Decision Trees for Analytics**	**7 Hours**
Classification and Regression Trees (CART), splitting criteria, pruning, overfitting and model validation. Applications of decision trees in analytics.		
#Exemplar/Case Studies: Applying a decision tree to predict whether a patient is likely to have diabetes based on health data		
***Mapping of Course Outcomes**	**CO5**	
Learning Resources		
Text Books		
T1. McKinney, W. (2012). Python for data analysis: Data wrangling with Pandas, NumPy, and IPython. " O'Reilly Media, Inc.". **T2.** Jiawei Han and Micheline Kamber (2006). Data Mining: Concepts and Techniques.		
Reference Books :		
R1. Douglas C. Montgomery, George C. Runger (2002). Applied Statistics & Probability for Engineering. "John Wiley & Sons, Inc" **R2.** Jay L. Devore (2011). Probability and Statistics for Engineering and the Sciences. "Cengage Learning"		

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Additional Resources: (Books, e-Resources)
MOOC Courses links : ● https://nptel.ac.in/courses/106107220

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24-DMC-CS-3-04: Business Intelligence & Analytics

Teaching Scheme: Theory: 3 Hours/Week	**Credits:** 3	**Examination Scheme:** **SEE :** 100 Marks

Prerequisites Courses: 24-DMC-CS-2-01 : Foundation of Data Science, 24-DMC-CS-3-03: Data analytics with Python.

Companion Course: NA

Course Objectives:

- Understand the foundations and technical architecture of Business Intelligence & Analytics.
- Apply data visualization and descriptive analytics techniques for business insights.
- Understand predictive models using data mining, regression, and classification methods.
- Analyze and evaluate decision-making models through clustering, decision trees, and customer segmentation.
- Design advanced analytics solutions using neural networks and text mining for real-world business problems.

Course Outcomes:

After completion of the course, learners should be able to

CONo	CO	BL
CO1	**Understand** Business Intelligence & Analytics fundamentals, architecture, and data management concepts.	2
CO2	**Apply** descriptive analytics & visualization for insights.	3
CO3	**Understand** predictive models using regression, classification & decision trees.	2
CO4	**Apply** clustering and customer segmentation techniques.	3
CO5	**Understand** ANN and text mining–based solutions for business problems.	2

Course Contents

Unit I	**Foundations of Business Intelligence & Analytics**	**7 Hours**

Introduction to Business Intelligence & Analytics (BIA), its driving forces, types of analytics (descriptive, predictive, prescriptive), and vocabulary of business analytics.

#Exemplar/Case Studies: Amazon uses Business Intelligence (BI) systems and recommendation algorithms to analyze customer behavior and suggest the most relevant products.

***Mapping of Course Outcomes**	**CO1**

Unit II	**Data Warehousing**	**8 Hours**

Technical architecture of BIA, case study of AT&T, fundamentals of data management, OLTP systems, database design, normalization, SQL queries, data warehousing, OLAP, data cubes.

#Exemplar/Case Studies: Walmart: Data warehousing for inventory management using OLAP.

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***Mapping of Course Outcomes**	**CO1**	
Unit III	**Descriptive Analytics & Visualization**	**7 Hours**
Descriptive analytics, data visualization, customer analytics, survival analysis, customer lifetime value, and associated case studies.		
#Exemplar/Case Studies: Design an interactive dashboard using the tool.		
***Mapping of Course Outcomes**	**CO2, CO4**	
Unit IV	**Data Mining and Predictive Modeling**	**7 Hours**
Data mining process, statistical learning, data preprocessing, ensuring data quality, and regression analysis as a modeling technique.		
#Exemplar/Case Studies: Bank loan defaulter prediction using predictive analysis.		
***Mapping of Course Outcomes**	**CO3**	
Unit V	**Classification and Clustering**	**8 Hours**
Classification techniques, scoring models, ROC/PR curves, decision trees (induction, purity, pruning, ensembles), implementation in Python, clustering methods, clustering quality, customer segmentation (RFM analysis), and profiling.		
#Exemplar/Case Studies: Diabetes Risk Prediction using Classification & Clustering (with Python / WEKA) using Dataset: PIMA Indian Diabetes Dataset (public dataset).		
***Mapping of Course Outcomes**	**CO3, CO4**	
Unit VI	**Advanced Analytics – Neural Networks & Text Mining**	**8 Hours**
Artificial Neural Networks (structure, backpropagation), financial time-series modeling using ANN in Python, text mining fundamentals, sentiment scoring, and implementation in R through a movie discussion forum case study.		
#Exemplar/Case Studies: WhatsApp chat sentiment analysis of any WhatsApp group using an Android application.		
***Mapping of Course Outcomes**	**CO5**	
Learning Resources		
Text Books		
T1. Han, J., Pei, J. & Tong, H. Data Mining Concepts and Techniques, 2023, 4th ed, New Delhi: Elsevier.		
Reference Books :		
R1. James, G., Witten, D., Hastie, T., and Tibshiran, R. (2013). An Introduction to Statistical Learning with Applications in R, Springer.		
Additional Resources: (Books, e-Resources) **e-Resources**		

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- https://nptel.ac.in/courses/106106361

e-Books

- https://www.knime.com/sites/default/files/inline-images/KNIME_quickstart.pdf
- www.cs.ccsu.edu/~markov/weka-tutorial.pdf
- http://www.biomedicahelp.altervista.org/Magistrale/Clinics/BIC_PrimoAnno/IdentificazioneMod
- https://download.e-bookshelf.de/download/0000/5791/06/L-G-0000579106-0002359656.pdf

MOOC Courses links :

- https://nptel.ac.in/courses/106106361

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24-DMC-ET-3-03: Analog Circuits

Teaching Scheme: Theory: 3 Hours/Week	**Credit:** 3	**Examination Scheme:** **SEE** : 100 Marks

Prerequisites Courses: –

Companion Course: –

Course Objectives:

- Introduce the basic operation and characteristics of BJT and MOSFET devices, along with their amplifier configurations.
- Study of differential amplifiers and their role in analog circuit design.
- Understand the fundamental concepts of operational amplifier by identifying key parameters and their applications in linear circuits.
- Explain the principles of feedback systems, their effect on amplifier performance, and stability considerations.
- Explore the concepts, design, and applications of oscillators, multivibrators, and waveform generating circuits.

Course Outcomes:

After completion of the course, learners should be able to

CONo	**CO**	**BL**
CO1	**Analyze** CE amplifier using small signal models and frequency response.	4
CO2	**Apply** small signal equivalent models for MOSFET-based circuits.	3
CO3	**Differentiate** between single-ended and differential signaling.	2
CO4	**Design and analyze** op-amp based circuits.	4
CO5	**Understand** the effect of feedback on amplifier performance.	2
CO6	**Design** Oscillator and multivibrator.	3

Course Contents

Unit I	**Bipolar Junction Transistor**	**8 Hours**

BJT: Basic Structure,Bias conditions,I-V characteristics. Common emitter amplifier. small signal equivalent circuit of transistor. Frequency response of CE amplifier. Limitations of CE amplifiers and hence the need for buffers. Multi transistor Amplifiers(operation and analysis): CE-CC.

#Exemplar/Case Studies: Performance Analysis of a Common-Emitter Amplifier.

***Mapping of Course Outcomes**	**CO1**

Unit II	**Field Effect Transistors**	**8 Hours**

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MOSFET : Operation and I-V characteristics. MOSFET Biasing,Parameters of MOSFET small signal equivalent circuit, Small signal analysis of Common source (CS) amplifier,Frequency response of CS amplifiers considering High frequency models of MOSFET. Multi transistor Amplifiers (operation and analysis): CS-CD.		
#Exemplar/Case Studies: Design a Common Source (CS) MOSFET amplifier to amplify a weak audio signal.		
***Mapping of Course Outcomes**	**CO2**	
Unit III	**Differential Amplifier**	**6 Hours**
Single-ended signaling vs. differential signaling, Differential amplifier: Basic structure and principle of operation, analysis for differential mode gain, common mode gain, ICMR and output swing.		
#Exemplar/Case Studies: Differential Amplifier in Biomedical Signal Acquisition(ECG)		
***Mapping of Course Outcomes**	**CO3**	
Unit IV	**The Operational Amplifier**	**6 Hours**
Ideal OpAmp ,Parameters, Applications of OPAMP – Inverting and Non Inverting Amplifier,Summing Amplifier, Difference Amplifier, Integrator, Differentiator, Non Linear Applications of OPAMPS, Non Idealities in an OPAMP – Finite Gain, Bandwidth, Slew Rate, Saturation, Offset Voltage, Bias Current.		
#Exemplar/Case Studies: Operational Amplifiers in Real-World Applications: Signal Conditioning		
***Mapping of Course Outcomes**	**CO4**	
Unit V	**Feedback System**	**8 Hours**
Feedback system, Transfer characteristic of a feedback system ,Four different feedback configurations and their characteristics, Effects of feedback on frequency response of an amplifier. Application of feedback in practical circuits,Stability analysis of a feedback system, Two-stage differential amplifier and its stability analysis in feedback configuration.		
#Exemplar/Case Studies: Improving Stability and Performance of an Amplifier using Feedback.		
***Mapping of Course Outcomes**	**CO5**	
Unit VI	**Oscillators, Multivibrators & Filters**	**8 Hours**
Barkhausen Criterion, Condition for oscillations, Classification of Oscillators, Phase-shift and LC based sinusoidal oscillators. Multivibrator: Mono stable & Astable Multivibrator, Filter Design, Filter prototypes,Butterworth and Chebyshev Filters , Active Filters.		
#Exemplar/Case Studies: Simulation of astable multivibrator using IC555.		
***Mapping of Course Outcomes**	**CO6**	
Learning Resources		
Text Books		
T1. J. Millman and C. Halkias, Integrated Electronics: Analog and Digital Circuits and Systems, McGraw Hill.		

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T2. Ramakant A. Gaikwad, "Op Amps and Linear Integrated Circuits", Pearson Education .

Reference Books :

R1. David A.Bell,"Electronic Devices and Circuits",5th Edition, Oxford University Press.
R2. Sedra and Smith,Microelectronic Circuits : Theory and Applications, Oxford University Press.

MOOC Courses links :

1. NPTEL Course "Analog Electronic Circuits"https://nptel.ac.in/courses/108105158
2. NPTEL Course on "Analog Circuits"https://nptel.ac.in/courses/108101094

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24-DMC-ET-3-04: Mechatronics

Teaching Scheme: Theory: 3 Hours/Week	**Credit:** 3	**Examination Scheme:** **SEE** : 100 Marks

Prerequisites Courses: 24-DMC-ET-2-02: Microprocessors & Microcontrollers

Companion Course: NA

Course Objectives:

- Equip students with fundamental knowledge of mechatronics, sensor principles, and their characteristics.
- Provide understanding of signal processing concepts and the application of interfacing devices such as ADC, DAC, and Digital I/O.
- Develop the ability to construct block diagrams and understand transfer function concepts for control systems.
- Prepare students for system modeling and analysis in the frequency domain.
- Deliver insights into system modeling and analysis in the time domain, controller modes, and their industrial applications.
- Create awareness about the role and applications of mechatronics in industry.

Course Outcomes:

After completion of the course, learners should be able to

CONo	CO	BL
CO1	**Illustrate** the fundamentals of Mechatronics systems and their components.	2
CO2	**Describe** sensors, actuators, and signal conditioning methods.	2
CO3	**Apply** system modeling techniques to analyze mechanical, electrical and fluid systems.	3
CO4	**Develop** simple mechatronic applications using sensors, actuators and controllers.	3

Course Contents

Unit I	**Introduction to mechatronics**	**6 Hours**

Introduction, Examples of Mechatronic systems, Electric circuits and components, Semiconductor Electronics, Transistor Applications.

#Exemplar/Case Studies: IoT-Enabled Mechatronic System for Autonomous Water Pump Control and Monitoring.

***Mapping of Course Outcomes**	**CO1**

Unit II	**Sensors and Transducers**	**7 Hours**

Performance terminology of sensors, Displacement, Position & Proximity Sensors-I, Displacement, Position & Proximity Sensors-II, Force, Fluid pressure, Liquid flow sensors, temperature, light sensor, Acceleration and Vibration measurement, Semiconductor sensor and MEM, SAW

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#Exemplar/Case Studies- "Advanced Robotics and Vision-Based Quality Control in Automated Bottle Filling Systems"		
***Mapping of Course Outcomes**	**CO2**	
Unit III	**Actuators and Signal Conditioning**	**7 Hours**
Mechanical Actuation System, Hydraulic & Pneumatic Actuation System, Electrical Actuation System-I, Electrical Actuation System-II, Data Presentation system. Introduction to signal processing & Op-Amp, Op-Amp as signal conditioner, Analogue to Digital Converter, Digital to Analogue Converter.		
#Exemplar/Case Studies- Automotive Fuel Injection System.		
***Mapping of Course Outcomes**	**CO2**	
Unit-IV	**Microprocessors and microcontrollers**	**7 Hours**
Digital circuits-I, Digital circuits-II, Microprocessor, Micro Controller, Programming of Microcontrollers.		
#Exemplar/Case Studies: Microcontroller-Driven Automatic Street Light Management for Sustainable Urban Infrastructure		
***Mapping of Course Outcomes**	**CO4**	
Unit-V	**Modeling and system response**	**7 Hours**
Mechanical system model, Electrical system model, Fluid system model, Dynamic response of systems, Transfer function and frequency response. P,I, PID Controllers, Digital Controllers, Program Logic Controllers, Input/output & Communication systems, Fault findings.		
#Exemplar/Case Studies: AI-Driven Mechatronic System for Intelligent Boiler Temperature and Pressure Control		
***Mapping of Course Outcomes**	**CO3**	
Unit VI	**Design and mechatronics**	**7 Hours**
Project using Microcontroller-Atmega 16, Myoelectrically Controlled, Robotic Arm, Robocon-Part I, Robocon-Part II, Design of a Legged Robot.		
#Exemplar/Case Studies: Development of an Advanced Myoelectric-Driven Robotic Arm for Enhanced Assistive Rehabilitation in Individuals with Disabilities.		
***Mapping of Course Outcomes**	**CO4**	
Learning Resources		
Text Books		
T1. William Bolton, Mechatronics: Electronics Control Systems in Mechanical and Electrical Engineering, 6th Ed, Pearson Education, 2016. **T2.** K.P. Ramchandran, G.K. Vijyaraghavan, M.S. Balasundaram, Mechatronics: Integrated Mechanical Electronic Systems, Willey Publication, 2008.		
Reference Books :		

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R1. D.G. Alciatore & Michael B. Histand, Introduction to Mechatronics, 4th Ed, Tata Mc Graw Hill**,** 2016.
R2. Shetty Dedas, Kolk and Richard, Mechatronic system Design, Cengage Learning India Private Limited, 1st Ed, 2008

Additional Resources: (Books, e-Resources)
Prof. Pushparaj Mani Pathak, Mechatronics, IIT Roorkee.
https://www.vlab.co.in/participating-institute-coe-pune

MOOC Courses links :
https://nptel.ac.in/courses/112107298

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24-DMC-ME-3-03: Future Solar Energy Harnessing Technologies

Teaching Scheme: Theory: 03 Hours/Week	**Credit:** 03	**Examination Scheme:** **SEE**: 100 Marks

Prerequisites Courses: (24-ESC-1-01) Basic Electrical & Electronics Engineering, (24-HOC-ME-2-01B) Introduction to Sustainable Energy Systems, (24-DMC-ME-2-01) Introduction to Sustainable Energy Systems, (24-DMC-ME-2-02) Solar PV Design Optimization & Manufacturing.

Companion Course:

Course Objectives:

- To study solar resource assessment and advanced photovoltaic technologies for efficient energy conversion
- To understand the design and applications of concentrated solar power and thermal technologies
- To learn the principles and applications of integrated photovoltaic systems.
- To study the design and application of photovoltaic systems integrated into buildings
- To study solar technologies for sustainable industrial processes.
- To explore applications and emerging trends shaping the future of solar technologies.

Course Outcomes:

After completion of the course, learners should be able to

CO No	CO	BL
CO1	**Understand** solar resource assessment methods and advanced photovoltaic technologies.	2
CO2	**Understand** working principles of concentrated solar power and thermal technologies.	2
CO3	**Apply** integration techniques to evaluate photovoltaic system performance.	3
CO4	**Apply** design principles to evaluate the performance of BIPV systems	3
CO5	**Apply** solar energy technologies to design sustainable industrial processes.	3
CO6	**Understand** to describe emerging trends in solar energy technologies	2

Course Contents

Unit I	**Solar Resource Assessment & Advanced Photovoltaics**	**7 Hours**

Solar radiation fundamentals, resource analysis, Design principles and efficiency factors of Third-generation solar cells (Perovskite Solar Cells, Quantum Dot Solar Cells, Organic Solar Cells), Multi-junction and Tandem cells.

#Exemplar/Case Studies: Perovskite-Silicon Tandem Pilot on MSME Rooftops in Ahmedabad

***Mapping of Course Outcomes**	**CO1**

Unit II	**Concentrated Solar Power & Thermal Technologies**	**7 Hours**

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Solar collectors and concentrators, CSP systems (Parabolic Troughs, Solar Towers, Solar Dish), Thermal storage strategies (sensible, latent, thermochemical), Solar Thermal Power Generation (Solar Concentrators).		
#Exemplar/Case Studies: Sakri Solar Power Plant 1,200 MW, Solar Thermal (CSP) Project in Solapur, Maharashtra		
***Mapping of Course Outcomes**	**CO2**	
Unit III	**Integrated PV Systems**	**7 Hours**
Applications of PVT Systems (hot water heating, space heating, and industrial process heat), PV System Design with batteries and energy storage, Performance Metrics (Electrical, Thermal, Overall System efficiency).		
#Exemplar/Case Studies: Indira Paryavaran Bhawan, New Delhi		
***Mapping of Course Outcomes**	**CO3**	
Unit IV	**Building-Integrated Photovoltaics (BIPV)**	**7 Hours**
Principles of BIPV, BIPV materials and applications, passive solar building design, Integration and Economics.		
#Exemplar/Case Studies: Data Centre, Navi Mumbai – India's Largest BIPV Installation		
***Mapping of Course Outcomes**	**CO4**	
Unit V	**Solar-based Industrial Processes**	**7 Hours**
Solar energy for process heating, solar cooling and refrigeration, and solar desalination. PV for water pumping, hydraulic power. Grid connection principle.		
#Exemplar/Case Studies: Shri Saibaba Sansthan Trust, Shirdi– Solar Cooking.		
***Mapping of Course Outcomes**	**CO5**	
Unit VI	**Application & Future Trends in Solar Technologies**	**7 Hours**
Passive architecture, emerging solar innovations, trends and R&D directions. Emerging technologies in solar energy, energy efficient design and integration with land use. Energy economy and futuristic PV research.		
#Exemplar/Case Studies: Suzlon One Earth, Pune – Passive Architecture with Solar Integration.		
***Mapping of Course Outcomes**	**CO6**	
Learning Resources		
Text Books		
T1. S. P. Sukhatme, "Solar Energy", Tata McGraw-Hill, 2008. **T2.** G. D. Rai, "Energy Sources", Khanna Publishers, 2009. **T3.** S. Rao, B. B. Parulekar, "Energy Technology", Khanna Publishers, 2005.		

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Reference Books:

R1. H. P. Garg, "Solar Energy", Tata McGraw-Hill, 2000.
R2. Non-Conventional Energy Resources, S. K. Dubey, Dhanpat Rai & Co., 2010.

MOOC Courses links :

- **M1:** Solar Photovoltaics Fundamentals, Technology And Applications, https://onlinecourses.nptel.ac.in/noc21_ph25/preview
- **M2:** Elements of Solar Energy Conversion, https://onlinecourses.nptel.ac.in/noc21_me34/preview
- **M3:** Solar Energy Engineering and Technology, https://onlinecourses.nptel.ac.in/noc20_ph14/preview
- **M4:** Design of Photovoltaic Systems, https://nptel.ac.in/courses/117108141
- **M5:** Sustainable Materials and Green Buildings, https://onlinecourses.nptel.ac.in/noc19_ce40/preview

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24-DMC-ME-3-04 Grid Integration and Smart Grid Technologies.

Teaching Scheme: Theory: 03 Hours/Week	**Credit:** 03	**Examination Scheme:** **SEE**: 100 Marks

Prerequisites Courses: (24-ESC-1-01) Basic Electrical & Electronics Engineering, (24-HOC-ME-2-01B) Introduction to Sustainable Energy Systems, (24-DMC-ME-2-01) Introduction to Sustainable Energy Systems, (24-DMC-ME-2-02) Solar PV Design Optimization & Manufacturing, 24-DMC-ME-3-03: Future Solar Energy Harnessing Technologies.

Companion Course: -

Course Objectives:

- To understand the fundamental principles of smart grid and integration.
- To explain the foundational architecture and components of a smart grid.
- To learn the application of micro grids and energy storage solutions for enhancing grid stability.
- To understand renewable energy integration and stability control principles in grid-connected systems.
- To understand cyber security principles and their application in smart grid systems.
- To understand emerging technologies like V2G and the role of AI in grid management.

Course Outcomes:

After completion of the course, learners should be able to

CO No	CO	BL
CO1.	**Identify** motivation and the need for transitioning towards a smart grid system.	3
CO2.	**Interpret** the architecture of a smart grid and its key components.	3
CO3.	**Demonstrate** the use of micro grids and energy storage solutions for grid stability.	3
CO4.	**Employ** renewable integration and stability control strategies in grid-connected systems.	3
CO5.	**Apply** knowledge of cyber security to identify vulnerabilities and propose mitigation strategies in smart grid systems.	3
CO6.	**Articulate** emerging technologies like V2G and AI in future grid management.	2

Course Contents

Unit I	**Introduction to Grid Integration**	**7 Hours**

Indian National Grid and Challenges of the Existing Grid, Basics of electric power grid, motivation for smart grid and integration, concept of smart grid, standards and policies for smart grid, comparison: Existing vs. Smart Grid

 # Exemplar/Case Studies: Simulation-based comparison of existing Indian grid vs. smart grid.

***Mapping of Course Outcomes**	**CO1**

Unit II	**Smart Grid Fundamentals**	**7 Hours**

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Smart Grid Architecture and Components, Smart Power Generation: Types of Distributed Generators, Smart Information and Communication, Key elements of smart information include, advanced metering infrastructure (AMI), smart meters, Communication types.		
# Exemplar/Case Studies: Puducherry Smart Grid Pilot Project (India).		
***Mapping of Course Outcomes**	**CO2**	
Unit III	**Grid Modernization**	**7 Hours**
Demand-side management (DSM) of smart grid, demand response analysis of smart grid, modeling of storage devices, operation and control of AC/DC micro grids, and optimal storage planning..		
# Exemplar/Case Studies: MATLAB/Simulink model of AC-DC hybrid micro grid.		
***Mapping of Course Outcomes**	**CO3**	
Unit IV	**Renewable Energy Integration and Power Conditioning**	**7 Hours**
Overview of interface technologies for renewable integration: grid synchronization for solar/wind DG, bidirectional flow in hybrid systems, voltage and frequency control strategies for grid stability: droop control, power sharing in RES-dominant setups, applications and limitations in renewable-dominant grids: intermittency handling, mechanical reliability in interfaces.		
# Exemplar/Case Studies: Simulink simulation of droop control in solar-wind hybrid micro grid.		
***Mapping of Course Outcomes**	**CO4**	
Unit V	**Grid Management & Security.**	**7 Hours**
Introduction to Energy Management, Control Schemes and Power Flow Control Strategy (PFCS), Energy management systems (EMS), SCADA systems, and cyber security challenges in smart grids.		
# Exemplar/Case Studies: Mysore Smart Grid Pilot Project (India).		
***Mapping of Course Outcomes**	**CO5**	
Unit VI	**Future Trends**	**7 Hours**
Transactive energy, vehicle-to-grid (V2G) technology, artificial intelligence and machine learning in grid management.		
# Exemplar/Case Studies: V2G simulations with AI load forecasting.		
***Mapping of Course Outcomes**	**CO6**	
Learning Resources		
MOOC Courses links : **M1.** Introduction to Smart Grid, https://onlinecourses.nptel.ac.in/noc21_ee68/preview		

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