NEW PRINCE SHRI BHAVANI COLLEGE OF ENGINEERING AND TECHNOLOGY

(An Autonomous Institution)

CURRICULUM
&
SYLLABUS

MINOR DEGREE PROGRAMME

(REGULATION 2023)

(Applicable to the students admitted from the Academic Year 2023 – 24)

Sl. No.	Name of the Minor Degree	Offering Department \	Offered to
1	Internet of Things (IoT)	ECE	EEE, CSE, IT, Mech, AIDS, Cyber Security
2	Data Science	AIDS	ECE, EEE, CSE, IT, Mech, Cyber Security
3	Augmented Reality (AR) and Virtual Reality (VR)	AIDS	ECE, EEE, CSE, IT, Mech, Cyber Security
4	Blockchain and Cyber Security	Cyber Security	ECE, EEE, CSE, IT, Mech, AIDS
5	Electric Vehicles	EEE	ECE, CSE, IT, Mech, AIDS, Cyber Security
6	Robotics	Mechanical Engineering	ECE, EEE, CSE, IT, AIDS, Cyber Security
7	Full Stack Development	CSE	ECE, EEE, Mech, AIDS, Cyber Security
8	Intelligent Apps Development	MCA	ECE, EEE, CSE, IT, Mech, AIDS, Cyber Security
9	FinTech and Entrepreneurship	MBA	ECE, EEE, CSE, IT, Mech, AIDS, Cyber Security

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Curriculum and Syllabus for Minor Degree Programme

Name of the Minor Degree	**Internet of Things (IoT)**
Minor Degree Offering Department	**ECE**
Eligible Departments	**All branches except ECE**

Sl. No.	Course Code	Course Title	L	T	P	Total Contact Periods	Credits
1	U23MDEC101	Introduction to Internet of Things	3	0	0	3	3
2	U23MDEC102	Introduction to Sensor Technology	3	0	0	3	3
3	U23MDEC103	IoT: Communication Technologies	3	0	0	3	3
4	U23MDEC104	Industry 4.0 and IIoT	3	0	0	3	3
5	U23MDEC105	IoT System Design	3	0	2	5	4
6	U23MDEC106	Mini Project	0	0	3	3	2
TOTAL CREDITS							**18**

Approved

Dr. G. [illegible]
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U23MDEC101	INTRODUCTION TO INTERNET OF THINGS	L	T	P	C
Prerequisites: Nil		3	0	0	3

COURSE OBJECTIVES:

- To acquire knowledge in fundamentals of Internet of Things (IoT) and protocols like SCADA and RFID.
- To gain conceptual understanding in various IoT architectures like architecture of WoT
- To apply the concept of Internet of Things in the real-world scenario.

UNIT I **IOT – AN OVERVIEW** **9**

Introduction to IoT – Elements of an IoT ecosystem, Technology drivers, Business drivers, Trends and implications, Overview of Governance, Privacy and Security Issues.

UNIT II **IOT PROTOCOLS** **9**

Protocol Standardization for IoT – Efforts – M2M and WSN Protocols – Issues with IoT Standardization – Unified Data Standards – Protocols – IEEE802.15.4 – BACNet Protocol – SCADA and RFID Protocols - Modbus – KNX – Zigbee– Network layer – APS layer – Security.

UNIT III **IOT ARCHITECTURE** **9**

M2M high –level ETSI architecture – IETF architecture for IoT - OGC architecture - IoT reference model – Domain model - information model – functional model – communication model.

UNIT IV **WEB OF THINGS** **9**

Web of Things versus Internet of Things – Two Pillars of the Web – Architecture Standardization for WoT– Platform Middleware for WoT – Unified Multi-tier WoT Architecture – WoT Portals and Business Intelligence.

UNIT V **IOT APPLICATIONS** **9**

Applications of IoT in Agriculture, Logistics, Smart home, Health and Energy - IoT applications for industry: Future Factory Concepts, Brownfield IoT.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Ovidiu Vermesan, Peter Friess, "Internet of Things Applications - From Research and Innovation to Market Deployment", River Publishers, 2024.
2. Pramod R Gunjal, Satish R Jondhale, Jaime Lloret Mauri, Karishma Agrawal, "Internet of Things: Theory to Practice", 1st Edition, CRC Press, 2024.

REFERENCES:

1. Vijay Madisetti, Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)",1st Edition, VPT, 2014
2. Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1st Edition, Apress Publications, 2013

3 Cuno Pfister, Getting Started with the Internet of Things, O"Reilly Media, 2011, ISBN: 978-1-4493-9357-1

ONLINE RESOURCES

1 https://www.coursera.org/specializations/iot

2 https://www.mygreatlearning.com/iot/free-courses

3 https://onlinecourses.nptel.ac.in/noc22_cs53/preview

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain the fundamentals of IoT.

CO2 Apply suitable protocol for IoT applications.

CO3 Analyze various architectures of IoT.

CO4 Apply the architecture of WoT for various applications.

CO5 Design an IoT application and connect to the cloud.

CO – PO – PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	-	-	-	-	-	-	-	1	2	2
CO2	3	2	1	2	-	-	-	-	-	-	-	1	2	2
CO3	3	3	2	2	-	-	-	-	-	-	-	1	2	2
CO4	3	2	1	2	1	-	-	-	-	-	-	1	2	2
CO5	3	3	3	3	1	-	-	-	-	-	-	1	2	2

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U23MDEC102	INTRODUCTION TO SENSOR TECHNOLOGY	L	T	P	C
Prerequisites: Nil		3	0	0	3

COURSE OBJECTIVES:

- To understand the transduction principles, sensors and measurement systems.
- To gain conceptual understanding of velocity and acceleration measurement methods and various measurement methods of physical and electrical Parameters.
- To apply calibration methods for sensors attached with real time systems.

UNIT I INTRODUCTION TO MEASUREMENT SYSTEMS 9

General concepts and terminology, measurement systems, sensor classifications: Analog Input and Output, Digital Input and Output, general input-output configuration, methods of correction. Passive Sensors Resistive Sensors: Potentiometers, Strain Gauges, RTDs, LDRs, Resistive Hygrometers, Capacitive Sensors, Inductive Sensors.

UNIT II SELF-GENERATING SENSORS 9

Thermoelectric Sensors: Thermocouples, Thermo electric effects, Common thermocouples, Practical thermocouple laws, cold junction compensation in thermocouple circuits. Piezoelectric Sensors: Piezoelectric effect, piezoelectric materials, applications.

UNIT III VELOCITY AND ACCELERATION MEASUREMENT 9

Relative velocity – Translational and Rotational velocity measurements – Revolution counters and Timers – Magnetic and Photoelectric pulse counting stroboscopic methods. Accelerometers-different types, Gyroscopes – applications.

UNIT IV DENSITY, VISCOSITY AND OTHER MEASUREMENTS 9

Units of Viscosity, specific gravity scales used in Petroleum Industries, Different Methods of measuring consistency and Viscosity – Two float viscorator – Industrial consistency meter. Sound-Level Meters, Microphones.

UNIT V CALIBRATION AND INTERFACING 9

Calibration using Master Sensors, Interfacing of Force, Pressure, Velocity, Acceleration, Flow, Density and Viscosity Sensors, Variable Frequency Drives.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Sinha G R, "Advances in Modern Sensors", Illustrated Edition, IOP Publishing Limited, 2020.
2. Ahmed Barhoum, Zeynep Altintas, "Fundamentals of Sensor Technology: Principles and Novel Designs", 1st Edition, Elsevier Science, 2023.

REFERENCES:

1. Jon S Wilson, "Sensor Technology Handbook – Volume 1", 1st Edition, Elsevier Science, 2005.
2. John Vetelino, Aravind Reghu, "Introduction to Sensors", 1st Edition, CRC Press, 2017.

3 Ahmed Barhoum, Zeynep Altintas, "Fundamentals of Sensor Technology", Elsevier Science, 2023.

ONLINE RESOURCES

1 https://onlinecourses.nptel.ac.in/noc23_ee95/preview

2 https://www.coursera.org/learn/sensors-circuit-interface

3 https://alison.com/course/introduction-to-electronic-sensors

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Analyze the working of sensors using various measurement methods.

CO2 Analyze the actuation of sensors using their fundamental principles.

CO3 Analyze the velocity and acceleration of accelerometers and gyroscopes.

CO4 Apply various measurement methods of physical and electrical parameters.

CO5 Apply the calibration methods for sensors attached with real time systems.

CO – PO – PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	-	-	-	-	-	-	-	1	2	2
CO2	3	3	2	2	-	-	-	-	-	-	-	1	2	2
CO3	3	3	2	2	-	-	-	-	-	-	-	1	2	2
CO4	3	2	1	2	-	-	-	-	-	-	-	1	2	2
CO5	3	2	1	2	1	-	-	-	-	-	-	1	2	2

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U23MDEC103	IOT: COMMUNICATION TECHNOLOGIES	L	T	P	C
		3	0	0	3

Prerequisites: Nil

COURSE OBJECTIVES:

- To understand the fundamentals of communication networks and various IoT models to build efficient IoT platform.
- To analyze different design methodologies and build IoT platform using python using Raspberry PI.
- To apply IoT platforms in real time environment.

UNIT I FUNDAMENTALS OF COMMUNICATION NETWORKS 9

Data Communication, Networks, Protocols and standards, Line configuration, Topology, Transmission mode, Signaling, RS232 Serial Communication and Manchester encoding, OSI reference model – layers and duties. TCP/IP reference model – layers and duties, Addressing.

UNIT II IOT AND M2M 9

IoT Architecture: State of the art introduction, state of the art; Architecture reference model: Introduction, reference model and architecture, IoT reference model.

UNIT III IOT PLATFORMS DESIGN METHODOLOGY 9

IoT Architecture, Architecture reference model: Introduction, reference model and architecture, Logical design using Python: Installing Python, Python data types and data structures, control flow, functions, modules, packages, file handling.

UNIT IV IOT PHYSICAL DEVICES AND ENDPOINTS 9

Introduction to Raspberry Pi interfaces (Serial, SPI, I2C), programming Raspberry PI with Python, other IoT devices.

UNIT V IOT PHYSICAL SERVERS AND CLOUD OFFERINGS 9

Introduction to cloud storage models and communication APIs, WAMP – AutoBahn for IoT, Xively cloud for IoT, case studies illustrating IoT design – home automation, smart cities, smart environment.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Rolando Herrero, "Fundamentals of IoT Communication Technologies", Illustrated Edition, Springer International Publishing, 2022.
2. Veena S Chakravarthi, "Internet of Things and M2M Communication Technologies Architecture and Practical Design Approach to IoT in Industry 4.0", 1st Edition, Springer International Publishing, 2021.

REFERENCES:

1. Debosree Ghosh, "Basic IoT Blueprint: From Devices to Data", 1st Edition, Kitab Writing Publication, 2023.
2. John Vetelino, Aravind Reghu, "Introduction to Sensors", 1st Edition, CRC Press, 2017.
3. Arshdeep Bahga, Vijay Madisetti, "Cloud Computing A Hands-on Approach", VPT, 1st Edition, 2014.

ONLINE RESOURCES

1 https://onlinecourses.nptel.ac.in/noc22_cs53/preview

2 https://www.coursera.org/learn/internet-of-things-communication

3 https://www.edx.org/learn/iot-internet-of-things

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain the fundamentals of communication networks.

CO2 Apply various IoT platform based on architecture analysis

CO3 Apply accurate design methodologies and build IoT platform

CO4 Write Program for Raspberry PI using Python

CO5 Design IoT platforms in a real time environment.

CO – PO – PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	-	-	-	-	-	-	-	1	2	2
CO2	3	2	1	2	-	-	-	-	-	-	-	1	2	2
CO3	3	2	1	2	-	-	-	-	-	-	-	1	2	2
CO4	3	3	3	3	-	-	-	-	-	-	-	1	2	2
CO5	3	3	3	3	1	-	-	-	-	-	-	1	2	2

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U23MDEC104	INDUSTRY 4.0 AND IIOT	L	T	P	C
Prerequisites: Nil		3	0	0	3

COURSE OBJECTIVES:

- To understand the basics of Industry 4.0 and IIoT.
- To analyze IIOT platform and SDN using big data analytics and implement safety protocols in Industrial IoT.
- To apply IIOT in various applications.

UNIT I INTRODUCTION 9

Introduction – Definition and characteristics of IoT – Physical and Logical Design of IoT - Communication models and APIs – Challenges in IoT - Evolution of IoT- Components of IoT - A Simplified IoT Architecture – Core IoT Functional Stack.

UNIT II BASICS OF INDUSTRIAL IOT 9

IIoT-Introduction, Industrial IoT: Business Model and Reference Architecture: IIoT-Business Models, Industrial IoT- Layers: IIoT Sensing, IIoT Processing, IIoT Communication, IIoT Networking.

UNIT III INDUSTRIAL IOT-BIG DATA ANALYTICS AND SOFTWARE DEFINED NETWORKS 9

Big Data Analytics and Software Defined Networks, Machine Learning and Data Science, Julia Programming, Data Management with Hadoop.

UNIT IV INDUSTRIAL IOT SECURITY 9

Fog Computing in IIoT, Security in IIoT, Industrial IoT – Application Domains; Industrial IoT – Application Domains: Healthcare, Power Plants, Inventory Management & Quality Control, Plant Safety and Security, Facility Management.

UNIT V INDUSTRIAL IOT – APPLICATION DOMAINS 9

Oil, chemical and pharmaceutical industry, Applications of UAVs in Industries, Real case studies.

TOTAL: 45 PERIODS

TEXT BOOKS:

1 Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, 2017.

2 Giacomo Veneri, Antonio Capasso, "Hands-On Industrial Internet of Things: Create a Powerful Industrial IoT", Packt, 2018.

REFERENCES:

1 Sabina Jeschke, Christian Brecher, Houbing Song, Danda B Rawat, "Industrial Internet of Things: Cyber Manufacturing Systems", Springer International Publishing, 2017.

2 John Vetelino, Aravind Reghu, "Introduction to Sensors", 1st Edition, CRC Press, 2017.

3 Ismail Butun, "Industrial IoT Challenges, Design Principles, Applications, and Security", Springer International Publishing, 1st Edition, 2020.

ONLINE RESOURCES

1 https://www.coursera.org/courses?query=industry%204.0

2 https://onlinecourses.nptel.ac.in/noc20_cs69/preview

3 https://www.classcentral.com/tag/industry-4-0

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain the basics of Industry 4.0.

CO2 Explain the basics of IIoT.

CO3 Analyze IIOT platform and SDN using big data analytics

CO4 Analyze the safety protocols in Industrial IoT.

CO5 Apply IIOT in various applications

CO – PO – PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	-	-	-	-	-	-	-	1	2	2
CO2	2	2	1	1	-	-	-	-	-	-	-	1	2	2
CO3	3	3	2	2	-	-	-	-	-	-	-	1	2	2
CO4	3	3	2	2	-	-	-	-	-	-	-	1	2	2
CO5	3	2	1	2	1	-	-	-	-	-	-	1	2	2

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U23MDEC105	IOT SYSTEM DESIGN	L T P C
Prerequisites: Nil		3 0 2 4

COURSE OBJECTIVES:

- To understand various design techniques for configuration of distributed embedded systems
- To learn programming of Edge devices with Raspberry Pi and to explore machine learning with python
- To demonstrate workability of IoT platform using data analytics tools.

UNIT I **INTRODUCTION TO DESIGN TECHNIQUES** **9**

Design methodologies- Design flows - Requirement analysis – Specifications-System analysis and architecture design – Quality assurance techniques- Distributed embedded systems.

UNIT II **EDGE DEVICES** **9**

Raspberry Pi, Programming edge node, Introduction to Gateways, Gateways types and configurations, HTTP access method using API, Introduction and installing the Raspbian Stretch OS, Computer and Rpi configuration to connect Rpi remotely without Ethernet cable via SSH, IP address, Raspberry pi3 interfacing with Sensor DHT11, Raspberry pi python library install and reading sensor feed, MySQL server on Raspberry pi.

UNIT III **MACHINE LEARNING USING PYTHON** **9**

Python basics and its libraries for machine learning, NumPy, Pandas, SciPy, MatPlot Lib and SciKit Learn.

UNIT IV **IOT AND DATA ANALYTICS** **9**

IoT and Data Management, Data cleaning and processing, Deep Web, Semantic sensor web, Semantic Web Data Management, Searching in IoT, Real-time and Big Data Analytics for Internet of Things, Heterogeneous Data Processing, Data Processing, Parallel and Distributed Data Processing.

UNIT V **CLOUD OF THINGS** **9**

IoT Physical Servers, Cloud Offerings, and IoT Case Studies, Introduction to Cloud Storage Models, Communication API, Eclipse IoT, AWS IoT, Google Cloud IoT, ThingWorx.

45 PERIODS

LIST OF EXPERIMENTS:

1. Design and analysis of the following experiments using Arduino/Raspberry Pi:
2. Blinking of LED with different delays
3. Digital I/O Interface [IR Sensor, PIR Sensor]
4. Analog Interface [ADC, Temperature Sensor]
5. Motor speed and direction control
6. Wireless Interface –Bluetooth & Wi-Fi Technologies

30 PERIODS
TOTAL:75 PERIODS

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TEXT BOOKS:

1. Shrirang Ambaji Kulkarni, "Introduction to IOT with Machine learning and Image Processing using Raspberry Pi", CRC Press, 2020.
2. Rahul Dubey, "An Introduction to Internet of Things: Connecting Devices, Edge Gateway, and Cloud with Applications", 1st Edition, Cengage India Publication, 2019.

REFERENCES:

1. Richardson M, Wallace S, "Getting started with raspberry PI", "O"Reilly Publisher Media, Inc., 2012.
2. SudipMisra, Chandana Roy, Anandarup Mukherjee, "Introduction to Industrial Internet of Things and Industry 4.0", 1st Edition, CRC Press, 2020.
3. Rao, M, "Internet of Things with Raspberry Pi 3: Leverage the power of Raspberry Pi 3 and JavaScript to build exciting IoT projects", Packt Publishing Ltd., 2018.

ONLINE RESOURCES

1. https://www.classcentral.com/report/iot-free-online-courses/
2. https://onlinecourses.nptel.ac.in/noc23_cs65/preview
3. https://www.coursera.org/learn/iot-devices-il

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain various design techniques for configuration of distributed embedded systems

CO2 Comprehend programming of Edge devices with Raspberry Pi.

CO3 Apply the concept of Internet of Things in the real world scenario

CO4 Apply data analytics tools in IoT

CO5 Analyze IoT platform using various cloud storage models.

CO – PO – PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	2	2	2	1	1	1	-	1	2	2
CO2	2	2	1	1	2	2	2	1	1	1	-	1	2	2
CO3	3	2	1	2	2	2	2	1	1	1	-	1	2	2
CO4	3	2	1	2	2	2	2	1	1	1	-	1	2	2
CO5	3	3	2	2	2	2	2	1	1	1	-	1	2	2

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New Prince Shri Bhavani College of Engineering and Technology

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CURRICULUM

&

CURRICULUM AND SYLLABUS FOR MINOR DEGREE PROGRAMME

(REGULATION 2023)

Department of ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

(CHOICE BASED CREDIT SYSTEM)

(Applicable to the students admitted from the Academic Year 2023-24)

MINOR DEGREE

Sl. No.	Name of the Minor Degree	Offering Department	Offered to
1	Internet of Things (IoT)	ECE	EEE, CSE, IT, Mech, Civil, AIDS, Cyber Security
2	FinTech and Entrepreneurship	MBA	ECE, EEE, CSE, IT, Mech, Civil, AIDS, Cyber Security
3	Data Science	AIDS	ECE, EEE, CSE, IT, Mech, Civil, Cyber Security
4	Blockchain and Cyber Security	Cyber Security	ECE, EEE, CSE, IT, Mech, Civil, AIDS
5	Augmented Reality (AR) and Virtual Reality (VR)	AIDS	ECE, EEE, CSE, IT, Mech, Civil, Cyber Security
6	Electric Vehicles	EEE	ECE, CSE, IT, Mech, Civil, AIDS, Cyber Security
7	Robotics	Mechanical Engineering	ECE, EEE, CSE, IT, Civil, AIDS, Cyber Security
8	Full Stack Development	CSE, IT, AIDS, Cyber Security	ECE, EEE, Mech, Civil

DEPARTMENT OFARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Curriculum and Syllabus for Minor Degree Programme

Name of the Minor Degree	**Data Science (DS)**
Minor Degree Offering Department	**AIDS**
Eligible Departments	**All branches except AIDS**

Sl. No.	Course Category	Course Code	Course Title	L	T	P	Credits
1	PE	U23MDAI01	Introduction to Data Analytics	3	0	0	3
2	PE	U23MDAI02	Introduction to Data Visualization	3	0	0	3
3	PE	U23MDAI03	Elements of AI	3	0	0	3
4	PE	U23MDAI04	Decision Support System	3	0	0	3
5	PE	U23MDAI05	Digital Marketing	2	0	2	3
6	PE	U23MDAI06	Advanced Database Technologies	2	0	2	3
TOTAL CREDITS							**18**

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U23MDAI01	INTRODUCTION TO DATA ANALYTICS	L T P C 3 0 0 3

COURSE OBJECTIVES:

- Understand and apply key concepts of data operations.
- Understand simple statistical models and the fundamentals of machine learning regression techniques.
- Understand and apply best practices in data science.

UNIT I INTRODUCTION OF DATA OPERATIONS 9

Introduction, Toolboxes: Python, fundamental libraries for data Scientists. Integrated development environment (IDE). Data operations: Reading, selecting, filtering, manipulating, sorting, grouping, rearranging, ranking, and plotting.

UNIT II DATA ANALYSIS 9

Descriptive statistics, data preparation. Exploratory Data Analysis data summarization, data distribution, measuring asymmetry. Sample and estimated mean, variance and standard score. Statistical Inference frequency approach, variability of estimates, hypothesis testing using confidence intervals, using p- values

UNIT III SUPERVISED LEARNING 9

Supervised Learning: First step, learning curves, training-validation and test. Learning models generalities, support vector machines, random forest. Examples

UNIT IV REGRESSION ANALYSIS 9

Regression analysis, Regression: linear regression simple linear regression, multiple & Polynomial regression, Sparse model. Unsupervised learning, clustering, similarity and distances, quality measures of clustering, case study.

UNIT V NETWORK ANALYSIS 9

Network Analysis, Graphs, Social Networks, centrality, drawing centrality of Graphs, PageRank, Ego-Networks, community Detection

TOTAL:45 PERIODS

TEXT BOOKS:

1 Joel Grus, "Data Science from Scratch: First Principles with Python", 1st Edition, O'Reilly Media, 2019.

2 Wes McKinney, "Python for Data Analysis", 2nd Edition, O'Reilly Media, 2017.

REFERENCES:

1 Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", 1st Edition, MIT Press, 2017.

2 Martin Kleppmann., "Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Systems", 1st Edition, O'Reilly Media, 2017.

3 Paul Crickard, "Data Engineering with Python", 1st Edition, O'Reilly Media, 2020.

ONLINE RESOURCES:

1 https://www.coursera.org/learn/data-analytics-introduction

2 https://archive.nptel.ac.in/courses/110/106/110106064

3 https://www.simplilearn.com/data-analyst-masters-certification-training-course

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Describe what Data Science is and the skill sets needed to be a data scientist

CO2 Explain the significance of exploratory data analysis (EDA) in data science

CO3 Describe to learn the supervised learning, SVM

CO4 Apply basic machine learning algorithms (Linear Regression)

CO5 Explain the concepts of Networks, Graphs, PageRank and community Detection

CO – PO – PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	-	1	-	-	-	-	-	1	2	2
CO2	2	2	1	1	-	1	-	-	-	-	-	1	2	2
CO3	2	2	1	1	2	1	-	-	-	-	-	1	2	2
CO4	3	3	2	1	-	1	-	1	-	-	-	1	2	2
CO5	2	2	1	1	-	1	-	-	-	-	-	1	2	2

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U23MDAI02	INTRODUCTION TO DATA VISUALIZATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To Understand the fundamental principles of data visualization, including how visual representations of data can help people understand complex datasets
- To provide hands-on experience with the tools and technologies used to create data visualizations, as well as knowledge of various visualization types.
- To introduce students to interactive data visualizations that allow users to explore data on their own.

UNIT I INTRODUCTION TO DATA VISUALIZATIONS AND PERCEPTION 9

Introduction of visual perception, Gestalt principles, Information overload. Data foundation: Types of data – Structure within and between records – Data preprocessing – Human perceptions and information processing

UNIT II VISUAL REPRESENTATIONS 9

Creating visual representations, visualization reference model, visual mapping, visual analytics, Design of visualization application, various visual representation, visual reference model and mapping, different applications of visualizations.

UNIT III VISUALIZATION SYSTEMS AND MULIVARIATE TECHNIQUES 9

Classification of visualization systems, Interaction and visualization techniques, misleading visual representation of data, Visualization of one, two and multi-dimensional data, text and text documents, visualization of networks, visualization of software, Data Visualization Multivariate Data : Point-Based Techniques – Line Based Techniques – Region-Based Techniques

UNIT IV VISUALIZATION OF GROUPS AND INTERACTION TECHNIQUES 9

Visualization of groups, trees, graphs, clusters, Metaphorical visualization. Various visualization techniques, data structures used in data visualization, Data segmentation. Text Visualizations Interaction Concepts: Interaction Operators – Interaction Operands and Spaces , Interaction Techniques: – Animating Transformations – Interaction Control.

UNIT V VISUALIZATION OF GIS AND BIG DATA 9

Visualization of volumetric data, vector fields, processes and simulations, Visualization of maps, geographic information, GIS systems, collaborative visualizations, visualization of Big Data.

TOTAL:45 PERIODS

TEXT BOOKS:

1 Edward R Tufte, "The Visual Display of Quantitative Information", 2nd Edition, Graphic Press, 2019.

2 Cole Nussbaumer Knaflic, "Storytelling with Data: A Data Visualization Guide for Business Professionals", 1st Edition, O'Reilly Media, 2017.

REFERENCES:

1 Nathan Yau, "Data Points: Visualization That Means Something", 1st Edition, O'Reilly Media, 2017.

2 Scott Murray, "Interactive Data Visualization for the Web: An Introduction to Designing with D3", 1st Edition, Media Press, 2018.

3 Andy Kirk "Data Visualization: A Successful Design Process", 1st Edition, Sage Publications, 2020.

ONLINE RESOURCES:

1 https://www.coursera.org/learn/datavisualization

2 https://introductiontodatavisualization.commons.gc.cuny.edu/

3 http://kcl.digimat.in/nptel/courses/video/106106179/L11.html

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Identify the visual perception and representation of data.

CO2 Illustrate about projections of different views of objects.

CO3 Apply various Interaction and visualization techniques.

CO4 Analyze various groups for visualization.

CO5 Evaluate the visualizations of Groups

CO – PO – PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO 2
CO1	3	2	1	2	-	1	-	-	-	-	-	1	2	2
CO2	2	2	2	1	-	1	-	-	-	-	-	1	2	2
CO3	3	2	1	2	1	1	-	-	-	-	-	1	2	2
CO4	3	3	2	2	-	1	-	1	-	-	-	1	2	2
CO5	3	3	2	3	-	1	-	-	-	-	-	1	2	2

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U23MDAI03	ELEMENTS OF AI	L T P C 3 0 0 3

COURSE OBJECTIVES:

- To Understand the Foundations of Deep Learning visual representations of data can help people understand complex datasets
- To Learn the Key concepts of Deep Learning Models and Architectures
- To introduce students to Gain Practical Experience in Training Deep Learning Models

UNIT I **INTRODUCTION** 9

Overview of Deep Learning : History and evolution of deep learning. Differences between traditional machine learning and deep learning. Real-world applications (e.g., image recognition, natural language processing).Artificial Neural Networks (ANNs): Basic structure and components of a neural network (neurons, layers, weights, biases).Activation functions (e.g., sigmoid, ReLU, tanh).Forward propagation.

UNIT II **FUNDAMENTALS OF NEURAL NETWORKS** 9

Feedforward Neural Networks (FNNs) Architecture of a simple neural network. Forward pass and backward pass. Loss functions (e.g., Mean Squared Error, Cross-Entropy). Backpropagation Algorithm Concept of back-propagation. Gradient descent optimization and variants (stochastic, mini-batch).Understanding gradients, chain rule, and weight updates. Optimization Techniques Learning rate, momentum, and optimization methods like Adam, SGD, and RMSprop.

UNIT III **CONVOLUTIONAL NEURAL NETWORKS (CNNs)** 9

Introduction to CNNs Convolution and pooling operations. Filters, kernels, and feature maps. Architecture of CNNs layers in CNNs: Convolutional layer, pooling layer, fully connected layer. Use cases in image classification, object detection, and image segmentation. Advanced CNN Architectures AlexNet, VGGNet, GoogLeNet, ResNet ,Transfer learning with pre-trained models.

UNIT IV **RECURRENT NEURAL NETWORKS (RNNS)** 9

Introduction to RNNs RNN architecture and the concept of sequential data. Training RNNs and challenges like vanishing and exploding gradients. Long Short-Term Memory (LSTM)Understanding LSTM architecture and how it addresses the vanishing gradient problem. Applications in time-series forecasting and natural language processing. Gated Recurrent Unit (GRU) Comparison of GRU and LSTM architectures.

UNIT V **ADVANCED DEEP LEARNING ARCHITECTURES** 9

Autoencoders Structure and applications of auto-encoders. Variational auto-encoders (VAE) and their applications in generative models. Generative Adversarial Networks (GANs)Overview of GANs: Generator and Discriminator. Training GANs and challenges. Applications GANs in image generation, deep fakes, and data augmentation. Transformer Networks . Introduction the Transformer model (Attention mechanism).Applications in NLP: BERT, GPT, and their variants

TOTAL:45 PERIODS

TEXT BOOKS:

1 Nikhil Buduma, "Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithm", O'Reilly Media, 2020.

2 Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", MIT Press, 2021.

REFERENCES:

1 AurélienGéron, "Hands-On Machine Learning with Scikit- Learn and TensorFlow", O'Reilly, 2020.

2 Nikhil Ketkar, "Deep Learning with Python: A Hands-on Introduction", Apress, 2019.

3 Charu Aggarwal, "Neural Networks and Deep Learning: A Textbook", 1st Edition, Springer, 2020.

ONLINE RESOURCES:

1. https://www.youtube.com/nptel.ac.in/courses/watch?v=aPfkYu_qiF4
2. https://www.youtube.com/nptel.ac.in/courses/watch?v=W3_yaf3HvHU
3. http://kcl.digimat.in/nptel/courses/watch?v=ctg14QIspRo

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Understanding the Fundamentals of Deep Learning Concepts

CO2 Illustrate about the fundamentals of Neural Networks

CO3 Apply various Interaction Architectures of Convolutional Neural Networks.

CO4 Explain the various groups for Recurrent Neural Networks.

CO5 Illustrate the advanced Deep Learning Architecture

CO – PO – PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	-	1	-	-	-	-	-	1	2	2
CO2	2	2	1	1	-	1	-	-	-	-	-	1	2	2
CO3	3	2	1	1	1	1	-	-	-	-	-	1	2	2
CO4	2	2	1	1	-	1	-	1	-	-	-	1	2	2
CO5	2	2	1	1	-	1	-	-	-	-	-	1	2	2

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U23MDAI04	DECISION SUPPORT SYSTEMS	L T P C 3 0 0 3

COURSE OBJECTIVES:

- To Understand the concept of managerial decision systems
- To Learn the Key concepts of DSS components and identify sources of data for business intelligence
- To Gain the Categorize the methodologies involved in DSS development

UNIT I **DECISION MAKING** **9**

Managerial decision making and information systems - framework and concept for decision support, Decision making - introduction – definition - systems and models, phases of decision making process - Personality Types – Gender - Human Cognition - and Decision Styles.

UNIT II **MODELING AND ANALYSIS** **9**

Definition – Characteristics and capabilities of DSS – DSS components - Modeling and issues – Static and dynamic models – Certainty, Uncertainty and Risk – Influence Diagrams – Structure of Mathematical models

UNIT III **DSS DEVELOPMENT** **9**

Introduction – Traditional and alternative development methodologies - Change Management – DSS Technology Levels and Tools – Development Platforms – Tool Selection.

UNIT IV **ENTERPRISE DSS AND KNOWLEDGE MANAGEMENT** **9**

Communication support – Collaboration support - Group support systems and technologies – GSS meeting process – Creativity and idea generation – Enterprise information systems – Evolution – Characteristics and capabilities of executive support systems – Organizational DSS - Organizational learning and transformation – Knowledge management initiatives – approaches – implementation.

UNIT V **BUSINESS INTELLIGENCE** **9**

Nature and Sources of data – Data collection, problems and quality – Database organizations and structures -Data warehousing, Data mining and Data visualization.

TOTAL:45 PERIODS

TEXT BOOKS:

1 Efraim Turban, Jay E Aronson, Ting Peng Liang, "Decision Support and Intelligent Systems", 7th Edition, Prentice Hall of India, 2021.

2 I Elain Rich, Kevin Knight, "Artificial intelligence", Tata McGraw-Hill, 2020.

REFERENCES:

1 Efraim Turban, Ramesh Sharda, Dursun Delen, "Decision support and Business Intelligence systems", 9th Edition, Pearson Education, 2021.
2 Nikhil Ketkar, "Deep Learning with Python: A Hands-on Introduction", Apress, 2021.
3 Efraim Turban, Decision Support Systems and Intelligent Systems", 9th Edition, Pearson, 2020.

ONLINE RESOURCES:

1 https://onlinecourses.nptel.ac.in/noc20_mg59/preview
2 https://www.coursera.org/learn/wharton-decision-making-scenarios
3 https://enine.digimat.in/nptel/courses/video/109104198/L01.html

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Comprehend concept of managerial decision systems and outline its various phases.
CO2 Demonstrate DSS components and identify sources of data for business intelligence.
CO3 Categorize the methodologies involved in DSS development
CO4 Analyze evolution of enterprise DSS and knowledge management initiatives.
CO5 Describe the concepts of Business Intelligence , Problems and Quality

CO – PO – PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	-	1	-	-	-	-	-	1	2	2
CO2	2	2	1	1	-	1	-	-	-	-	-	1	2	2
CO3	3	3	2	2	-	1	-	-	-	-	-	1	2	2
CO4	3	3	2	2	1	1	-	1	-	-	-	1	2	2
CO5	2	2	1	1	-	1	-	-	-	-	-	1	2	2

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U23MDAI05 **DIGITAL MARKETTING** L T P C

3 0 0 3

COURSE OBJECTIVES:

- To Understand the Fundamentals of Digital Marketing
- To Learn the Key concepts and Ability to design and execute strategies across various digital platforms to achieve business goals.
- To Learn how to create and distribute valuable, relevant, and consistent content to attract and engage a target audience.

UNIT I **INTRODUCTION** 6

introduction to Digital Marketing (DM)-Meaning, Definition, Need of DM, Scope of DM, History of DM, Concept and approaches to DM, Examples of good practices in DM.

UNIT II **MARKETING AUTOMATION** 6

Definition, Advantages, Marketing Automation Software: CRM, Sales force, Analytics; Customer Experience (CX), How does marketing automation help marketers, Marketing automation tools.

UNIT III **DIGITAL MARKETING MIX** 6

Online Advertising, Lead Generation, Social Media Marketing, Content and Copywriting. Influencer Marketing: Influencer, Payment to Influencer, difference between influencer marketing and celebrity endorsements.

UNIT IV **EMAIL MARKETING** 6

Need for Emails, Types of Emails, options in Email advertising, Features of MailChimp, Mobile Marketing: Overview of the B2B and B2C Mobile Marketing.

UNIT V **BLOGS** 6

What are Blogs, Importance of Blogs, Personal Blogs, Corporate Blogs, Popular Blog Platforms, What are Tags, Widgets, Blog Optimization, and Blog Stats.

30 PERIODS

TEXT BOOKS:

1. Dave Evans, Susan Bratton, "Social Media Marketing: The Next Generation of Business Engagement", 3rd Edition, John Wiley & Sons, 2021.
2. Ryan Robinson , "How To Start a Blog", Tata McGraw-Hill, 2022.

REFERENCES:

1. George Pain, "Marketing Automation and Online Marketing", 4th Edition, Pearson Education, 2021.
2. Nikhil Ketkar, "Marketing AI: From Automation to Revenue Performance Marketing ", 2nd Edition, John Wiley & Sons, 2022.
3. Michael J Thibault, " The Influencer Blueprint: A Step-by-Step Guide to Harnessing the Power of Influencer Marketing for Business Success", 5th Edition, Pearson Education, 2022.

ONLINE RESOURCES:

1 https://www.coursera.org/specializations/digital-marketing

2 https://www.guvi.in/zen-class/digital-marketing-course/

3 https://www.udemy.com/courses/marketing/digital-marketing/

PRACTICAL EXERCISES: **30 PERIODS**

1 Evaluate a business's website, social media pages, and online ads to assess its digital marketing strategy and suggest improvements

2 Sign up for a free CRM tool (e.g., HubSpot, Zoho), add sample customer data, and explore its features.

3 Design a flowchart showing how marketing automation enhances customer experience with automated emails and follow-ups.

4 Create a basic online advertisement using Canva or Photoshop with a headline, image, and call-to-action.

5 Develop a sample social media post (text + image) promoting a product or service with an engaging caption and relevant hashtags.

6 Sign up for a free MailChimp account, create a basic email campaign, and explore features like templates and automation.

7 Set up a blog on WordPress, Blogger, or Medium, write a 200–300 word post, and add tags and categories for organization

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Upon the completion of the course, the students will be able to Comprehend the key concepts, tools, and techniques used in digital marketing

CO2 Describe the Marketing Automation , Customer Relationship Management and Customers Experiences

CO3 Explain the concept of lead generation , the role of social media in digital marketing, different compensation models for influencer marketing

CO4 Create and implement targeted email marketing campaigns, applying segmentation strategies.

CO5 Analyze the importance of blogs for businesses and individuals in building authority, fostering customer relationships

CO – PO – PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	-	1	-	-	-	-	-	1	2	2
CO2	2	2	1	1	-	1	-	-	-	-	-	1	2	2
CO3	2	2	1	1	-	1	-	-	-	-	-	1	2	2
CO4	3	3	3	2	1	1	-	1	-	-	-	1	2	2
CO5	3	3	2	2	1	1	-	1	-	-	-	1	2	2

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U23MDAI06	ADVANCED DATABASE TECHNOLOGIES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To acquire knowledge on parallel and distributed databases and its applications.
- To study the usage and applications of Object Oriented and Intelligent databases.
- To understand the emerging databases like Mobile, XML, Cloud and Big Data.

UNIT I PARALLEL AND DISTRIBUTED DATABASES 6

Database System Architectures: Centralized and Client-Server Architectures – Server System Architectures – Parallel Systems- Distributed Systems – Parallel Databases: I/O Parallelism – Inter and Intra Query Parallelism – Inter and Intra operation Parallelism – Design of Parallel Systems Distributed Database Concepts - Distributed Data Storage – Distributed Transactions – Commit Protocols – Concurrency Control – Distributed Query Processing – Case Studies .

UNIT II INTELLIGENT DATABASES 6

Active Databases: Syntax and Semantics (Starburst, Oracle, DB2) - Taxonomy – Applications -Design Principles for Active Rules - Temporal Databases: Overview of Temporal Databases TSQL2-Deductive Databases - Recursive Queries in SQL - Spatial Databases- Spatial Data Types - Spatial Relationships - Spatial Data Structures - Spatial Access Methods - Spatial DB Implementation.

UNIT III OBJECT AND XML DATABASES 6

Concepts for Object Databases: Object Identity – Object structure – Type Constructors – Encapsulation of Operations – Methods – Persistence – Type and Class Hierarchies – Inheritance. XML Databases: XML - Related Technologies - XML Schema - XML Query Languages - Storing XML in Databases - XML and SQL

UNIT IV MOBILE AND MULTIMEDIA DATABASES 6

Mobile Databases: Location and Handoff Management - Effect of Mobility on Data Management -Location Dependent Data Distribution - Mobile Transaction Models - Concurrency Control -Transaction Commit Protocols - Multimedia Databases - Image Databases – Audio Databases - Video Databases.

UNIT V EMERGING TECHNOLOGIES 6

Web Databases - Geographic Information Systems - Biological Data Management - Cloud Based Databases: Data Storage Systems on the Cloud - Cloud Storage Architectures - Cloud Data Models- Query Languages - Introduction to Big Data-Storage - Analysis

30 PERIODS

TEXT BOOKS:

1 Henry F Korth, Abraham Silberschatz, S Sudharshan, "Database System concepts", 6th Edition, Tata McGraw Hill, 2021.

2 R Elmasri, S B Navathe, "Fundamentals of Database Systems", 5th Edition, Pearson Education, 2022.

REFERENCES:

1 Thomas Cannolly, Carolyn Begg, "Database Systems, A Practical Approach to Design, Implementation and Management", 3rd Edition, Pearson Education, 2021.

2 C J Date, A Kannan, S Swamynathan, "An Introduction to Database Systems", 8th Edition, Pearson Education, 2020.

3 Raghu Ramakrishnan, Johannes Gehrke, "Database Management Systems", 3rd Edition, McGraw Hill, 2019.

ONLINE RESOURCES:

1 https://gec.digimat.in/nptel/courses/video/106102237/L21.html

2 https://onlinecourses.nptel.ac.in/noc22_cs91

3 https://archive.nptel.ac.in/courses/106/105/106105175/

PRACTICAL EXERCISES: **30 PERIODS**

1 Set up replication between two database instances. Insert data in the primary database and check if it is automatically replicated in the secondary database.

2 Create a simple bank account transfer system where two transactions update the same account balance. Implement a locking mechanism to prevent data inconsistencies due to concurrent updates.

3 Create a Manager Employee table with hierarchical relationships (EmpID, Name, ManagerID) and write a recursive SQL query to retrieve all employees under a specific manager

4 Create a table for Employee with columns EmpID, Name, Salary and write a trigger that automatically logs changes to the salary in an Audit Log table whenever it is updated.

5 Write an XML file representing student data. Convert and store the data in a relational table using SQL queries.

6 Create a database table to store images with metadata (e.g., ImageID, FileName, Upload Date) and write an SQL query to retrieve all images uploaded within the last 7 days.

7 Create a simple biological database table (e.g., storing DNA sequences or patient records) and write SQL queries to retrieve sequences based on specific conditions.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Summarize the usage of high performance database like parallel and distributed database.

CO2 Explain the real world data using object oriented database.

CO3 Apply the rule set in the database to implement intelligent databases.

CO4 Analyze the data using XML database for better interoperability.

CO5 Describe use of big data and store in a transparent manner in the cloud.

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CO – PO – PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	-	1	-	-	-	-	-	1	2	2
CO2	2	2	1	1	-	1	-	-	-	-	-	1	2	2
CO3	3	2	1	2	1	1	-	1	-	-	-	1	2	2
CO4	3	3	2	2	1	1	-	1	-	-	-	1	2	2
CO5	2	2	1	1	-	1	-	-	-	-	-	1	2	2

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DEPARTMENT OFARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Curriculum and Syllabus for Minor Degree Programme

Name of the Minor Degree	**AR AND VR**
Minor Degree Offering Department	**AIDS**
Eligible Departments	**All branches except AIDS**

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	Total Contact Periods	Credits
1	U23MDAI07	Introduction to AR and VR	2	0	2	4	3
2	U23MDAI08	Motion and tracking using VR	3	0	0	3	3
3	U23MDAI09	Virtual reality for game development	2	0	2	4	3
4	U23MDAI10	AR and VR app development with unity	2	0	2	4	3
5	U23MDAI11	AR techniques –marker based and markerless tracking	3	0	0	3	3
6	U23MDAI12	Programming languages for AR & VR applications	3	0	0	3	3
TOTAL CREDITS							**18**

U23MDAI07 **INTRODUCTION TO AR AND VR** L T P C

2 0 2 3

Prerequisites: Nil

COURSE OBJECTIVES:

- To understand the basics of AR and VR.
- To learn to describe the data for the data science process.
- To learn to describe the relationship between data.

UNIT I **INTRODUCTION** 6

Introduction to Augmented-Virtual and Mixed Reality, Taxonomy, technology and features of augmented reality, difference between AR, VR and MR, Challenges with AR, AR systems and functionality, Augmented reality methods, visualization techniques for augmented reality.

UNIT II **VR SYSTEMS** 6

VR as a discipline, Basic features of VR systems, Architecture of VR systems, VR hardware: VR input hardware: tracking systems, motion capture systems, data gloves, VR output hardware: visual displays.

UNIT III **VR SOFTWARE DEVELOPMENT** 6

Challenges in VR software development, Master/slave and Client/server architectures, Cluster rendering, Game Engines and available sdk to develop VR applications for different hardware (HTC VIVE, Oculus, Google VR).

UNIT IV **AR SOFTWARE DEVELOPMENT** 6

AR software, Camera parameters and camera calibration, Marker-based augmented reality, AR Toolkit. 3D interaction techniques: 3D Manipulation tasks, Manipulation Techniques and Input Devices, Interaction Techniques for 3D Manipulation.

UNIT V **APPLICATION** 6

Application of VR in Digital Entertainment: VR Technology in Film & TV Production. VR Technology in Physical Exercises and Games. Demonstration of Digital Entertainment by VR.

30 PERIODS

PRACTICAL EXERCISES:

1. Install the necessary tools and create a basic AR/VR scene.
2. Detect real-world surfaces and spawn objects on them.
3. Implement movement mechanics in a VR environment.
4. Display a 3D model when scanning an image (like a QR code).
5. Implement grabbing objects (pick up and drop items) and interact with objects in VR.

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30 PERIODS

TOTAL: 60 PERIODS

TEXT BOOKS:

1 Alan Craig, William Sherman, Jeffrey Will, "Developing Virtual Reality Applications, Foundations of Effective Design", 3rd Edition, Morgan Kaufmann Publishers, 2019.

2 Burdea, G. C., P. Coffet., "Virtual Reality Technology", 4th Edition, Wiley-IEEE Press, 2020.

REFERENCES:

1 George Mather, "Foundations of Sensation and Perception", 4th Edition, Psychology Press, 2019.

2 Jason Jerald, "The VR Book: Human-Centered Design for Virtual Reality", 2nd Edition, Morgan & Claypool Publishers, 2021

3 Alan B. Craig, Understanding Augmented Reality, Concepts and Applications, 2nd Edition, Morgan Kaufmann Publishers, 2019.

ONLINE RESOURCES

1 http://msl.cs.uiuc.edu/vr/

2 www.vresources.org

3 www.w3.org/MarkUp/VRM

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain AR and VR Basic concepts.

CO2 Analyze the features of VR Systems.

CO3 Analyze the VR System Software.

CO4 Evaluate the AR System Software.

CO5 Apply VR technology in real life.

CO – PO – PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	-	-	-	-	-
CO2	3	3	2	2	-	-	-	-	-	-	-	-
CO3	3	3	2	2	-	-	-	-	-	-	-	-
CO4	3	3	2	2	-	-	-	-	-	-	-	-
CO5	3	2	1	2	-	-	-	-	-	-	-	-

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U23MDAI08 **MOTION AND TRACKING USING VR** L T P C

Prerequisites: Nil 3 0 0 3

COURSE OBJECTIVES:

- To understand the basics of Virtual Reality.
- To learn to describe about representation of Virtual World.
- To learn to Motion and Tracking using VR.

UNIT I INTRODUCTION TO VIRTUAL REALITY 9

Introduction, Defining Virtual Reality, History of VR, Human Physiology and Perception, Key Elements of Virtual Reality Experience, Virtual Reality System, Interface to the Virtual World-Input & output- Visual, Aural & Haptic Displays, Applications of Virtual Reality.

UNIT II REPRESENTING THE REAL WORLD 9

Defining Virtual Reality, History of VR, Human Physiology and Perception, Key Elements of Virtual Reality Experience, Virtual Reality System, Interface to the Virtual World-Input & output- Visual, Aural & Haptic Displays, Applications of Virtual Reality.

UNIT III THE GEOMETRY OF VIRTUAL WORLDS & PHYSIOLOGY OF HUMAN VISION 9

Geometric Models, Changing Position and Orientation, Axis-Angle Representations of Rotation, Viewing Transformations, Chaining the Transformations, Human Eye, eye movements & implications for VR.

UNIT IV AUGMENTED AND MIXED REALITY 9

Visual Perception - Perception of Depth, Perception of Motion, Perception of Color, Combining Sources of Information Visual Rendering -Ray Tracing and Shading Models, Rasterization, Correcting Optical Distortions, Improving Latency and Frame Rates, Case Studies - Automatic stitching of panoramas in Virtual Reality.

UNIT V MOTION AND TRACKING 9

Motion in Real and Virtual Worlds- Velocities and Accelerations, The Vestibular System, Physics in the Virtual World, Mismatched Motion and Vection Tracking- Tracking 2D & 3D Orientation, Tracking Position and Orientation, Tracking Attached Bodies-A virtual Study Use Case- NICE, An Educational Experience-Interaction - Motor Programs and Remapping, Locomotion, Manipulation, Social Interaction. Audio -The Physics of Sound, The Physiology of Human Hearing, Auditory Perception, Auditory Rendering.

TOTAL: 45 PERIODS

TEXT BOOKS:

1 Burdea, G. C., P. Coffet, "Virtual Reality Technology", 4th Edition, John Wiley & Sons, 2020.

2 Liz Falconer, "Virtual World concept, Applications and Future Directions", 2nd Edition, Nova Science Publishers, 2019.

Approved

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REFERENCES:

1 Doug A Bowman, Ernest Kuijff, Joseph J LaViola, Jr, Ivan Poupyrev, "3D User Interfaces, Theory and Practice", 4th Edition, Addison Wesley, 2019.

2 Oliver Bimber, Ramesh Raskar, "Spatial Augmented Reality: Merging Real and Virtual Worlds", 6th Edition, A.K. Peters Limited, 2022.

3 Burdea, Grigore C, Philippe Coiffet, "Virtual Reality Technology", 5th Edition, John Wiley & Sons, 2018.

ONLINE RESOURCES:

1 https://www.neuroscigroup.us/articles/APT-8-160.pdf

2 https://vajiramandravi.com/upsc-exam/virtual-reality/

3 https://steantycip.com/blog/vr-motion-tracking/

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain the basics of Virtual Reality.

CO2 Design virtual reality techniques for the real world.

CO3 Analyze the geometry of Virtual worlds and physiology of Human Eye.

CO4 Create rate rising in Augmented and Mixed Reality

CO5 Design 2D orientation in Virtual World.

CO – PO – PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	-	-	-	-	-
CO2	3	3	3	3	-	-	-	-	-	-	-	-
CO3	3	3	2	2	-	-	-	-	-	-	-	-
CO4	3	3	3	3	-	-	-	-	-	-	-	-
CO5	3	3	3	3	-	-	-	-	-	-	-	-

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U23MDAI09 VIRTUAL REALITY FOR GAME DEVELOPMENT L T P C

Prerequisites: Nil 2 0 2 3

COURSE OBJECTIVES:

- To understand the basics of Virtual Reality.
- To learn to describe Augmented and Mixed Reality.
- To learn to develop game design process.

UNIT I INTRODUCTION TO VIRTUAL REALITY 6

Introduction, Fundamental Concept and Components of Virtual Reality-Primary Features and Present Development on Virtual Reality- Computer graphics, Real time computer graphics, Flight Simulation, Virtual environment requirement.

UNIT II INTERACTIVE TECHNIQUES IN VIRTUAL REALITY 6

Introduction-From 2D to 3D-3D space curves-3D boundary representation Geometrical Transformations: Introduction, Frames of reference, Modelling transformations, Instances, Picking-Flying, Scaling the VE-Collision detection Generic VR system.

UNIT III VISUAL COMPUTATION IN VIRTUAL REALITY 6

Animating the Virtual Environment-Introduction, The dynamics of numbers, Linear and Nonlinear interpolation, the animation of objects, linear and non-linear translation, shape & object in betweening, free from deformation-particle system. Physical Simulation.

UNIT IV AUGMENTED AND MIXED REALITY 6

Taxonomy, technology and features of augmented reality, difference between AR and VR, Challenges with AR, AR systems and functionality, Augmented reality methods, visualization techniques for augmented reality, wireless displays in educational augmented reality applications, mobile projection interfaces.

UNIT V GAME DEVELOPMENT 6

Game Design and Development-Cultural and function definition of games, Rudiments of game design, Development processes, Game Development Technical Aspects- User input, Graphics, Audio, Game Engine Architecture, Publication. Game mechanics-High level diagrams.

30 PERIODS

PRACTICAL EXERCISES:

1 Implement basic movement mechanics in VR.

2 Enable players to grab and interact with objects using controllers.

3 Implement a VR-friendly user interface.

4 Create a physics-based gun shooting system.

5 Build a basic VR puzzle-solving game.

30 PERIODS

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TOTAL: 60 PERIODS

TEXT BOOKS:

1 Alan Craig, William Sherman, Jeffrey Will, "Developing Virtual Reality Applications, Foundations of Effective Design", 3rd Edition, Morgan Kaufmann Publishers, 2019.

2 Ernest Adams, "3Game Mechanics: Advanced Game Design ", 1st Edition, New Riders Publications, 2022.

REFERENCE BOOKS:

1 Burdea, Grigore C, Philippe Coiffet, "Virtual Reality Technology", 5th Edition, Wiley Interscience, 2018.

2 Anand R., "Augmented and Virtual Reality", 2nd Edition, Khanna Publishing House, 2021.

3 Alan B. Craig, "Understanding Augmented Reality, Concepts and Applications", 3rd Edition, Morgan Kaufmann Publishers, 2019.

ONLINE RESOURCES:

1 https://www.techtarget.com/whatis/definition/virtual-reality-gaming-VR-gaming

2 https://sdlccorp.com/post/a-comprehensive-guide-to-virtual-reality-game-development-for-beginners/

3 https://www.techved.com/blog/future-of-virtural-reality-in-game-development

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Summarize the basics of Virtual Reality.

CO2 Apply the Techniques in Virtual Reality.

CO3 Evaluate the Virtual Reality using visual computation.

CO4 Explain Augmented and Mixed Reality.

CO5 Design Game Development concepts.

CO – PO – PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	-	-	-	-	-
CO2	2	2	1	1	-	-	-	-	-	-	-	-
CO3	3	3	2	2	-	-	-	-	-	-	-	-
CO4	3	3	2	2	-	-	-	-	-	-	-	-
CO5	3	3	3	3	-	-	-	-	-	-	-	-

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U23MDAI10 **AR AND VR APP DEVELOPMENT WITH UNITY** L T P C

Prerequisites: Nil 2 0 2 3

COURSE OBJECTIVES:

- To understand the basics of Virtual Reality.
- To learn to describe the features of AR Tool Kit.
- To learn to describe the Game development with Unity.

UNIT I **INTRODUCTION TO VIRTUAL REALITY** 6

Introduction, Fundamental Concept and Components of Virtual Reality-Primary Features and Present Development on Virtual Reality- Computer graphics, Real time computer graphics, Flight Simulation, Virtual environment requirement, benefits of virtual reality, Historical development of VR- Scientific Landmark 3D Computer Graphics.

UNIT II **FEATURES OF AR TOOL KIT** 6

AR-working with ARCore and ARKit Working with AR Tools– ARCore, ARToolkitx ARCore - Features of ARCore, integration with Unity/Unreal/iOS/Android Studio, augmented reality applications with ARCore. ARToolkit – Features of ARToolkit.

UNIT III **VR DEVELOPMENT WITH UNITY** 6

VR SDK'S and Frameworks – OpenVR SDK, StreamVR SDK, VRTK, Oculus SDK, Google VR SDK. VR Concept Integration- Motion Tracking, Controllers, Camera, Hardware and Software requirements Setting up Unity with VR- Framework/SDK Integration with Unity, Unity XR API's, Mobile VR Controller Tracking.

UNIT IV **AR DEVELOPMENT WITH UNITY** 6

AR Foundation – Detection of surfaces, identifying feature points, track virtual objects in real world, face and object tracking. AR Algorithms – Briefing on SLAM Algorithm (Simultaneous Localization and Mapping), understanding uncertain spatial relationship, Anatomy of SLAM.

UNIT V **GAME DEVELOPMENT WITH UNITY** 6

Overview, Building Your Project and Character, Getting Animated, The Town View, Working with Unity's UI System, NPCs and Interactions, The World Map, Encountering Enemies and Running Away - Case Studies Animation in Unreal Engine vs Unity Engine.

30 PERIODS

PRACTICAL EXERCISES:

1 Set up a basic AR/VR project and display a 3D object.

2 Detect real-world surfaces and place objects on them.

3 Implement basic movement and object interaction.

4 Create a small interactive VR game.

5 Implement AR-based navigation in an indoor environment.

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30 PERIODS

TOTAL: 60 PERIODS

TEXT BOOKS:

1 Alan Craig, William Sherman, Jeffrey Will, "Developing Virtual Reality Applications, Foundations of Effective Design", 3rd Edition, Morgan Kaufmann publishers, 2019.

2 Allan Fowler, "Beginning iOS AR Game Development Developing Augmented Reality Apps with Unity and C#", 2nd Edition, Apress Publications, 2020.

REFERENCES:

1 Burdea, Grigore C, Philippe Coiffet, "Virtual Reality Technology", 5th Edition, John Wiley & Sons, 2018.

2 Ernest Adams, Joris Dormans, "Game Mechanics-Advanced Game Design", 2nd Edition, New Riders Publications, 2019.

3 Michael Lanham," Augmented Reality Game Development", 4th Edition, Packt Publications, 2021.

ONLINE RESOURCES

1 https://unity.com/solutions/xr/ar

2 https://www.freecodecamp.org/news/the-ultimate-beginners-guide-to-game-development-in-unity-f9bfe972c2b5/

3 https://docs.unity3d.com/Manual/AROverview.html

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain the concept of Virtual Reality.

CO2 Apply AR Tool Kit Features.

CO3 Create VR Frameworks with Unity.

CO4 Analyze spatial relationship in AR Development.

CO5 Design Game Development with Unity.

CO – PO – PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	-	-	-	-	-
CO2	3	2	1	2	-	-	-	-	-	-	-	-
CO3	3	3	3	3	-	-	-	-	-	-	-	-
CO4	3	3	2	2	-	-	-	-	-	-	-	-
CO5	3	3	3	3	-	-	-	-	-	-	-	-

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U23MDAI11 **AR TECHNIQUES –MARKER BASED AND MARKERLESS TRACKING**

L	T	P	C
3	0	0	3

Prerequisites: Nil

COURSE OBJECTIVES:

- To understand the basics of Augmented Reality.
- To learn to describe the AR Devices & Components.
- To learn to describe the AR Techniques Marker & Markerless Tracking.

UNIT I INTRODUCTION TO AUGMENTED REALITY 9

Augmented Reality - History of augmented reality, The Relationship Between Augmented Reality and Other Technologies-Media, Technologies, Other Ideas Related to the Spectrum Between Real and Virtual Worlds, Applications of augmented reality Augmented Reality Concepts- Working of Augmented Reality, Concepts Related to Augmented Reality, Ingredients of an Augmented Reality Experience.

UNIT II AUGMENTED REALITY HARDWARE 9

Augmented Reality Hardware – Displays – Audio Displays, Haptic Displays, Visual Displays, Other sensory displays, Visual Perception, Requirements and Characteristics, Spatial Display Model. Processors – Role of Processors, Processor System Architecture, Processor Specifications. Tracking & Sensors - Tracking, Calibration, and Registration, Characteristics of Tracking Technology, Stationary Tracking Systems, Mobile Sensors, Optical Tracking, Sensor Fusion.

UNIT III COMPUTER VISION FOR AUGMENTED REALITY & A.R. SOFTWARE 9

Computer Vision for Augmented Reality - Marker Tracking, Multiple-Camera Infrared Tracking, Natural Feature Tracking by Detection, Simultaneous Localization and Mapping, Outdoor Tracking Augmented Reality Software - Introduction, Major Software Components for Augmented Reality Systems, Software used to Create Content for the Augmented Reality Application.

UNIT IV AR DEVICES AND COMPONENTS 9

AR Components – Scene Generator, Tracking system, monitoring system, display, Game scene AR Devices – Optical See- Through HMD, Virtual retinal systems, Monitor bases systems, Projection displays, Video see-through systems.

UNIT V AR TECHNIQUES- MARKER BASED & MARKERLESS TRACKING 9

Marker-based approach- Introduction to marker-based tracking, types of markers, marker camera pose and identification, visual tracking, mathematical representation of matrix multiplication Marker types- Template markers, 2D barcode markers, imperceptible markers. Marker-less approach.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Alan B. Craig, "Understanding Augmented Reality, Concepts and Applications", 5th Edition, Morgan Kaufmann Publishers, 2023.

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2. Indika Wijesooriya, "Mastering Augmented Reality Development with Unity: Create immersive and engaging AR experiences with Unity", 2nd Edition, BPB Publishers, 2022.

REFERENCES:

1 Anand R., "Augmented and Virtual Reality", 2nd Edition, Khanna Publishing House, 2021

2 Alan B. Craig, "Understanding Augmented Reality, Concepts and Applications", 3rd Edition, Morgan Kaufmann Publishers, 2019.

3 Dr. A. Sivaranjani, A. Senthil Murugan, Dr. B. Ashok Kumar, Dr. S. Senthilrani, J. Rajeswari, "Augmented Reality/Virtual Reality", 1st Edition, Technical Publications, 2023.

ONLINE RESOURCES

1 https://www.coursera.org/learn/augmented-reality

2 https://program-ace.com/blog/types-of-ar/

3 https://www.aircards.co/blog/markerless-vs-marker-based-ar-with-examples

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain the basics of Augmented Reality.

CO2 Analyze the Augmented Reality hardware.

CO3 Explain computer vision for AR & AR Software.

CO4 Apply tracking system in real world.

CO5 Design Marker & Marker less Tracking.

CO – PO – PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	-	-	-	-	-
CO2	3	3	2	2	-	-	-	-	-	-	-	-
CO3	2	2	1	1	-	-	-	-	-	-	-	-
CO4	3	2	1	2	-	-	-	-	-	-	-	-
CO5	3	3	3	3	-	-	-	-	-	-	-	-

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U23MDAI12 **PROGRAMMING LANGUAGES FOR AR & VR APPLICATIONS**

L	T	P	C
3	0	0	3

Prerequisites: Nil

COURSE OBJECTIVES:

- To understand the basics of AR & VR.
- To learn to describe the programming languages of AR & VR Applications.
- To learn to describe the relationship between data.

UNIT I **INTRODUCTION TO AR AND VR** 9

Categorizing the realities – Virtual Reality, Augmented Reality & Mixed Reality, Introduction, features and application areas of Virtual Reality, Augmented Reality & Mixed Reality, VR – Integration of VR techniques, Contents objects and scale, GazeBased Control, Handy Intractable, IDE setup with package files, concepts and features of VR AR - Working with AR techniques, compatibility with the environment, system architecture, AR terminology, application areas of AR.

UNIT II **PROGRAMMING LANGUAGES FOR AR & VR APPLICATIONS** 9

C# with Unity – OOL concepts, classes in C#, setting up visual studio or code editor for C#, 3D models compatibility with C#, C# for AR and VR C++ with Unreal Engine – Building and compiling C++ programs with unreal engine, variables and memory, looping and if else structures with unreal engine, functions and macros, adding actors to the scene, dynamic memory allocations, spell book.

UNIT III **AR APP DEVELOPMENT IN UNITY** 9

Basic AR scene elements - AR packages, AR provider plug-ins, AR Foundation - Platform support, PolySpatial visionOS packages, Unity Mars, XR Interaction Toolkit, Integration of AR toolkits with existing IDE's (Unity-Vuforia, Visual Studio, Netbeans, intellij IDEA, Android, iOS), connectivity of smart devices with AR.

UNIT IV **VR APP DEVELOPMENT IN UNITY** 9

VR SDK's – VR SDK'S and Frameworks – OpenVR SDK, StreamVR SDK, VRTK, Oculus SDK, Google VR SDK. VR Concept Integration- Motion Tracking, Controllers, Camera , Hardware and Software requirements Setting up Unity with VR- Framework/SDK Integration with Unity, Debugging VR projects, Unity XR API's, Mobile VR Controller Tracking, Object Manipulation, Text optimizing and UI for VR.

UNIT V **USE CASES FOR AR AND VR IN SINGLE APPLICATION** 9

Trending Application Areas - Gaming and Entertainment, Architecture and Construction, Science and Engineering, Health and Medicine, Aerospace and Defence, Education, Telerobotics and Telepresence Human Factors, Legal and Social Considerations - Human Factors Considerations, Legal and Social Considerations, The Future.

TOTAL: 45 PERIODS

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TEXT BOOKS:

1. Steve Aukstakalnis," Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR", 3rd Edition, Addison-Wesley Professional, 2024.
2. Jesse Glover, Jonathan Linowes, "Complete Virtual Reality and Augmented Reality Development with Unity: Leverage the power of Unity and become a pro at creating mixed reality applications", 1st Edition, Packt publishing, 2019.

REFERENCES:

1. Jonathan Linowes, Krystian Babilinski, "Augmented Reality for Developers: Build practical augmented reality applications with Unity, ARCore, ARKit, and Vuforia", 2nd Edition, Packt Publishing, 2019.
2. Baruah, Rakesh, "Virtual Reality with VRTK4, Create Immersive VR Experiences Leveraging Unity3D and Virtual Reality Toolkit", 1st Edition, Apress Publications, 2019.
3. Allan Fowler, "Beginning iOS AR Game Development Developing Augmented Reality Apps with Unity and C#", 2nd Edition, Apress Publications, 2020.

ONLINE RESOURCES

1. https://www.coursera.org/learn/augmented-reality
2. https://bigohtech.com/programming-languages-for-ar-vr-app-development
3. https://www.qualium-systems.com/blog/ar-vr/the-best-programming-languages-for-ar-development/

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain the concepts of AR and VR.

CO2 Describe OOL concepts for AR and VR Applications.

CO3 Analyze AR application development with Unity.

CO4 Evaluate VR Application development with Unity.

CO5 Create Gaming applications for the real world.

CO – PO – PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	-	-	-	-	-
CO2	2	2	1	1	-	-	-	-	-	-	-	-
CO3	3	3	2	2	-	-	-	-	-	-	-	-
CO4	3	3	2	2	-	-	-	-	-	-	-	-
CO5	3	3	3	3	-	-	-	-	-	-	-	-

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DEPARTMENT OF COMPUTER SCIENCE ENGINEERING
(CYBER SECURITY)

Curriculum and Syllabus for Minor Degree Programme

Name of the Minor Degree	**Blockchain and Cyber Security**
Minor Degree Offering Department	**Cyber Security**
Eligible Departments	**All branches except Cyber Security**

Sl. No.	Course Category	Course Code	Course Title	L	T	P	Credits
1	MD	U23MDCB01	Fundamentals of blockchain	2	0	2	3
2	MD	U23MDCB02	Blockchain architecture design	3	0	0	3
3	MD	U23MDCB03	Cybersecure Blockchain Performance	2	0	2	3
4	MD	U23MDCB04	Resilient Business with Blockchain	3	0	0	3
5	MD	U23MDCB05	Secure Fintech Ecosystems	3	0	0	3
6	MD	U23MDCB06	Blockchain And Cryptocurrency	2	0	2	3
						TOTAL CREDITS	**18**

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U23MDCB01	FUNDAMENTALS OF BLOCKCHAIN	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To comprehend and analyze the basic concepts of blockchain.
- To demonstrate the blockchain technologies and mechanisms.
- To apply blockchain technologies in financial applications.

UNIT I **BASICS OF BLOCKCHAIN** **6**

Distributed Database, Two General Problem, Byzantine General Problem and Fault Tolerance, Hadoop Distributed File System, Distributed Hash Table, ASIC resistance, Turing Complete. Cryptography: Hash function, Digital Signature - ECDSA, Memory Hard Algorithm, and Zero Knowledge Proof.

UNIT II **TECHNOLOGY STACK** **6**

Introduction, Advantage over conventional distributed database, Blockchain Network, Mining Mechanism, Distributed Consensus, Merkle Patricia Tree, Gas Limit, Transactions and Fee, Anonymity, Reward, Chain Policy, Life of Blockchain application, Soft & Hard Fork, Private and Public blockchain.

UNIT III **DISTRIBUTED CONSENSUS** **6**

Nakamoto consensus Proof of Work, Proof of Stake, Proof of Burn, Difficulty Level, Sybil Attack, Energy utilization and alternate.

UNIT IV **CRYPTOCURRENCY** **6**

History, Distributed Ledger Bitcoin protocols - Mining strategy and rewards, Ethereum - Construction, DAO, Smart Contract, GHOST, Vulnerability, Attacks, Sidechain, Namecoin.

UNIT V **CRYPTOCURRENCY REGULATION** **6**

Stakeholders, Roots of Bitcoin, Legal Aspects-Crypto currency Exchange, Black Market and Global Economy. Applications: Internet of Things, Medical Record Management System, Domain Name Service and future of Blockchain.

30 PERIODS

PRACTICAL EXCERCISES:

1. Creating and Building Up Bitcoin Wallet, Namecoin.
2. Ethereum Wallet.
3. Building a Private Ethereum Network and Deploying Smart Contract.
4. Ethereum Smart Contract.
5. Creating and Building Up Crypto Token.
6. Creating a Business Network using Hyperledger.
7. Building and Deploying multichain private Blockchain.

30 PERIODS

30 PERIODS

TOTAL: 60 PERIODS

TEXTBOOKS

1 Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller and Steven Goldfeder, "Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction",1st Edition, Princeton University Press, 2016.

2 Kumar Saurabh, Ashutosh Saxena, "Blockchain Technology: Concepts and Applications", 1st Edition, John Wiley & Sons, 2020.

REFERENCES:

1 Tiana Laurence, "Blockchain for Dummies", 2nd Edition John Wiley & Sons, 2019.

2 Gavin Wood, "ETHEREUM: A Secure Decentralized Transaction Ledger", 1st Edition Yellow paper, 2014.

3 Imran Bashir, "Mastering Blockchain: Deeper insights into decentralization, cryptography, Bitcoin, and Popular Blockchain framework", 1st Edition Packt Publishing, 2017.

ONLINE RESOURCES:

1 https://www.coursera.org/specializations/blockchain.

2 https://nptel.ac.in/courses/106105184/

3 https://swayam.gov.in/nd1_noc20_cs01/preview 4

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain the core principles of blockchain.

CO2 Describe the blockchain network structures, consensus mechanisms, and the lifecycle of blockchain applications.

CO3 Analyze various consensus algorithms and security implications.

CO4 Describe the history and functioning of cryptocurrencies like Bitcoin and Ethereum.

CO5 Explain the legal, economic, and regulatory aspects of cryptocurrency, assess its societal impacts.

CO-PO-PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	-	-	-	-	-
CO2	2	2	1	1	-	-	-	-	-	-	-	-
CO3	3	3	2	2	-	-	-	-	-	-	-	-
CO4	2	2	2	1	-	-	-	-	-	-	-	-
CO5	2	2	2	1	-	-	-	-	-	-	-	1

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U23MDCB02	BLOCKCHAIN ARCHITECTURE DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To comprehend the foundational concepts of blockchain architecture, including and consensus protocols.
- To develop working knowledge of Hyperledger Fabric, including its components and blockchain in trade.
- To Analyze the role of blockchain in government systems.

UNIT I **ARCHITECTURE** **9**

Digital Money to Distributed Ledgers, Design Primitives: Protocols, Security, Consensus, Permissions, Privacy. Blockchain Architecture and Design: Basic crypto primitives: Hash, Signature,) Hashchain to Blockchain, Basic consensus mechanisms.

UNIT II **CONSENSUS** **9**

Requirements for the consensus protocols-Proof of Work (PoW)-Scalability aspects of Blockchain consensus protocols Permissioned-Blockchains: Design Goals-Consensus protocols for Permissioned Blockchains.

UNIT III **HYPERLEDGER FABRIC** **9**

Decomposing the consensus process-Hyperledger fabric components-Chaincode Design and Implementation. Beyond Chaincode: fabric SDK and Front End, Hyperledger composer tool.

UNIT IV **FINANCIAL SOFTWARE AND SYSTEMS** **9**

Blockchain in Financial Software and Systems (FSS): Settlements, KYC-Capital Markets-Insurance- Blockchain in trade/supply chain: Provenance of goods-visibility-trade/supply chain finance-invoice management discounting.

UNIT V **BLOCKCHAIN CRYPTOGRAPHY** **9**

Blockchain for Government: Digital identity-land records and other kinds of record keeping between government entities-public distribution system social welfare systems. Blockchain Cryptography- Privacy and Security on Blockchain.

TOTAL: 45 PERIODS

TEXTBOOKS

1 Udit Agarwal, Vinay Rishiwal," Blockchain Architecture Design", 1st Edition, S.K. Kataria & Sons, 2024.

2 Imran Bashir, "Mastering Blockchain: Inner workings of blockchain, from cryptography and decentralized identities, to DeFi, NFTs and Web3", 4th Edition, Packt Publishing Ltd, 2023.

REFERENCES

1 Chris Burniske, Jack Tatar," Cryptoassets: The Innovative Investor's Guide to Bitcoin and Beyond: Theory and Politics of Ambiguity", Tata McGraw Hill, 2017.

2 Melanie Swa, "Block chain: Blueprint for a new economy", 1st Edition, O'Reilly Media, 2015.

3 Elad Elrom, "The Blockchain Developer: A Practical Guide for Designing, Implementing, Publishing, Testing, and Securing Distributed Blockchain-based Projects ", 1st Edition, Apress Publications, 2019.

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COWRIVAKKAM, CHENNAI - 600 073.

ONLINE RESOURCES:

1 https://onlinecourses.swayam2.ac.in/aic21_ge01
2 https://www.blockchain.com/
3 https://www.coursera.org/specializations/blockchain

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Describe the basic understanding of Blockchain architecture along with its primitive.
CO2 Explain the requirements for basic protocol along with scalability aspects.
CO3 Design the consensus process using both frontend and backend.
CO4 Apply Blockchain techniques for different use cases like Finance, Trade Supply and Government activities.
CO5 Analyze blockchain-based solutions for secure and transparent digital identity management, land record systems, and other government applications.

CO – PO – PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	-	-	-	-	-
CO2	2	2	1	1	-	-	-	-	-	-	-	-
CO3	3	3	3	3	-	-	-	-	-	-	-	-
CO4	3	2	1	2	-	-	-	-	-	-	-	-
CO5	3	3	2	2	-	-	-	-	-	-	-	-

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U23MDCB03	CYBERSECURE BLOCKCHAIN PERFORMANCE	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To comprehend Security and Performance Challenges in Blockchain Systems
- To demonstrate Tools and Techniques for Blockchain Optimization.
- To Examine Real-World Applications of Blockchain Technology.

UNIT I **SECURITY ISSUES** **6**

Blockchain Related Issues, Higher-Level Language (Solidity) Related Issues, EVM Bytecode Related Issues, Real-Life Attacks on Blockchain Applications/Smart Contracts, Trusted Execution Environments.

UNIT II **SECURITY TOOLS FOR SMART CONTRACTS** **6**

Working, Advantages, And Disadvantages of Tools- Oyente, Securify, Maian, Manticore, Mythril, SmartCheck, Verx. Secure KeyManagement, Quantum Resilience Keys.

UNIT III **PERFORMANCE RELATED ISSUES** **6**

Transaction Speed, Transaction Fees, Network Size, Complexity, Interoperability Problems, Lack of Standardization. Lack of Supportive Regulations Related to Blockchain Applications.

UNIT IV **PERFORMANCE IMPROVEMENTS** **6**

Off-Chain State Channels, Sidechains, Parallels Chains, Concurrent Smart Contract Transactions, Sharding Technique and Its Benefits, Atomic Swaps Between Smart Contracts.

UNIT V **BLOCKCHAIN APPLICATIONS** **6**

Decentralized Cryptocurrency, Distributed Cloud Storage, E-Voting, Insurance Claims, Cross-Border Payments, Asset Management, SmartAppliances.

PRACTICAL EXCERCISES: **30 PERIODS**

1. Enhancing User Security in Blockchain Applications.
2. Implement Node Security in Blockchain Applications.
3. Denial of Service Attacks, Eclipse Attacks, Replay Attacks, Routing Attacks, Sybil Attacks.
4. Enhance Securing Digital Payment Transactions.
5. Enhance Smart contract security.
6. Blockchain Network Configuration and Security Best Practices.
7. Consensus Mechanism Vulnerabilities and Mitigation.

TEXTBOOKS: **30 PERIODS**
TOTAL: 60 PERIODS

1 Andrea Antonopoulos and Gavin Wood "Mastering Ethereum: Building Smart Contracts and Dapps", 1st Edition, O'Reilly Publisher, 2018.

2 SachinShetty, Charles A. Kamhoua, Laurent L. Njilla, "Blockchain for Distributed Systems Security", 1st Edition, John Wiely & Sons, 2019.

REFERENCES:

1 Rahul Neware, Brajesh Kumar, Parag Rastogi, Harshal Patil, "Blockchain Security", 1st Edition, Book Rivers (India), 2022.

2 Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller and Steven Goldfeder, "Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction", 1st Edition, Princeton University Press, 2016.

3 YassineMaleh, Mohammad Shojafar, MamounAlazab, ImedRomdhani, "Blockchain for Cybersecurity and Privacy: Architectures Challenges and Applications", 1st Edition, Taylor & Francis Ltd., 2020.

ONLINE RESOURCES:

1 https://www.edx.org/course/blockchain-for-business

2 https://www.coursera.org/lecture/blockchain-security-foundational-concepts

3 https://www.coursera.org/learn/blockchain-security

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain the security perspective of blockchain technology.

CO2 Apply security techniques related to blockchain.

CO3 Apply blockchain technology to provide solutions for Interoperability problems.

CO4 Analyze the performance of blockchain.

CO5 Design blockchain for various use cases.

CO – PO – PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	-	-	-	-	-
CO2	3	2	1	2	-	-	-	-	-	-	-	-
CO3	3	2	1	2	-	-	-	-	-	-	-	-
CO4	3	3	2	2	-	-	-	-	-	-	-	-
CO5	3	3	3	3	-	-	-	-	-	-	-	-

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U23MDCB04	RESILIENT BUSINESS WITH BLOCKCHAIN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To provide knowledge about the evolution of blockchain, its principles, and its role in transforming industries, including finance, supply chain, and healthcare.
- To equip an understanding of how blockchain can enhance data analytics, secure data storage, and address challenges in cybersecurity and cloud computing.
- To real-world use cases, evaluate the impact of blockchain on processes, and address scalability challenges through on-chain and off-chain solutions.

UNIT I INTRODUCTION TO BLOCKCHAIN AND BUSINESS APPLICATIONS 9

Evolution of blockchain, creation, Growth, Rise of crypto currencies, Blockchain Principles, Qualities, Popular blockchain platforms, Brief history of money, Impact of blockchain: Financial sector, internet.

UNIT II FINANCIAL SERVICES& GOVERNMENT PUBLIC SECTORS 9

Blockchain and Smart Contracts, Transparency in government services, Land Right Management, real world use cases, Manufacturing & Industrial: Blockchain for Supply chain, Logistics, IOT, Health Care and Life Sciences: Recordkeeping, Pharmaceuticals, Public health.

UNIT III DATA MANAGEMENT AND CYBER SECURITY 9

Data management: Blockchain for big data, CCT, Cloud based blockchain, Monetizing Big data, Blockchain and Big Data Analytics, Challenges, Blockchain for Gaming, Blockchain and cyber security.

UNIT IV IMPLEMENTING BLOCKCHAIN IN ENTERPRISES 9

Identifying opportunities and threats, People and partners, Determining use cases and impact on processes, Conceptual model of implementation, New Business applications of blockchain: Smart Cities, Digital Medicine, M2M Transactions.

UNIT V CURRENT ISSUES 9

Issues faced, Solutions for scalability issues, On-chain solutions: Proof of stake, sharding Off-chain solutions: Payment or state channels, Plasma Truebit, Next generation blockchain projects, A case study: The exciting world of blockchain.

TOTAL: 45 PERIODS

TEXTBOOKS

1 Mohsen Attaran, Angappa Gunasekaran, "Applications of Blockchain Technology in Business: Challenges and Opportunities ",1st Edition, Packt Publishing, 2019.

2 Peter Lipovyanov, "Blockchain for Business 2019: A user-friendly introduction to blockchain and its Business Application", 1st Edition, Packt Publishing, 2019.

REFERENCES

1 Bashir, Imran. "Mastering Blockchain: A Deep Dive into Distributed Ledgers, Consensus Protocols, Smart Contracts, DApps, Cryptocurrencies, Ethereum", 3rd Edition, Packt Publishing, 2020.

2 Daniel Drescher, "Blockchain Basics", 1st Edition, A press Publishers, 2017.

3 Grincalaitis, Merunas. "Mastering Ethereum: Implement Advanced Blockchain Applications Using Ethereum-Supported Tools, Services, and Protocols", 1st Edition, Packt Publishing, 2019.

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ONLINE RESOURCES:

1 https://www.coursera.org/learn/blockchain business/home/welcome

2 https://www.edx.org/professionalcertificate/linuxfoundationx-blockchain-for-business

3 https://onlinecourses.swayam2.ac.in/aic21_ge01

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Summarize the concept of blockchain cryptocurrency.

CO2 Explain the various blockchain functionalities.

CO3 Analyze Blockchain for Big data.

CO4 Apply Blockchain technology in various business domains of financial and commodities.

CO5 Design new Business application for the Blockchain.

CO – PO – PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	-	-	-	-	-
CO2	2	2	1	1	-	-	-	-	-	-	-	-
CO3	3	2	1	2	-	-	-	-	-	-	-	-
CO4	3	3	2	2	-	-	-	-	-	-	-	-
CO5	3	3	3	3	-	-	-	-	-	-	-	-

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U23MDCB05	SECURE FINTECH ECOSYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To comprehend the Fundamentals of Cryptocurrencies and Blockchain-Based Offerings.
- To Analyze Decentralized Finance (DeFi) and Decentralized Markets.
- To Examine Blockchain Regulations and Banking Applications.

UNIT I INTRODUCTION **9**

Concept, Cryptocurrency Mining, Uses of Cryptocurrencies, Tokens, Token vs Crypto Coin, Concept of ICOs (Initial Coin Offerings), Benefits of Using ICOs, STOs (Security token offerings), ICO vs STO, Cryptocurrency wallets.

UNIT II DECENTRALIZED FINANCE **9**

Concept, Benefits and Risks Associated with DeFi, Centralized vs Decentralized finance, DeFi Projects, DeFi future trends.

UNIT III DECENTRALIZED MARKETS **9**

Concept of Decentralized markets, impact of decentralization on financial market, Decentralized Exchanges (DEX), Security, control and privacy concerns related to DEX, Liquidity and Usability of DEX, best DEXs for trading, Fund Management and Trading logic of DEX, Concept of Decentralized Web.

UNIT IV BLOCKCHAIN AND CRYPTOCURRENCY REGULATIONS **9**

Introduction, History Stance of the Government, Judicial Approach to Cryptocurrency, Possible Reasons for Ban, Virtual Currency Regulations, Global Perspective of Regulations on Blockchain, Future needs for Regulations.

UNIT V BANKING AND BLOCKCHAIN **9**

Cross-Border Payments Using Blockchain and Its Benefits, Study of blockchain platforms used for cross-border payments, Impact of Blockchain on Banking Services. Stable Coin: Concept, Uses and Types of Stable Coins, Case-Study: Tether and Libra Coins.

TOTAL :45 PERIODS

TEXTBOOKS

1 Steve Brown, "The Innovation Ultimatum", John Wiley & Sons ,2020.

2 Antony Lewis, "The Basics of Bitcoins and Blockchains: An Introduction to Cryptocurrencies and the Technology that Powers Them (Cryptography, Crypto Trading, Digital Assets, NFT)", Mango Media, 2018.

REFERENCES

1 Susanne Chishti, Tony Craddock, Robert Courtneidge, "The Paytech Book - The Payment Technology Handbook for Investors, Entrepreneurs and Fintech Visionaries", 1st Edition, John Wiley & Sons, 2019.

2 Arvind Narayanan, Joseph Bonneau, Edward Felten, "Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction",1st Edition, Princeton University, 2016.

3 Kiran Mehta, Renuka Sharma, Poshan Yu, "Revolutionizing Financial Services and

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Markets Through FinTech and Blockchain" ,1st Edition, IGI Global, 2023.

ONLINE RESOURCES:

1 https://www.coursera.org/specializations/blockchain
2 https://nptel.ac.in/courses/106105184/
3 https://swayam.gov.in/nd1_noc20_cs01/preview 4

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain the basic notion of distributed systems.
CO2 Summarize the working of an immutable distributed ledger and trust model that defines blockchain.
CO3 Explain the essential components of a blockchain platform.
CO4 Summarize the blockchain cryptocurrency regulations.
CO5 Apply blockchain in various domains.

CO – PO – PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	-	-	-	-	-
CO2	2	2	1	1	-	-	-	-	-	-	-	-
CO3	2	2	1	1	-	-	-	-	-	-	-	-
CO4	2	2	1	1	-	-	-	-	-	-	-	-
CO5	3	2	1	2	-	-	-	-	-	-	-	-

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CHENNAI - 6

U23MDCB06	BLOCKCHAIN AND CRYPTOCURRENCY	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES

- To comprehend Blockchain Fundamentals and Cryptocurrency Concepts.
- To demonstrate Blockchain Consensus Mechanisms and DeFi.
- To Apply Blockchain Technologies to Real-World Use Cases.

UNIT I INTRODUCTION 6

A basic crypto currency, Creation of coins, Payments and double spending, FORTH – the precursor for Bitcoin scripting, Bitcoin Scripts, Bitcoin P2P Network, Transaction in Bitcoin Network, Block Mining, Block propagation and block relay.

UNIT II BITCOIN AND CRYPTOCURRENCY 6

Concept, Benefits and Risks Associated with DeFi, Centralized vs Decentralized finance, DeFi Projects, DeFi future trends.

UNIT III BITCOIN CONSENSUS 6

Bitcoin Consensus, Proof of Work (PoW)- Hashcash PoW, Bitcoin PoW, Attacks on PoW, monopoly problem- Proof of Stake- Proof of Burn - Proof of Elapsed Time - Bitcoin Miner, Mining Difficulty, Mining Pool-Permissioned model and use cases.

UNIT IV HYPERLEDGER FABRIC & ETHEREUM 6

Architecture of Hyperledger fabric v1.1- chain code- Ethereum: Ethereum network, EVM, Transaction fee, Mist Browser, Ether, Gas, Solidity.

UNIT V BLOCKCHAIN APPLICATIONS 6

Smart contracts, Truffle Design and issue- DApps- NFT. Blockchain Applications in Supply Chain Management, Logistics, Smart Cities, Finance and Banking, Insurance, etc- Case Study.

30 PERIODS

PRACTICAL EXERCISES:

1 Install and understand Docker container, Node.js, Java and Hyperledger Fabric, Ethereum and perform necessary software installation on local machine create instance on cloud to run.
2 Create and deploy a blockchain network using Hyperledger Fabric SDK for Java Set up and initialize the channel, install and instantiate chain code, and perform invoke and query on your blockchain network.
3 Interact with a blockchain network. Execute transactions and requests against a blockchain network by creating an app to test the network and its rules.
4 Deploy an asset-transfer app using blockchain. Learn app development within a Hyperledger Fabric network.
5 Use blockchain to track fitness club rewards. Build a web app that uses Hyperledger Fabric to track and trace member rewards.
6 Car auction network: A Hello World example with Hyperledger Fabric Node SDK and IBM Blockchain Starter Plan. Use Hyperledger Fabric to invoke chain code while storing results and data in the starter plan.

30 PERIODS

TOTAL: 60 PERIODS

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TEXT BOOKS:

1 Bashir and Imran, "Mastering Blockchain: Deeper insights into decentralization, cryptography, Bitcoin, and popular Blockchain frameworks",1st Edition, Packt Publishing, 2017.

2 Andreas Antonopoulos, "Mastering Bitcoin: Unlocking Digital Cryptocurrencies", 1st Edition, O'Reilly Media, 2015.

REFERENCES

1 Saravanan Krishnan, Valentina Emilia Balas, E. Golden Julie, "Handbook of Research on Blockchain Technology", 1st Edition, Academic Press Inc, 2020.

2 Daniel Drescher, "Blockchain Basics", 1st Edition, Apress, 2017.

3 Ritesh Modi, "Solidity Programming Essentials: A Beginner's Guide to Build Smart Contracts for Ethereum and Blockchain", Public library Edition, Packt Publishing,2018.

ONLINE RESOURCES:

1 https://www.coursera.org/specializations/blockchain

2 https://nptel.ac.in/courses/106104220

3 https://onlinecourses.nptel.ac.in/noc19_cs63/preview

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Summarize the emerging abstract models for Blockchain Technology.

CO2 Explain the concepts, benefits, risks, and future trends of Decentralized Finance (DeFi).

CO3 Comprehend the various Bitcoin consensus mechanisms along with their security challenges, mining concepts, and permissioned blockchain use cases.

CO4 Apply hyperledger Fabric and Ethereum platform to implement the Block chain Application.

CO5 Apply blockchain technology in real-world applications by designing smart contracts with Truffle and developing decentralized applications (DApps).

CO – PO – PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	-	-	-	-	-
CO2	2	2	1	1	-	-	-	-	-	-	-	-
CO3	2	2	1	1	-	-	-	-	-	-	-	-
CO4	3	2	1	2	-	-	-	-	-	-	-	-
CO5	3	2	1	2	-	-	-	-	-	-	-	-

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING	
Name of the Minor Degree	Electric Vehicles
Department Offering the Minor Degree	Electrical and Electronics Engineering
Eligible Departments	ECE, CSE, IT, Mech., Civil, AIDS, Cyber Security

Sl. No.	Course Code	Course Title	L	T	P	Total Contact Periods	Credits
1	U23MDEE01	Basics of Electric Vehicles	2	0	2	4	3
2	U23MDEE02	Electric Vehicle Architecture	3	0	0	3	3
3	U23MDEE03	Power Converters and Motors for Electrical Drives	2	0	2	4	3
4	U23MDEE04	Energy Storage Systems in Electric Vehicles	2	0	2	4	3
5	U23MDEE05	Control of Electric Vehicles	2	0	2	4	3
6	U23MDEE06	Integration of Plug in Electric Vehicles	3	0	0	3	3

TOTAL CREDITS :18

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U23MDEE01	BASICS OF ELECTRIC VEHICLES	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To understand the different configurations of EV.
- To understand the basics of battery charging in EV.
- To understand the different motors used in EV.

UNIT I **HISTORY OF ELECTRIC VEHICLES** **6**

Introduction-Electric Vehicles – Promotion year of EV, Basic Types of Electric Vehicles, Advantages and Disadvantages.

UNIT II **DRIVE TRAIN OF ELECTRIC VEHICLES** **6**

Introduction to Battery Electric vehicles-Hybrid Electric Vehicles-Types-Plug In Hybrid EV-Basic Architecture.

UNIT III **EV CONFIGURATIONS** **6**

Introduction – EV Configuration Basic Architecture-Single and Multi-Motor Drives-Construction and working of the drives.

UNIT IV **ENERGY STORAGE IN EV** **6**

Overview of different types of Batteries-Parameters of batteries-Concept of Battery Charging-Fuel Cell Concept-Basic working and operation of batteries.

UNIT V **ELECTRIC VEHICLE MOTORS** **6**

Introduction to Electric Motors –AC Motors-permanent magnet motors-Series wound motors-Shunt wound motors-Brushless DC Motors-Basics and working-Regenerative Braking.

30 PERIODS

PRACTICAL EXERCISES

Using SCILAB/MATLAB Simulation Software

1 Simulation of Basic Models of EV.
2 Design and Simulation of different EV Configurations.
3 Simulation of Different energy storage systems in EV.
4 Simulation of any two motors in EV.
5 Simulate the torque speed characteristics of BLDC motor used in EV.

30 PERIODS

TOTAL : 60 PERIODS

TEXT BOOKS:

1 S Sujatha, B Senthilkumar, "A Text Book on Electric Vehicle Technology", 1st Edition, Scientific International Publishers, 2024.
2 Yimin Gao, Stefano Lango, "Modern Electric Hybrid & Fuel Cell Vehicles", 2nd Edition, CRC Press, 2021.

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REFERENCES:

1 Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban, "Electric Vehicles Modern Technologies and Trends", 1st Edition, Springer, 2021.

2 Arvind J Bosale, S S Raghuvanshi, Amit R Patil, "Fundamentals of Hybrid and Electric Vehicles", 1st Edition, Khanna Publishers, 2024.

ONLINE RESOURCES:

1 https://archive.nptel.ac.in/courses/108/105/108105058/

2 https://onlinecourses.nptel.ac.in/noc21_ge04/preview

3 https://archive.nptel.ac.in/courses/108/105/108105061/

COURSE OUTCOMES:

Upon completion of the course, students will be able to

CO1 Summarize the Basics of Electric Vehicles.

CO2 Explain the different types of Electric Vehicles..

CO3 Design an EV Configuration drives.

CO4 Describe the concept of energy storage in EV.

CO5 Explain the Concept of different motors used in EV.

CO - PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	1	-	-	1	1	1	-	-
CO2	2	2	1	1	1	-	-	1	1	1	--	-
CO3	3	3	3	3	1	-	-	1	1	1	-	-
CO4	2	2	1	1	1	-	-	1	1	1	-	-
CO5	2	2	1	1	1	-	-	1	1	1	-	-

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U23MDEE02	ELECTRIC VEHICLE ARCHITECTURE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the structure of Electric Vehicle, Hybrid Electric Vehicle, Plug in Hybrid EV
- To understand about the EV conversion components, specifications for EV.
- To model and simulate all types of DC motors.

UNIT I **VEHICLE ARCHITECTURE AND SIZING** **(7+2 Skill) 9**

Electric Vehicle History, and Evolution of Electric Vehicles. Series, Parallel and Series parallel Architecture, Micro and Mild architectures. Mountain Bike - Motorcycle-Electric Cars and Heavy Duty EVs. -Details and Specifications.

UNIT II **VEHICLE MECHANICS** **(7+2 Skill) 9**

Vehicle mechanics- Roadway fundamentals, Laws of motion, Vehicle Kinetics, Dynamics of vehicle motion, propulsion power, velocity and acceleration, Tire –Road mechanics, Propulsion System Design.

UNIT III **POWER COMPONENTS AND BRAKES** **(7+2 Skill) 9**

Powertrain Component sizing- Gears, Clutches, Differential, Transmission and Vehicle Brakes. EV powertrain sizing, HEV Powertrain sizing, Examples.

UNIT IV **HYBRID VEHICLE CONTROL STRATEGY** **(7+2 Skill) 9**

Vehicle supervisory control, Mode selection strategy, Modal Control strategies.

UNIT V **PLUG-IN HYBRID ELECTRIC VEHICLE** **(7+2 Skill) 9**

Introduction-History-Comparison with electrical and hybrid electrical vehicle-Construction and working of PHEV-Block diagram and components-Charging mechanisms-Advantages of PHEVs.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/ Mini Project/Assignment/ Content Preparation / Quiz/ Surprise Test / Simulation using MATLAB or SCILAB)

1 Group Seminar on Electric Vehicle History and EV Architecture.

2 Assignment on vehicle mechanics.

3 Quiz on power components and brakes.

4 Surprise test on hybrid vehicle control strategy.

5 Simulation of plug in hybrid vehicles.

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CHENNAI - 600 073.

TOTAL : 45 PERIODS

TEXT BOOKS:

1 Shashank Arora, Alireza Tashakori, Abkenar, Shantha Gamini Jayasinghe, Kari Tammi, "Heavy-duty Electric Vehicles from Concept to Reality", 2nd Edition, Elsevier Science Publishers, 2021.

2 Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban , "Electric Vehicles Modern Technologies and Trends", 12th Edition, Springer, 2021.

REFERENCES:

1 G C Karg, "Utilization of Electric Power and Electric Traction", 2nd Edition, Khanna Publishers, 2021.

2 C L Wadhwa,"Generation Distribution and Utilization of Electrical Energy", 3rd Edition, New Age International Publishers, 2021.

3 H Partab, "Art and Science of Utilization of Electrical Energy", 4th Edition, Dhanpat Rai Publishers, 2021.

ONLINE RESOURCES:

1 https://archive.nptel.ac.in/courses/108/105/108105058/

2 https://onlinecourses.nptel.ac.in/noc21_ge04/preview

3 https://archive.nptel.ac.in/courses/108/105/108105061/

COURSE OUTCOMES:

Upon completion of the course, students will be able to

CO1 Summarize suitable electric drives for different applications in electric traction.

CO2 Design various illumination systems for energy saving.

CO3 Explain the utilization of electrical energy for heating and welding purposes.

CO4 Summarize the effective usage of solar and wind energies for various electrical applications.

CO5 Explain the electric connection for any domestic appliance like refrigerator, battery charging circuit for a specific household application.

CO - PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	1	1	1	-	-
CO2	3	3	3	3	1	-	-	1	1	1	-	-
CO3	2	2	1	1	1	-	-	1	1	1	-	-
CO4	2	2	1	1	1	-	-	1	1	1	-	-
CO5	2	2	1	1	-	-	-	1	1	1	-	-

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U23MDEE03	POWER CONVERTERS AND MOTORS FOR ELECTRICAL DRIVES	L T P C
		2 0 2 3

COURSE OBJECTIVES:

- To impart knowledge on different types of DC-DC Power Converters used in Electric Vehicles.
- To impart knowledge on construction, working and design of Induction and PMBLDC Motors, Permanent Magnet Synchronous Motors, and Axial Flux Motors
- To provide knowledge on different types of Inverters used in Electric Vehicles

UNIT I POWER CONVERTERS FOR ELECTRIC VEHICLES 6

Introduction to Components of Electric Vehicles, Non-Isolated DC-DC Converter: Boost Converter, Buck Converter Buck-Boost Converter, and Isolated DC- DC Converters: Fly back Converter, Forward Converter- Modes of Operation and Analysis.

UNIT II INDUCTION MOTOR AND PMBLDC MOTOR 6

Induction motor - Construction and operation, torque and power equation, Torque-Speed Characteristics, Braking methods.PMBLDC Motor - Constructional features, Operating principle, EMF and torque developed, Torque-Speed Characteristics.

UNIT III PERMANENT MAGNET SYNCHRONOUS MOTOR 6

PMSM Motor – Construction and types of PMSM - EMF and torque developed, Torque - Speed Characteristics - Phasor diagram, Braking methods

UNIT IV AXIAL FLUX MOTOR 6

Axial Flux Motor - Constructional features, Principle of operation, Torque developed and Speed Control. Introduction to axial motor.

UNIT V INVERTERS FOR ELECTRIC VEHICLES 6

Introduction to H Bridge Inverter, Three Phase Voltage and Current source inverters - operation and analysis. Modulation techniques for VSI – SPWM, SVPWM.

30 PERIODS

PRACTICAL EXERCISES

Using SCILAB/MATLAB Simulation Software

1 Simulation of DC-DC Power Converters used in Electric Vehicles.

2 Simulation of Inverters for Electric Vehicles.

3 Simulation of PMBLDC motors.

4 Simulation of Axial Flux Motors.

5 Simulation of PMSM motors.

30 PERIODS

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TOTAL : 60 PERIODS

TEXT BOOKS:

1 Jigneshkumar P Desai, "Special Electrical Machinery", 1st Edition, John Wiley & Sons, 2023.

2 L Ashok Kumar, S Albert Alexander, "Power Converters for Electric Vehicles", 1st Edition, CRC Press, 2021.

REFERENCES:

1 Simmi P Burman, "Special Electrical Machines", 1st Edition, S K Kataria & Sons, 2023.

2 Atif Iqbal, Shaikh, "Electrical Machines Fundamentals with Numerical Solutions using MATLAB/SIMULINK", 1st Edition, John Wiley &Sons, 2021.

3 Md Rabiul Islam, Rakibuzzaman Shah, "Emerging Power Converters for Renewable Energy and Electric Vehicles: Modelling Design and Control", 1st Edition, CRC Press, 2021.

ONLINE RESOURCES:

1 https://onlinecourses. nptel.ac.in/noc25_ee33/preview

2 https://innovationspace.ansys.com//courses/learning-track.

3 https://onlinecourses.nptel.ac.in/noc22_ee33/preview

COURSE OUTCOMES:

Upon completion of the course, students will be able to

CO1 Summarize the operation of power converters used in Electric Vehicles.

CO2 Explain the working of Induction Motors and PMBLDC Motors.

CO3 Design Permanent Magnet Synchronous Motors.

CO4 Comprehend the working of Axial Flux Motors.

CO5 Explain the operation of inverters used in Electric Vehicles

CO - PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	1	1	1	-	-
CO2	2	2	1	1	-	-	-	1	1	1	--	-
CO3	3	3	3	3	1	-	-	1	1	1	-	-
CO4	2	2	1	1	-	-	-	1	1	1	-	-
CO5	2	2	1	1	-	-	-	1	1	1	-	-

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U23MDEE04	ENERGY STORAGE SYSTEMS IN ELECTRIC VEHICLES	L T P C
		2 0 2 3

COURSE OBJECTIVES:

- To impart knowledge on general physical mechanism and standards for EV charging systems and battery management systems
- To familiarize the estimation methods for different battery parameters and wireless power transfer in EV and its standards
- To provide knowledge on renewable energy powered EV charging systems.

UNIT I **EV CHARGING METHODS AND STANDARDS** **6**

Introduction- Building Blocks of EV charging station, Types of battery chargers – Slow, rapid and DC fast chargers - Charging technologies- Conductive charging - Need for inductive charging of EV - Inductive charging – International standards and regulations - Indian standard IS 17017-part-1,2,23-25;

UNIT II **BATTERY MANAGEMENT SYSTEMS** **6**

Significance of Battery Management Systems - Functions of the Battery Management System – Topology of the BMS - Methods of Battery Management - Introduction to IoT based Battery Monitoring System.

UNIT III **BATTERY STATE ESTIMATION** **6**

Single Cell – Series and Parallel combination of Batteries - Characteristic Parameters: State of Charge (SoC), Depth of Discharge (DoD) and State of Health (SoH) – Estimation methods of SoC and SoH - Ampere-hour integral.

UNIT IV **WIRELESS POWER TRANSFER FOR EVs** **6**

Introduction – Types of Wireless Charging - Inductive, Magnetic Resonance and Capacitive - Benefits of WPT - Standards for EV Wireless Chargers, SAE J2954, IEC 61980, ISO 19363.

UNIT V **EV CHARGING USING RENEWABLE ENERGY SYSTEMS** **6**

Introduction – EV charging systems for residential and commercial buildings - solar PV system – wind energy conversion systems - charging infrastructure with hybrid solar PV, wind and battery.

30 PERIODS

PRACTICAL EXERCISES

Use any Renewable energy kit /open source platform

1 Determine the SOH and SOC of the given battery.
2 Simulate the thermal characteristics of a cell.
3 Simulate the primary battery monitoring system.
4 Simulate the charging system of the given battery for a specified time period
5 Simulate the charging system of the given battery fed from Photovoltaic panel.

30 PERIODS

TOTAL : 60 PERIODS

TEXT BOOKS:

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1 Rajiv Singh, Sanjeevikumar Padmanaban, Sanjeet Dwivedi, Marta Molinas and Frede Blaabjerg, "Cable Based and Wireless Charging Systems for Electric Vehicles, Technology and control, management and grid integration", 1st Edition, Springer, 2021.

2 Rui Xiong, "Battery Management Algorithm for Electric Vehicles", 1st Edition, Springer, 2021.

REFERENCES:

1 Chitra A, Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen, S Himavathi, "Artificial Intelligent Techniques for Electric and Hybrid Electric Vehicles", 1st Edition, John Wiley&Sons, 2021.

2 Alicia Trevino,-Cabrera, José M González-González, José A. Aguado, " Wireless Power Transfer for Electric Vehicles: Foundations and Design Approach", 1st Edition, Springer, 2021.

3 Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen, "Electric Vehicles Modern Technologies and Trends", 1st Edition, Springer, 2021.

ONLINE RESOURCES:

1 https://archive.nptel.ac.in/courses/113/105/113105102/

2 https://www.dqindia.com/iit-madras-offers-free-online-course-electric-vehicles-can-completed-12-weeks/

3 https://archive.nptel.ac.in/courses/108/106/108106182/

COURSE OUTCOMES:

Upon completion of the course, students will be able to

CO1 Comprehend the general physical mechanism of EV charging systems and standards

CO2 Design basic battery management system.

CO3 Evaluate the different parameters of the battery.

CO4 Analyze the different types of wireless power transfer.

CO5 Explain the challenges and problems associated with the use of various energy sources for EV charging systems.

CO - PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	1	1	1	-	-
CO2	3	3	3	3	1	-	-	1	1	1	--	-
CO3	3	3	2	3	1	-	-	1	1	1	-	-
CO4	3	3	1	2	1	-	-	1	1	1	-	-
CO5	2	2	1	1	-	-	-	1	1	1	-	-

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U23MDEE05	CONTROL OF ELECTRIC VEHICLES	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To impart knowledge on basics control strategy on power converter and different control schemes applied to Induction Motors
- To provide knowledge on different methods of control of synchronous reluctanc Motors
- To familiarize the different control techniques for PMBLDC motor and axial flux motors.

UNIT I **CONTROL OF POWER CONVERTERS** 6

Need for Closed Loop Control – Voltage Mode Control (VMC) – Current Mode Control (CMC) – Advantages of CMC over VMC –Cascade Control Strategy – Condition for implementing Cascade Control Strategy - Introduction to fixed and variable frequency PWM methods.

UNIT II **CONTROL OF INDUCTION MOTOR** 6

d-q Model, Scalar Control - v/f Control, Voltage Fed Inverter Control, Current Fed Inverter Control, Direct torque control.

UNIT III **CONTROL OF PERMANENT MAGNET BRUSHLESS DC MOTORS** 6

Control of PMBLDC Motor using 3-pulse Converter and 6 pulse Inverter, Structure of controller, Closed loop Current Mode Control - Microcontroller based implementation of PMBLDC Drive. Control of E-bike

UNIT IV **CONTROL OF PERMANENT MAGNET SYNCHRONOUS MOTORS** 6

Self-control, v/f control, Direct Torque control, Vector control, Sensor less control, Microcontroller based PMSM Drive.

UNIT V **CONTROL OF AXIAL FLUX MOTORS** 6

Current Control Schemes- Hysteresis and PWM control - Embedded control of axial flux motor.

30 PERIODS

PRACTICAL EXERCISES:

Use any open source platform

1 Simulate the Testing of v/f controller for Induction motor

2 Simulate the Speed control of PMDC motor

3 Simulate the Speed control of BLDC motor

4 Simulate the Speed of control of SRM motor

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5 Simulate the Testing of PMSM motor

30 PERIODS

TOTAL: 60 PERIODS

TEXT BOOKS:

1 Rolf Isermann," Automotive Control: Modelling and Control of Vehicles" 1st Edition, Springer Berlin, Heidelberg, 2021.

2 Per Enge, Nick Enge, Stephen Zoepf, "Electric Vehicle Engineering", 1st Edition, Tata McGraw Hill Publishers, 2021.

REFERENCES:

1 João Pedro F, Trovão, Minh Cao Ta," Electric Vehicle Efficient Power and Propulsion Systems", 1st Edition, Multidisciplinary Digital Publishing Institute(MDPI), 2022.

2 Kundan Kumar, Ambrish Devanshu, Sanjeet K. Dwivedi," Electric Vehicle Propulsion Drives and Charging Systems",1st Edition, CRC Press, 2024.

3 Raj Kamal, "Embedded Systems", 4th Edition, Tata McGraw Hill, 2020.

ONLINE RESOURCES:

1 https://www.embitel.com/motor-control-solution-for-electric-vehicle-drivetrain

2 https://onlinecourses.nptel.ac.in/noc24_ee30/preview

3 https://onlinecourses.nptel.ac.in/noc25_ee33/preview

COURSE OUTCOMES:

Upon completion of the course, students will be able to

CO1 Summarize the concept of power converters.

CO2 Describe the control of induction motors.

CO3 Design permanent magnet brushless DC Motors.

CO4 Explain the concepts of permanent magnet synchronous motors and axial flux motors.

CO5 Design various motors used in electric vehicles.

CO - PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	1	-	-	1	1	1	-	-
CO2	2	2	1	1	1	-	-	1	1	1	--	-
CO3	3	3	3	3	1	-	-	1	1	1	-	-
CO4	2	2	1	1	1	-	-	1	1	1	-	-
CO5	3	3	3	3	1	-	-	1	1	1	-	-

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U23MDEE06 INTEGRATION OF PLUG IN ELECTRIC VEHICLES

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To acquire knowledge on energy exchange between storage element and power grid and benefits of V2G
- To learn the challenges in V2G integrated power system , impacts of EV and V2G on the power grid
- To familiarize the management of EV

UNIT I INTRODUCTION TO G2V AND V2G 9

Introduction to power grid and smart grid. Definition of G2V and V2G - History and Development of V2G. Incorporating V2G for EV, Types of storage: Short-term and Long-Term.

UNIT II BENEFITS OF V2G 9

Benefits of V2G. Technical Benefits: Storage Superiority and Grid Efficiency - Economic Benefits: EV Owners and Societal Savings - Environment and Health Benefits: Sustainability in Electricity and Transport.

UNIT III CHALLENGES IN V2G 9

Technical Challenges- Effect of Battery Degradation, Conversion Efficiency of EV Charger. The Economic and Business Challenges of V2G - Evolving Nature of V2G Costs and Benefits. Introduction to Regulatory Challenges and Frameworks.

UNIT IV IMPACT OF EV AND V2G ON POWER GRID 9

Impact of Electric Vehicles on power quality issues - Load management using Renewable Energy Sources and EVs. Impacts of EV on environment.

UNIT V MANAGEMENT OF EV 9

Introduction to Machine to Machine (M2M) communication- M2M in distributed energy management systems - M2M communication for EV - Overview of cloud-based energy management service for Electric vehicles - Data loggers for EV. - Charging Station Discovery Selection and Status Server (CDSSS).

45 PERIODS

TEXT BOOKS:

1 Nand Kishor, Jesus Fraile-Ardanuy, "Electric Vehicle Integration with the Smart Grid", 1st Edition, Springer, 2020.

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2 Mohammad Saad Alam, Mahesh Krishnamurthy," Electric Vehicle Integration in a Smart Micro grid Environment", 1st Edition, CRC Press, 2021.

REFERENCES:

1 Lance Noel, Gerardo Zarazua de Rubens, Johannes Kester, Benjamin K Sovacool, " Vehicle-to-Grid A Sociotechnical Transition Beyond Electric Mobility", 1st Edition, Palgrave Macmillan, 2019.

2 Rajiv Singh, Sanjeevikumar Padmanaban," Cable Based and Wireless Charging Systems for Electric Vehicles: Technology and Control, Management and Grid Integration", 1st Edition, Springer, 2021.

3 Rather Z, Nath A, "Integration of Electric Vehicles Charging Infrastructure with Distribution Grid: Global Review, India's Gap Analyses and Way Forward", 1st Edition, Elsevier, 2021.

ONLINE RESOURCES:

1 https://onlinecourses.nptel.ac.in/noc25_ee79/preview

2 https://onlinecourses.nptel.ac.in/noc23_ee60/preview

3 https://archive.nptel.ac.in/courses/108/106/108106182/

COURSE OUTCOMES:

Upon completion of the course, students will be able to

CO1 Describe the methods of energy exchange between storage elements to power system grid

CO2 Explain the benefits of V2G

CO3 Analyze the technical and regulatory challenges related to V2G

CO4 Comprehend the impact of EV and V2G on power grid

CO5 Describe the concept of management of EV

CO PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	1	-	-	-	-	-
CO2	2	2	1	1	-	-	1	-	-	-	-	-
CO3	3	3	1	2	-	-	1	-	-	-	-	-
CO4	2	2	1	1	-	-	1	-	-	-	-	-
CO5	2	2	1	1	-	-	1	-	-	-	-	-

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DEPARTMENT OF MECHANICAL ENGINEERING

Curriculum and Syllabus for Minor Degree Programme

Name of the Minor Degree	**ROBOTICS**
Minor Degree Offering Department	**MECH**
Eligible Departments	**All branches except MECH**

Sl. No.	Course Code	Course Title	L	T	P	Total Contact Periods	Credits
1	U23MDME01	Introduction to Robotics	3	0	0	3	3
2	U23MDME02	Basics in Mechanics	3	0	0	3	3
3	U23MDME03	Kinematics of Robotics	3	0	0	3	3
4	U23MDME04	Sensor and actuators in Robotics	3	0	0	3	3
5	U23MDME05	PLC Programming of Robotics	3	0	0	3	3
6	U23MDME06	Robotics path planning and programming	3	0	0	3	3
TOTAL CREDITS							**18**

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U23MDME01	INTRODUCTION TO ROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives:

- To understand the operation and applications of stepper and servo motors
- To learn the fundamentals of digital electronics and Boolean logic
- To learn proficiency in analog electronics and Microprocessor fundamentals

UNIT I **INTRODUCTION TO ROBOTICS** 9

Brief History-Definition -Three laws -Robot anatomy-DOF- Misunderstood devices. Classification of Robotic systems- work volume- type of drive. Associated parameters- resolution, accuracy, repeatability, dexterity, compliance, RCC device. Introduction to Principles & Strategies of Automation-Types & Levels of Automations Need of automation- Industrial applications of robots

UNIT II **DIGITAL FUNDAMENTALS** 9

Stepper Motor: Classifications- Construction and Principle of Operation - Applications. Servo Mechanism – DC Servo motor - AC Servo motor. Number Systems – Decimal, Binary, Octal, Hexadecimal, 1's and 2's complements, Codes – Binary, BCD, Excess 3, Gray, Boolean theorems, Logic gates, Universal gates, Sum of products and product of sums

UNIT III **ANALOG ELECTRONICS** 9

Resistor, Inductor and Capacitor in Electronic Circuits- Semiconductor Materials: Silicon &Germanium – PN Junction Diodes, Zener Diode –Characteristics Applications – Bipolar Junction Transistor-Biasing, JFET, SCR, MOSFET,IGBT – Types, I-V Characteristics and Applications, Rectifier and Inverters

UNIT IV **PROGRAMMING PROCESSOR** 9

Instruction - format and addressing modes – Assembly language format – Data transfer, data manipulation & control instructions – Programming: Loop structure with counting & Indexing

UNIT V **MICROPROCESSOR & MICROCONTROLLER** 9

Introduction – Pin Configuration - Architecture of 8085 – Addressing Modes – Instruction set, Timing diagram of 8085-Microcontroller Systems -Single-Board Microcontroller Systems

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Ganesh S Hedge, "A textbook of Industrial Robotics", 2nd Edition, Lakshmi Publications, 2006
2. Mikell P Groover "Industrial Robotics Technology, Programming and applications", 2nd Edition, Tata McGraw Hill, 2012

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REFERENCES:

1. Fu K S Gonalz R C, ice C S G "Robotics Control, Sensing, Vision and Intelligence", 2nd Edition, Tata McGraw Hill, 2007
2. Janakiraman P A, "Robotics and Image Processing", 3rd Edition, Tata McGraw Hill, 2005
3. Jazar, "Theory of Applied Robotics: Kinematics, Dynamics and Control", 3rd Edition, Springer, 2010

ONLINE RESOURCES:

1. https://nptel.ac.in/courses/112105249
2. https://archive.nptel.ac.in/courses/108/105/108105112/
3. https://nptel.ac.in/courses/108108076

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain the operation, types and applications of stepper and servo motors

CO2 Apply digital electronics concepts to simplify logic circuits

CO3 Analyze the characteristics and working principles of PN junction diodes and Zener diodes

CO4 Write assembly language programs for debugging in microprocessors and interfacing

CO5 Explain the principles and components of microprocessor and microcontroller

CO-PO-PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	-	1	-	-	-	-	-	1	2	1
CO2	3	2	1	1	-	1	-	-	-	-	-	1	2	1
CO3	3	3	2	2	-	1	-	-	-	-	-	1	2	1
CO4	3	3	3	3	-	1	-	-	-	-	-	1	2	1
CO5	2	2	1	1	-	1	-	-	-	-	-	1	2	1

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U23MDME02	BASICS IN MECHANICS	L	T	P	C
		3	0	0	3

Course Objectives:

- To learn to use scalar and vector analytical techniques for analyzing forces in statically Determinate structures.
- To introduce the equilibrium of rigid bodies, vector methods and free body diagrams.
- To study and understand the distributed forces, surface, loading on beam and intensity.

UNIT I **STATICS OF PARTICLES** 9

Fundamental Concepts and Principles, Systems of Units, Method of Problem Solutions, Statics of Particles -Forces in a Plane, Resultant of Forces, Unit Vectors. Equilibrium of a Particle- Newton's First Law of Motion, Space and Free-Body Diagrams

UNIT II **EQUILIBRIUM OF RIGID BODIES** 9

Principle of Transmissibility, Equivalent Forces, Vector Product of Two Vectors, Moment of a Force about an Axis, Couple - Moment of a Couple, Equivalent Couples, Resolution of a Given Force into a Force -Couple system.

UNIT III **DISTRIBUTED FORCES** 9

Centroids of lines and areas – symmetrical and asymmetrical shapes, Determination of Centroids of Volumes by Integration. Moments of Inertia of Areas and Mass

UNIT IV **GEARS AND GEAR TRAINS** 9

Spur gear – law of toothed gearing – involute gearing – Interchangeable gears – Gear tooth action interference and undercutting – nonstandard teeth – gear trains – parallel axis gears trains – epicyclic gear trains

UNIT V **DYNAMICS OF PARTICLES** 9

Kinematics - Rectilinear Motion and Curvilinear Motion of Particles. Kinetics- Newton's Second Law of Motion -Equations of Motions, Dynamic Equilibrium, Energy and Principle of Work and Energy

TOTAL : 45 PERIODS

TEXT BOOKS:

1 Lynch, K M, Park, F C, "Modern Robotics: Mechanics, Planning and Control", 2nd Edition, Cambridge University Press, 2010

2 Ceccarelli, M," Fundamentals of Mechanics Manipulation of robotic", 2nd Edition, Springer International Publishing, 2013

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REFERENCES:

1 Boresi P, Schmidt J, "Engineering Mechanics: Statics and Dynamics", 2nd Edition, Cengage learning, 2008

2 Hibbeller, R C , "Engineering Mechanics: Statics and Engineering Mechanics" 2nd Edition, Pearson Education, 2007

3 Irving H Shames, Krishna Mohana Rao G, "Engineering Mechanics – Statics and Dynamics", 2nd Edition, Prentice Hall of India, 2005

ONLINE RESOURCES:

1 https://nptel.ac.in/courses/112/106/112106270/

2 https://ocw.mit.edu/courses/8-01sc-classical-mechanics-fall-2016/

3 https://www.khanacademy.org/science/mechanics

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain the vector and scalar representation of forces and moments

CO2 Analyze the moment of a force about a point and an axis using vector algebra.

CO3 Calculate the properties of distributed forces

CO4 Design the gear teeth and gear train by the law of toothed gearing

CO5 Calculate dynamic forces exerted in rigid body

CO–PO–PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	-	1	-	-	-	-	-	1	2	1
CO2	3	3	2	2	-	1	-	-	-	-	-	1	2	1
CO3	3	2	1	2	-	1	-	-	-	-	-	1	2	1
CO4	3	3	3	3	-	1	-	-	-	-	-	1	2	1
CO5	3	2	1	2	-	1	-	-	-	-	-	1	2	1

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U23MDME03	KINEMATICS OF ROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives:

- To introduce Robots history, terminologies, classification and configurations
- To get knowledge about basic Geometrical and Algebraic approach to solve forward kinematics of serial manipulator
- To get knowledge about advanced forward kinematics of serial manipulator

UNIT I **OVERVIEW OF ROBOTICS** 9

Introduction to Robotics - History - Definitions - Law of Robotics – Terminologies - Classifications Overview – Links & Joints - Degrees of Freedoms - Coordinate Systems - Work Volume - Precision, Repeatability & Accuracy - Position and Orientation of Objects - Roll, Pitch and Yaw Angles - Joint Configuration of Five Types of Serial Manipulators - Wrist Configuration- Overview of end effector

UNIT II **FORWARD KINEMATICS GEOMETRICAL AND ALGEBRAIC APPROACH** 9

Need for forward and Inverse Kinematics Equation – Parameters in Design and Control – Methods of forward and inverse kinematics- Geometric and Algebraic Approach in Forward Kinematics Solution, 1 DOF - 2 DOF Planar Robot (2P and 2R); 3DOF 2RP Spatial Robot

UNIT III **FORWARD KINEMATIC MODELING DENAVIT-HARTENBERG (DH) APPROACH** 9

Unit Circle Trigonometry - Translation Matrix - Rotation matrix, Euler Angles - Homogeneous Transformation - D-H and Modified D-H Convention and Procedures – Forward kinematics Solution using D-H Convention, Cartesian, Cylindrical, Spherical, SCARA and Articulated 3 DOF robots - 3 DOF robot with wrist

UNIT IV **INVERSE KINEMATICS MODELING** 9

Introduction to inverse kinematics -Issues in inverse kinematics - Inverse kinematics of 2 DOF Planar robot - 2 and 3 DOF planar and Spatial robot - Tool configuration - Inverse kinematics of 3 axis robot and 6 axis Robot - Inverse kinematics Computation- Closed loop solution

UNIT V **KINEMATIC MODELING OF DIFFERENTIAL DRIVE ROBOT** 9

Degree of Mobility, Steer ability and Maneuverability- Mobile Robot kinematics - Kinematic model and constraints, Mobile robot workspace – Representation of robot position – Kinematic models of differential wheel drive - Fixed wheel and steered wheel

TOTAL : 45 PERIODS

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TEXT BOOKS:

1 Mikell P Groover, "Industrial Robotics", 2nd Edition, Tata McGraw Hill, 2012

2 Lynch, Kevin M, and Frank C, "Park Modern Robotics: Mechanics, Planning and Control", 1st Edition, Cambridge University Press, 2017

REFERENCES:

1 S K Saha , "Introduction to Robotics", 2nd Edition, Tata McGraw-Hill, 2017

2 John J Craig, "Introduction to Robotics", 3rd Edition, Pearson Education , 2021

3 Arthor Critchlow, "Introduction to Robotics", 1st Edition, Macmillan , 2009

ONLINE RESOURCES:

1 https://archive.nptel.ac.in/courses/112/105/112105236/
2 https://onlinecourses.nptel.ac.in/noc21_me76/preview
3 https://archive.nptel.ac.in/courses/112/105/112105249/

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain the basic terminologies of robotics and its classification

CO2 Evaluate forward kinematic model for planar and spatial robot manipulator

CO3 Evaluate the transformation matrices including translation and rotation matrices, to model position of robotic links

CO4 Explain the concept of inverse kinematics and its significance in robotic motion planning and control.

CO5 Analyze the kinematic model for differential drive mobile robot

CO-PO-PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	-	1	-	-	-	-	-	1	2	1
CO2	3	3	2	2	-	1	-	-	-	-	-	1	2	1
CO3	3	3	2	2	-	1	-	-	-	-	-	1	2	1
CO4	2	2	1	1	-	1	-	-	-	-	-	1	2	1
CO5	3	3	2	2	-	1	-	-	-	-	-	1	2	1

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U23MDME04	SENSORS AND ACTUATORS	L	T	P	C
		3	0	0	3

Course Objectives:

- To understand the concepts of measurement technology.
- To learn the fundamentals of signal conditioning, data acquisition and communication systems used in mechatronics system development.
- To understand the signal conditioning and DAQ systems.

UNIT I **INTRODUCTION** 9

Basics of Measurement – Classification of errors – Error analysis – Static and dynamic characteristics of transducers – Performance measures of sensors – Classification of sensors – Sensor calibration techniques – Sensor Output Signal Types

UNIT II **MOTION, PROXIMITY AND RANGING SENSORS** 9

Motion Sensors – Potentiometers, Resolver, Encoders – Optical, Magnetic, Inductive, Capacitive, LVDT – RVDT – Synchro – Microsyn, Accelerometer – GPS, Bluetooth, Range Sensors – RF beacons, Ultrasonic Ranging, Reflective beacons, Laser Range Sensor (LIDAR).

UNIT III **FORCE, MAGNETIC AND HEADING SENSORS** 9

Strain Gage, Load Cell, and Magnetic Sensors –types, principle, requirement and advantages: Magneto resistive – Hall Effect – Current sensor Heading Sensors – Compass, Gyroscope, Inclinometers

UNIT IV **OPTICAL, PRESSURE AND TEMPERATURE SENSORS** 9

Force, torque, power — mechanical, Pneumatic, Hydraulic and Electrical type. bimetallic strip, thermocouples, electrical resistance thermometer — Reliability and Calibration

UNIT V **SIGNAL CONDITIONING AND DAQ SYSTEMS** 9

Amplification – Filtering – Sample and Hold circuits – Data Acquisition: Single channel and multi-channel data acquisition – Data logging - Applications - Automobile, Aerospace, Home appliances, Manufacturing and Environmental monitoring

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Ernest O Doebelin , "Measurement Systems – Applications and Design", 2nd Edition ,Tata McGraw Hill, 2009
2. Sawney A K, Puneet Sawney , "A Course in Mechanical Measurements and Instrumentation and Control", 12th Edition, Dhanpat Rai , 2013

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REFERENCES:

1 Richard Zurawski, "Industrial Communication Technology Handbook", 2nd Edition, CRC Publications, 2015

2 Patranabis D, "Sensors and Transducers", 2nd Edition Prentice Hall of India publication, 2011

3 Hans Kurt Tonshoff, Ichiro, "Sensors in Manufacturing", 2nd Edition, John Wiley & sons, 2021

ONLINE RESOURCES:

1 https://onlinecourses.nptel.ac.in/noc21_ee32/preview

2 http://ndl.iitkgp.ac.in/he_document/nptel/16331_16332

3 http://digimat.in/nptel/courses/video/108108147/L01.html

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain the various calibration techniques and types of sensors

CO2 Describe the working principle and characteristics of force, magnetic, heading, pressure and temperature sensors

CO3 Explain the sensors and transducers in various applications

CO4 Analyze the reliability and calibration aspects in measurement systems

CO5 Describe the operation and importance of data logging in various applications

CO-PO-PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	-	1	-	-	-	-	-	1	2	1
CO2	2	2	1	1	-	1	-	-	-	-	-	1	2	1
CO3	2	2	1	1	-	1	-	-	-	-	-	1	2	1
CO4	3	3	2	2	-	1	-	-	-	-	-	1	2	1
CO5	2	2	1	1	-	1	-	-	-	-	-	1	2	1

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U23MDME05	PLC PROGRAMMING OF ROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives:

- Understand basic PLC terminologies, digital principles, PLC architecture and operation
- Familiarize different programming language of PLC
- Develop PLC logic for simple applications using ladder logic

UNIT I **INTRODUCTION TO PLC** 9

Introduction to PLC: Microprocessor, I/O Ports, Isolation, Filters, Drivers, Microcontrollers/DSP, PLC/DDC- PLC Construction: PLC, PLC Memories, PLC I/O,PLC Special I/O, PLC Types

UNIT II **PLC INSTRUCTIONS** 9

PLC Basic Instructions: PLC Ladder Language- Function block Programming-Ladder/Function Block functions- PLC Basic Instructions, Basic Examples (Start Stop Rung, Entry/Reset Rung)- Configuration of Sensors, Switches, Solid State Relays-Interlock examples- Timers, Counters, Examples

UNIT III **PLC PROGRAMMING** 9

Different types of PLC program, Basic Ladder logic, logic functions, PLC module addressing, registers basics, basic relay instructions, Latching Relays, data handling, data move functions, timer-counter instructions, input-output instructions, sequencer instructions

UNIT IV **COMMUNICATION OF PLC AND SCADA** 9

Communication Protocol – Modbus, HART, Profibus, SCADA: Hardware and software, Remote terminal units, Master Station and Communication architectures

UNIT V **CASE STUDIES** 9

Stepper Motor Control - Elevator Control-CNC Machine Control- conveyor control-Interlocking Problems

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Frank Petruzzula,"Programmable Logic Controllers",2nd Edition, Tata McGraw Hill , 2008
2. John W Webb, Ronald A Reis, "Programmable Logic Controllers Principles and Applications", 2nd Edition, Prentice Hall of India, 2019

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REFERENCES:

1. Madhuchhanda Mitra, Samarjit Sengupta, "Programmable Logic Controllers Industrial Automation and Introduction", 3rd Edition, Penram publishing, 2020
2. J R ackworth, F D Hackworth, "Programmable Logic Controllers Principles and Applications", 2nd Edition, Pearson Education , 2017
3. Hans Kurt Tonshoff, Ichiro, "Sensors in Manufacturing", 3rd Edition, John Wiley & Sons, 2001

ONLINE RESOURCES:

1. https://nptel.ac.in/courses/108/105/108105062
2. https://nptel.ac.in/courses/112/107/112107297
3. https://archive.nptel.ac.in/courses/112/102/112102011/

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain the basic requirement of a PLC input/output devices and architecture

CO2 Apply the Basics Instruction Sets used for ladder Logic and Function Block Programming

CO3 Apply data handling and data move functions effectively in PLC-based systems

CO4 Analyze the communication architecture between SCADA components in a control system.

CO5 Explain the Concepts of Communication used for PLC/SCADA

CO-PO-PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	-	1	-	-	-	-	-	1	2	1
CO2	3	2	1	2	-	1	-	-	-	-	-	1	2	1
CO3	3	2	1	2	-	1	-	-	-	-	-	1	2	1
CO4	3	3	2	2	-	1	-	-	-	-	-	1	2	1
CO5	2	2	1	1	-	1	-	-	-	-	-	1	2	1

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U23MDME06	ROBOT PATH PLANNING AND PROGRAMMING	L	T	P	C
		3	0	0	3

Course Objectives:

- To introduce the fundamental concepts of robot motion and path planning
- To understand the principles and techniques of robot programming
- To understand path planning programming strategies and expose students to real-time applications

UNIT I **TRAJECTORY PLANNING APPROACHES** 9

Definitions – Task planning and Trajectory planning – Representation of end-effector: Cartesian and joint space schemes -Workspace Analysis: work envelope of a multi DOF manipulator - Applications: Point to point motion and continuous path motion

UNIT II **TRAJECTORY PLANNING OF MANIPULATOR** 9

Joint space techniques – Motion profiles – Cubic polynomial, Linear Segmented Parabolic Blends and cycloidal motion – Straight line and circular trajectories

UNIT III **PATH PLANNING OF MOBILE ROBOT** 9

Introduction - Representation of the Robot's Environment - Review of configuration spaces - Visibility Graphs - Voronoi diagrams – Attractive and Repulsive– Planning with moving obstacles - Probabilistic Roadmaps - Random trees

UNIT IV **PATH PLANNING ALGORITHMS** 9

Planning - A* Algorithm - the D*Algorithm - Path control-Graph search and discrete planning algorithms - Sensor-Based Motion Planning Algorithms

UNIT V **ROS PROGRAMMING** 9

Introduction to Robot Operating System (ROS) - ROS examples - Introduction to programming using ROS - Industrial ROS - Programming for point to point /continuous – operations - Case Study

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Mason, M T , " Mechanics of Robotic Manipulation", 2nd Edition, MIT Press , 2016
2. LaValle, S M, "Planning algorithms Italy: Cambridge University", 3rd Edition, Cambridge University Press, 2008

REFERENCES:

1. Rafael C Gonzales, Richard E Woods, "Digital Image Processing ", 4th Edition, Pearson Education, 2015
2. Emanuele Trucco, Alessandro Verri, "Introductory Techniques for 3D Computer Vision", 1st Edition, Prentice Hall of India , 2008
3. Hans Kurt Tonshoff, Ichiro, "Sensors in Manufacturing", 3rd Edition, John Wiley & Sons publications, 2016

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ONLINE RESOURCES:

1 https://archive.nptel.ac.in/courses/112/104/112104308/
2 https://nptel.ac.in/courses/112105249
3 https://ocw.mit.edu/courses/2-12-introduction-to-robotics-fall-2005/

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Apply trajectory planning techniques for both point-to-point and continuous path motion in robotic applications

CO2 Describe the trajectory planning and path planning for mobile robot and Manipulator

CO3 Apply the Path and Trajectory planning algorithms for various Applications

CO4 Analyze heuristic-based algorithms such as A* and D* for optimal path finding

CO5 Design a path and trajectory for real time robot applications

CO–PO–PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	-	1	-	-	-	-	-	1	2	1
CO2	2	2	1	1	-	1	-	-	-	-	-	1	2	1
CO3	3	2	1	1	-	1	-	-	-	-	-	1	2	1
CO4	3	3	2	2	-	1	-	-	-	-	-	1	2	1
CO5	3	3	3	3	-	1	-	-	-	-	-	1	2	1

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

Curriculum and Syllabus for Minor Degree Programme

Name of the Minor Degree	**Full Stack web Development**
Minor Degree Offering Department	**CSE**
Eligible Departments	**ECE, EEE, Mech, Civil**

Sl. No.	Course Code	Course Title	L	T	P	Total Contact Periods	Credits
1	U23MDCS01	Principles of Programming Languages	3	0	0	3	3
2	U23MDCS02	Web Essentials	2	0	2	3	3
3	U23MDCS03	Cloud Services Management	2	0	2	3	3
4	U23MDCS04	Stream Processing	2	0	2	3	3
5	U23MDCS05	Devops	2	0	2	3	3
6	U23MDCS06	Design of UI / UX	3	0	0	3	3
TOTAL CREDITS							**18**

U23MDCS01 PRINCIPLES OF PROGRAMMING LANGUAGES

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To understand and describe syntax and semantics of programming languages.
- To understand call-return architecture and ways of implementing them
- To learn programs in non-procedural programming paradigms

UNIT I SYNTAX AND SEMANTICS 9

Evolution of programming languages – describing syntax – context-free grammars – attribute grammars – describing semantics – lexical analysis – parsing – recursive-descent – bottom-up parsing

UNIT II DATA, DATA TYPES, AND BASIC STATEMENTS 9

Names – variables – binding – type checking – scope – scope rules – lifetime and garbage collection – primitive data types – strings – array types – associative arrays – record types – union types – pointers and references – Arithmetic expressions – overloaded operators – type conversions – relational and boolean expressions – assignment statements – mixed mode assignments – control structures – selection – iterations – branching – guarded statements

UNIT III SUBPROGRAMS AND IMPLEMENTATIONS 9

Subprograms – design issues – local referencing – parameter passing – overloaded methods generic methods – design issues for functions – semantics of call and return – implementing simple subprograms – stack and dynamic local variables – nested subprograms – blocks – dynamic scoping.

UNIT IV OBJECT-ORIENTATION, CONCURRENCY, AND EVENT HANDLING 9

Object-orientation – design issues for OOP languages – implementation of object-oriented constructs – concurrency – semaphores – monitors – message passing – threads - statement level concurrency – exception handling – event handling.

UNIT V FUNCTIONAL AND LOGIC PROGRAMMING LANGUAGES 9

Introduction to lambda calculus– fundamentals of functional programming languages– Programming with Scheme – Programming with ML– Introduction to logic and logic programming – Programming with Prolog – multi-paradigm languages.

TOTAL: 45 PERIODS

TEXT BOOKS:

1 Robert W Sebesta, "Concepts of Programming Languages", 12th Edition, Pearson Education, 2022.

2 Rajiv Chopra, "Principles of Programming Languages", 9th Edition, Elsevier, 2019.

REFERENCES:

1 Bruce J MacLennan, "Principles of Programming Languages: Design, Evaluation, and Implementation", 1st Edition, Oxford University Press, 2019.

2 Gilles Dowek, "Principles of Programming Languages", 1st Edition, Springer Publications, 2020.

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S. AM

3 Saverio Perugini, "Programming Languages: Concepts and Implementation", 4th Edition, Jones & Bartlett Learning, 2021.

ONLINE RESOURCES:

1 http://digimat.in/nptel/courses/video/106102067/L40.html

2 http://acl.digimat.in/nptel/courses/video/106102067/L25.html

3 https://www.youtube.com/watch?v=e4fwY9ZsxPw

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Describe syntax and semantics of programming languages

CO2 Summarize data, data types, and basic statements of programming languages

CO3 Describe about functions and overloading

CO4 Comprehend about object-oriented concepts

CO5 Summarize and adopt new programming languages

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	1	-	-	-	1
CO2	2	2	1	1	-	-	-	1	-	-	-	1
CO3	2	2	1	1	-	-	-	1	-	-	-	1
CO4	2	2	1	1	-	-	-	1	-	-	-	1
CO5	2	2	1	1	-	-	-	1	-	-	-	1

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U23MDCS02 **WEB ESSENTIALS** L T P C
2 0 2 3

COURSE OBJECTIVES:

- To learn the basic concepts of web programming and internet protocols
- To learn the uses of scripting languages, write simple scripts for the creation of web sites
- To learn how to create database applications

UNIT I **WEBSITE BASICS** 6

Internet Overview - Fundamental computer network concepts - Web Protocols - URL – Domain Name- Web Browsers and Web Servers- Working principle of a website – Creating a Website - Client-side and server-side scripting

UNIT II **WEB DESIGNING** 6

HTML – Form Elements - Input types and Media elements - CSS3 - Selectors, Box Model, Backgrounds and Borders, Text Effects, Animations, Multiple Column Layout, User Interface.

UNIT III **CLIENT-SIDE PROCESSING AND SCRIPTING** 6

JavaScript Introduction – Variables and Data Types-Statements – Operators - Literals-Functions- Objects-Arrays-Built-in Objects- Regular Expression, Exceptions, Event handling, Validation - JavaScript Debuggers.

UNIT IV **SERVER-SIDE PROCESSING AND SCRIPTING – PHP** 6

PHP - Working principle of PHP - PHP Variables - Constants - Operators – Flow Control and Looping - Arrays - Strings - Functions - File Handling - File Uploading – Email Basics - Email with attachments - PHP and HTML - Simple PHP scripts - Databases with PHP

UNIT V **SERVLETS AND DATABASE CONNECTIVITY** 6

Servlets: Java Servlet Architecture – Servlet Life cycle- Form GET and POST actions - Sessions – Cookies – Database connectivity – JDBC Creation of simple interactive applications - Simple database applications

30 PERIODS

PRACTICAL EXERCISES:

1. Form validation using JavaScript
2. Creation of simple PHP scripts
3. Handling multimedia content in web sites
4. Write programs using Servlets:
   i) To invoke servlets from HTML forms
   ii) Session tracking using hidden form fields and Session tracking for a hit count
5. Creation of information retrieval system using web, PHP and MySQL
6. Creation of personal Information System

30 PERIODS

TOTAL: 60 PERIODS

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TEXT BOOKS:

1 Terry Felke Morris, "Web Development and Design Foundations", 8th Edition, Pearson Education, 2022.

2 Jon Duckett, "HTML and CSS: Design and Build Websites", 2nd Edition, John Wiley & Sons, 2020.

REFERENCES:

1 Jonathan Petersen, Richard Petersen," Web Applications: Concepts and Real-World Design", 2nd Edition, John Wiley & Sons, 2020.

2 Wendy Willard, "Web Design: A Beginner's Guide", 5th Edition, Tata McGraw Hill, 2020.

3 Roger Pressman, David Lowe, "Web Engineering: A Practitioner's Approach", 2nd Edition, Tata McGraw Hill, 2020.

ONLINE RESOURCES:

1 https://www.nptelvideos.com/php/php_video_tutorials.php

2 http://www.digimat.in/nptel/courses/video/106106156/L09.html

3 https://www.youtube.com/watch?v=h_RftxdJTzs

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Comprehend the basic concepts of internet and website.

CO2 Design simple HTML programs

CO3 Write simple JavaScript programs for client side scripting

CO4 Write simple PHP programs for server side scripting

CO5 Create database connectivity

CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	2	2	2	-	2
CO2	3	3	3	3	-	-	-	2	2	2	-	2
CO3	3	3	3	3	1	-	-	2	2	2	-	2
CO4	3	3	3	3	1	-	-	2	2	2	-	2
CO5	3	3	3	3	1	-	-	2	2	2	-	2

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U23MDCS03	CLOUD SERVICES MANAGEMENT	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To understand the Cloud Service Management terminology with traditional IT service management
- To learn the strategies to reduce risk and eliminate issues associated with adoption of cloud services select
- To understand the benefits and drive the adoption of cloud-based services to solve real world problems

UNIT I CLOUD SERVICE MANAGEMENT FUNDAMENTALS 6

Cloud Ecosystem, The Essential Characteristics, Basics of Information Technology service Management and Cloud Service Management, Service Perspectives, Cloud Service Models, Cloud Service Deployment Models

UNIT II CLOUD SERVICES STRATEGY 6

Cloud Strategy Fundamentals, Cloud Strategy Management Framework, Cloud Policy, Key Driver for Adoption, Risk Management, IT Capacity and Utilization, Demand and Capacity matching, Demand Queueing, Change Management, Cloud Service Architecture

UNIT III CLOUD SERVICE MANAGEMENT 6

Cloud Service Reference Model, Cloud Service LifeCycle, Basics of Cloud Service Design, Dealing with Legacy Systems and Services, Benchmarking of Cloud Services, Cloud Service Capacity Planning, Cloud Service Deployment and Migration, Cloud Marketplace, Cloud Service Operations Management

UNIT IV CLOUD SERVICE ECONOMICS 6

Pricing models for Cloud Services, Freemium, Pay Per Reservation, pay per User, Subscription based Charging, Procurement of Cloud-based Services, Capex vs Opex Shift, Cloud service Charging, Cloud Cost Models

UNIT V CLOUD SERVICE GOVERNANCE & VALUE 6

IT Governance Definition, Cloud Governance Definition, Cloud Governance Framework, Cloud Governance Structure, Cloud Governance Considerations, Cloud Service Model Risk Matrix, Understanding Value of Cloud Services, Measuring the value of Cloud Services, Balanced Scorecard, Total Cost of Ownership

30 PERIODS

PRACTICAL EXERCISES:

1. Create a Cloud Organization in AWS/Google Cloud/or any equivalent Open-Source cloud software's like OpenStack, Eucalyptus, Open Nebula with Role-based access control
2. Create a Cost-model for a web application using various services and do Cost-benefit analysis
3. Create alerts for usage of Cloud resources
4. Create Billing alerts for your Cloud Organization
5. Compare Cloud cost for a simple web application across AWS, Azure and GCP and suggest the best one

30 PERIODS

TOTAL: 60 PERIODS

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TEXT BOOKS:

1 Enamul Haque, "Cloud Service Management and Governance: Smart Service Management in Cloud Era ", 1st Edition, Enel Publication, 2023.

2 Thomas Erl, Ricardo Puttini, Zaigham Mohammad, "Cloud Computing: Concepts, Technology & Architecture", 1st Edition, Prentice Hall of India, 2020.

REFERENCES:

1 S S Iyengar, G S Sanyal, S K Ghosh, "Cloud Computing Management: A Systematic Review", 1st Edition, Pearson Education, 2020.

2 Enamul Haque, "Cloud Service Management and Governance", 2nd Edition, Lulu Press, 2023.

3 Nayan B. Ruparelia , "Cloud Computing", 2nd Edition, The MIT Press, 2023

ONLINE RESOURCES:

1 http://digimat.in/nptel/courses/video/106105167/L01.html

2 http://kcl.digimat.in/nptel/courses/video/106101234/L46.html

3 https://onlinecourses.nptel.ac.in/noc25_cs12/preview

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Comprehend cloud-design skills to build service models.

CO2 Analyze cloud service strategy using business solutions.

CO3 Describe cloud operation service management.

CO4 Apply economics towards adoption of cloud-based services

CO5 Solve the real-world problems using Cloud services and technologies.

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	1	-	-	2	2	2	-	-
CO2	3	3	2	2	2	-	-	2	2	2	-	1
CO3	2	2	1	1	3	-	-	2	2	2	-	-
CO4	3	2	1	2	3	-	-	2	2	2	-	1
CO5	3	2	1	2	2	-	-	2	2	2	-	1

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S.M

U23MDCS04 **STREAM PROCESSING** **L T P C**
2 0 2 3

COURSE OBJECTIVES:

- To learn the foundations of data systems
- To explain the concepts of Real-time Data processing and select appropriate structures for designing
- To learn the benefits and drive the adoption of real-time data services to solve real-world problems

UNIT I **FOUNDATIONS OF DATA SYSTEMS** **6**

Introduction to Data Processing, Stages of Data processing, Data Analytics, Batch Processing, Stream processing, Data Migration, Transactional Data processing, Data Mining, Data Management Strategy, Storage, Processing, Integration, Analytics, Benefits of Data as a Service, Challenges

UNIT II **REAL-TIME DATA PROCESSING** **6**

Introduction to Big data, Big data infrastructure, Real-time Analytics, Near real-time solution, Lambda architecture, Kappa Architecture, Stream Processing, Understanding Data Streams, Message Broker, Stream Processor, Batch & Real-time ETL tools, Streaming Data Storage

UNIT III **DATA MODELS AND QUERY LANGUAGES** **6**

Relational Model, Document Model, Key-Value Pairs, NoSQL, Object-Relational Mismatch, Many- to-One and Many-to-Many Relationships, Network data models, Schema Flexibility, Structured Query Language, Data Locality for Queries, Declarative Queries, Graph Data models, Cypher Query Language, Graph Queries in SQL, The Semantic Web, CODASYL, SPARQL

UNIT IV **EVENT PROCESSING WITH APACHE KAFKA** **6**

Apache Kafka, Kafka as Event Streaming platform, Events, Producers, Consumers, Topics, Partitions, Brokers, Kafka APIs, Admin API, Producer API, Consumer API, Kafka Streams API, Kafka Connect API

UNIT V **REAL-TIME PROCESSING USING SPARK STREAMING** **6**

Structured Streaming, Basic Concepts, Handling Event-time and Late Data, Fault-tolerant Semantics, Exactly-once Semantics, Creating Streaming Datasets, Schema Inference, Partitioning of Streaming datasets, Operations on Streaming Data, Selection, Aggregation, Projection, Watermarking, Window operations, Types of Time windows, Join Operations, Deduplication

30 PERIODS

PRACTICAL EXERCISES:

1. Install MongoDB and Design and Implement Simple application using MongoDB
2. Query the designed system using MongoDB
3. Create a Event Stream with Apache Kafka
4. Create a Real-time Stream processing application using Spark Streaming
5. Build a Micro-batch application
6. Real-time Fraud and Anomaly Detection
7. Real-time personalization, Marketing, Advertising

30 PERIODS

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TOTAL: 60 PERIODS

TEXT BOOKS:

1. Hubert Dulay, Ralph Matthias Debusmann, "Streaming Databases: Unifying Batch and Stream Processing", 1st Edition, O'Reilly Media, 2024.
2. Fabian Hueske, Vasiliki Kalavri," Stream Processing with Apache Flink Fundamentals, Implementation, and Operation of Streaming Applications", 1st Edition, O'Reilly Media, 2019.

REFERENCES:

1. Tyler Akidau, Slava Chemyak, Reuven Lax," Streaming Systems: The What, Where, When and How of Large-Scale Data Processing ", 2nd Edition, O'Reilly Media, 2023.
2. Shilpi Saxena, Saurabh Gupta, "Practical Real-time Data Processing and Analytics Distributed Computing and Event Processing using Apache Spark, Flink, Storm, and Kafka", 1st Edition, Kindle Edition, 2019.
3. Gerard Maas & François Garillot, "Stream Processing mit Apache Spark", 2nd Edition, O'Reilly Media, 2024.

ONLINE RESOURCES:

1. https://archive.nptel.ac.in/courses/127/101/106101224/
2. http://kcl.digimat.in/nptel/courses/video/106106093/L07.html
3. https://archive.nptel.ac.in/courses/106/104/106104189/

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Comprehend the applicability and utility of different streaming algorithms.

CO2 Describe about current research trends in data-stream processing.

CO3 Analyze the suitability of stream mining algorithms for data stream systems.

CO4 Create simple stream processing systems.

CO5 Solve problems in real-world applications that process data streams.

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	1	-	-	1	1	1	-	1
CO2	2	2	1	1	1	-	-	1	1	1	-	1
CO3	3	3	2	2	1	-	--	1	1	1	-	2
CO4	3	3	3	3	2	-	-	1	1	1	-	2
CO5	3	2	1	2	2	-	-	1	1	1	-	2

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U23MDCS05 **DEVOPS** L T P C
2 0 2 3

COURSE OBJECTIVES:

- To understand DevOps terminology, and the different Version control tools like Git, Mercurial
- To understand the concepts of Continuous Integration/ Continuous Testing/ Continuous Deployment) and Configuration management using Ansible
- To learn the benefits and drive the adoption of cloud-based Devops tools to solve real world problems

UNIT I **INTRODUCTION TO DEVOPS** 6

Devops Essentials - Introduction To AWS, GCP, Azure - Version control systems: Git and Github.

UNIT II **COMPILE AND BUILD USING MAVEN & GRADLE** 6

Introduction, Installation of Maven, POM files, Maven Build lifecycle, Build phases (compile build, test, package) Maven Profiles, Maven repositories (local, central, global), Maven plugins, Maven create and build Artificats, Dependency management, Installation of Gradle, Understand build using Gradle

UNIT III **CONTINUOUS INTEGRATION USING JENKINS** 6

Install & Configure Jenkins, Jenkins Architecture Overview, Creating a Jenkins Job, Configuring a Jenkins job, Introduction to Plugins, Adding Plugins to Jenkins, Commonly used plugins (Git Plugin, Parameter Plugin, HTML Publisher, Copy Artifact and Extended choice parameters). Configuring Jenkins to work with java, Git and Maven, Creating a Jenkins Build and Jenkins workspace.

UNIT IV **CONFIGURATION MANAGEMENT USING ANSIBLE** 6

Ansible Introduction, Installation, Ansible master/slave configuration, YAML basics, Ansible modules, Ansible Inventory files, Ansible playbooks, Ansible Roles, adhoc commands in ansible

UNIT V **BUILDING DEVOPS PIPELINES USING AZURE** 6

Create Github Account, Create Repository, Create Azure Organization, Create a new pipeline, Build a sample code, Modify azure-pipelines.yaml file

30 PERIODS

PRACTICAL EXERCISES:

1. Create Maven Build pipeline in Azure
2. Run regression tests using Maven Build pipeline in Azure
3. Install Jenkins in Cloud
4. Create CI pipeline using Jenkins
5. Create a CD pipeline in Jenkins and deploy in Cloud
6. Create an Ansible playbook for a simple web application infrastructure
7. Build a simple application using Gradle
8. Install Ansible and configure ansible roles and to write playbooks

30 PERIODS

TOTAL: 60 PERIODS

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TEXT BOOKS:

1 Gene Kim , Jez Humble , "The Devops Handbook: How to Create World-Class Agility, Reliability, & Security in Technology Organizations", 1st Edition, IT revolution Press, 2021.

2 Yevgeniy Brikman," Fundamentals of DevOps and Software Delivery", 1st Edition, O'Reilly Media, 2025.

REFERENCES:

1 Stefano Demiliani, Nemanja Jovic, Amit Malik, "Azure DevOps Explained", 2nd Edition, Packt Publishing, 2025.

2 Gaurav Agarwal," Modern DevOps Practices", 2nd Edition, Packt Publishing, 2024.

3 Sujeevan Vijayakumaran, "DevOps Frameworks, Techniques, and Tools", 1st Edition, SAP PRESS , 2025

ONLINE RESOURCES:

1 https://www.jenkins.io/user-handbook.pdf

2 https://maven.apache.org/guides/getting-started/

3 http://digimat.in/nptel/courses/video/106104182/L01.html

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 : Comprehend about different kinds of cloud environment.

CO2 Apply maven and gradle tools for building and compiling projects.

CO3 Apply Jenkins for Automated Continuous Deployment

CO4 Apply Ansible for configuration management

CO5 Create Pipelines in Devops using Azure

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	1	-	-	2	2	2	-	1
CO2	3	2	1	2	3	-	-	2	2	2	-	-
CO3	3	2	1	2	3	-	-	2	2	2	-	-
CO4	3	2	1	2	3	-	-	2	2	2	-	-
CO5	3	3	3	3	3	-	-	2	2	2	-	-

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U23MDCS06 **UI AND UX DESIGN** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

- To learn a sound knowledge in UI & UX
- To understand the need for UI and UX
- To understand the various Research Methods used in Design

UNIT I **FOUNDATIONS OF DESIGN** **9**

UI vs. UX Design - Core Stages of Design Thinking - Divergent and Convergent Thinking - Brainstorming and Game storming - Observational Empathy

UNIT II **FOUNDATIONS OF UI DESIGN** **9**

Visual and UI Principles - UI Elements and Patterns - Interaction Behaviours and Principles – Branding - Style Guides

UNIT III **FOUNDATIONS OF UX DESIGN** **9**

Introduction to User Experience - Why You Should Care about User Experience - Understanding User Experience - Defining the UX Design Process and its Methodology - Research in User Experience Design - Tools and Method used for Research - User Needs and its Goals - Know about Business Goals

UNIT IV **WIREFRAMING, PROTOTYPING AND TESTING** **9**

Sketching Principles - Sketching Red Routes - Responsive Design – Wire framing - Creating Wire flows - Building a Prototype - Building High-Fidelity Mock-up's - Designing Efficiently with Tools - Interaction Patterns - Conducting Usability Tests - Other Evaluative User Research Methods - Synthesizing Test Findings - Prototype Iteration

UNIT V **RESEARCH, DESIGNING, IDEATING, & INFORMATION ARCHITECTURE** **9**

Identifying and Writing Problem Statements - Identifying Appropriate Research Methods - Creating Personas - Solution Ideation - Creating User Stories - Creating Scenarios - Flow Diagrams - Flow Mapping - Information Architecture

TOTAL: 45 PERIODS

TEXT BOOKS:

1 Joel Marsh, "UX for Beginners", 1st Edition, O'Reilly Media, 2022.

2 Jon Yablonski, "Laws of UX using Psychology to Design Better Product & Services", 1st Edition, O'Reilly Media, 2021.

REFERENCES:

1 Steve Schoger, Adam Wathan, "Refactoring UI", 2nd Edition, Pearson Education, 2022.

2 David Travis, Philip Hodgson, "Think Like a UX Researcher", 1st Edition, CRC Press, 2019.

3 Aditi, "Ultimate Figma for UI/UX Design", 2nd Edition, Orange Education Pvt Ltd, 2025.

ONLINE RESOURCES:

1 https://enine.digimat.in/nptel/courses/video/124107008/L08.html

2 https://archive.nptel.ac.in/noc/courses/noc22/SEM1/noc22-ar02

3 https://www.youtube.com/watch?v=GDcOKMTxAq4

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COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Describe UI for user Applications

CO2 Summarize the UI design of any product or application

CO3 Describe UX Skills in product development

CO4 Comprehend Sketching principles and build prototype

CO5 Describe the various Research Methods used in Design

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	1	-	-	-	1
CO2	2	2	1	1	-	-	-	1	-	-	-	1
CO3	2	2	1	1	-	-	-	1	-	-	-	1
CO4	2	2	1	1	-	-	-	1	-	-	-	1
CO5	2	2	1	1	-	-	-	1	-	-	-	1

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DEPARTMENT OF COMPUTER APPLICATIONS

Curriculum and Syllabus for Minor Degree Programme

Name of the Minor Degree	**INTELLIGENT APPS DEVELOPMENT**
Minor Degree Offering Department	**MCA**
Eligible Departments	**All Branches except MCA**

Sl. No.	Course Code	Course Title	L	T	P	Total Contact Periods	Credits
1	U23MDMC101	Fundamentals of Internet and Web Technology	3	0	0	3	3
2	U23MDMC102	CSS3 for Web Design and Development	3	0	0	3	3
3	U23MDMC103	JavaScript Essentials: Advanced App Development	3	0	0	3	3
4	U23MDMC104	XML and Web Services: Foundations, Architecture, and Applications	3	0	0	3	3
5	U23MDMC105	Mobile Technology and App Design	3	0	0	3	3
6	U23MDMC106	AI for App Developers	3	0	0	3	3
TOTAL CREDITS							**18**

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U23MDMC101	FUNDAMENTALS OF INTERNET AND WEB TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To provide a comprehensive understanding of the history, evolution, and foundational concepts of the Internet and networking
- To learn basic HTML, CSS and multimedia elements for creating simple web pages.
- To equip students with the skills required for website development, hosting, and optimization.

UNIT I **INTERNET & NETWORK** **9**

History and Evolution of the Internet – Basic Internet Concepts - Internet vs. Intranet vs. Extranet - Network Topologies and Their Role in Internet Connectivity - Internet Infrastructure - Components: Routers, Switches, Modems - Introduction To Network - Network Types: LAN, WAN, MAN, PAN.

UNIT II **INTERNET SERVICES** **9**

Internet Services: WWW, Email, FTP, Telnet – Overview of Protocols: HTTP, HTTPS, FTP, SMTP, IMAP, POP3 - Concept of IP Addressing: IPv4 vs. IPv6 - Introduction to Packet Switching and Routing - Domain Names and DNS (Domain Name System) - Websites - Web Browsers and Search Engines - Components of WWW: HTML, URLs, - Social Media Platforms and Their Impact.

UNIT III **WEB TECHNOLOGIES** **9**

Basic HTML– Web Terminology – Structure of a HTML Document – HTML, Head and Body tags –Heading, Font, Image and Anchor Tags –Different types of Lists using tags – Table Tags, Image formats – Multimedia Elements: Images, Audio, and Video Embedding - Creation of simple HTML Documents.

UNIT IV **CSS (CASCADING STYLE SHEETS)** **9**

Introduction to CSS and Its Types - Selectors, Properties, and Values - CSS Syntax and Structure - CSS in HTML Documents - Linking External Stylesheets - Box Model and Layouts - Styling Text, Colors, and Backgrounds - Responsive Web Design: Media Queries and Flexbox - Debugging CSS.

UNIT V **WEBSITE DEVELOPMENT** **9**

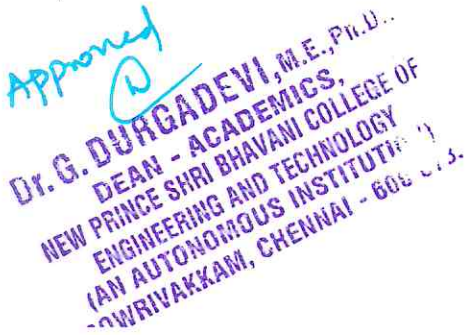
Website Development : Webpage anatomy – Web Development – Website Publishing – URL Registration – Website Hosting – Search Engine Optimization.

TOTAL: 45 PERIODS

TEXT BOOKS:

1 Santosh Choubey, "Introduction to Internet & Web Technology", All India Society for Electronics and Computer Technology (AISECT) Publications, 2024.

2 Ayush Mauryavamshi, "A Complete Overview On: Web-Development", Notion Press, 2024.



REFERENCES:

1 Prem kumar, "Web Design With HTML & CSS", Notion Press, 2021.

2 David Gordon, "Universal Design for Learning: Principles, framework and Practice", 2nd Edition, Cast Professional Publishing, 2024.

3 Julie C. Meloni, Jennifer Kyrnin, "HTML, CSS, and JavaScript All in One, Sams Teach Yourself", 3rd Edition, Pearson Education, 2020.

ONLINE RESOURCES

1 https://www.coursera.org/projects/images-and-links-in-html?

2 https://www.mygreatlearning.com/academy/learn-for-free/courses/introduction-to-web-designing

3 https://www.coursera.org/learn/web-development

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain the fundamentals of Internet and its Technology.

CO2 Describe various network types, topologies, components and their role in Internet connectivity

CO3 Create basic HTML documents, incorporating multimedia elements for enhanced web pages.

CO4 Apply CSS and its features for styling web pages.

CO5 Design user-friendly and interactive websites by integrating web technology concepts.

CO – PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	-	-	-	-	-
CO2	2	2	1	1	-	-	-	-	-	-	-	-
CO3	3	3	3	3	1	-	-	1	-	-	-	1
CO4	3	2	1	2	-	-	-	-	-	-	-	-
CO5	3	3	3	3	1	-	-	1	-	-	-	1

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U23MDMC102	CSS3 FOR WEB DESIGN AND DEVELOPMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To provide a comprehensive understanding of CSS3, its evolution, and its role in modern web development.
- To explore advanced CSS3 Box model and layout techniques for creating user interactive web pages.
- To enable students to design and build responsive web pages optimized for different devices using CSS3.

UNIT I **INTRODUCTION TO CSS3** 9

CSS3 and its Evolution - Features of CSS3 - CSS Syntax: Selectors, Properties, and Values - Types of CSS: Inline, Internal, and External - Linking CSS to HTML Documents - Importance of CSS in Modern Web Development.

UNIT II **CSS3 SELECTORS AND PROPERTIES** 9

CSS Selectors: Universal, Type, Class, ID, Descendant, Child, and Sibling - Attribute Selectors - Pseudo-classes and Pseudo-elements - Styling Text: Font Properties, Text Alignment, Line Height, and Text Decoration - Working with Colors: RGB, HEX, HSL, and Opacity - Background Properties: Images, Gradients, and Transparency.

UNIT III **CSS3 BOX MODEL** 9

Box Model (Introduction, Border properties, Padding Properties, Margin properties) - CSS Positioning: Static, Relative, Absolute, and Fixed -CSS Advanced (Grouping, Dimension, Display, Positioning, Floating, Align, Pseudo class, Navigation Bar, Image Sprites, Attribute sector) - CSS3 Animations and Transitions.

UNIT IV **STYLING WITH CSS3 LAYOUTS** 9

Understanding CSS layout techniques-Creating page Layout and Site Designs Working with CSS box model-Creating responsive layouts using CSS media queries-Exploring CSS frameworks for layout and design-Applying advanced CSS techniques for layout customization.

UNIT V **BUILDING RESPONSIVE WEB PAGES** 9

Understanding the principles of responsive web design- Creating responsive web pages using HTML and CSS - Testing and optimizing web pages for different devices and screen sizes- Introduction to CSS preprocessors for enhanced styling capabilities - Designing Interactive Forms with CSS3 - Case Studies: Building a Complete Web Page Using CSS3.

TOTAL: 45 PERIODS

TEXT BOOKS:

1 Patrick Carey, "New Perspectives on HTML 5 and CSS: Comprehensive", 8th Edition, Cengage Learning, 2020

2 Ben Frain, "Responsive Web Design with HTML5 and CSS", 4th Edition, Packt Publishing, 2022.

REFERENCES:

1 David DuRocher, "HTML and CSS Quick Start Guide", Clydebank Media, 2021.

2 Keith J. Grant, "Css in Depth", 2nd Edition, Manning Publications, 2024.

3 Paul McFedries, "Web Design Playground", 2nd Edition, Manning Publications, 2024.

ONLINE RESOURCES:

1 https://unacademy.com/course/learn-web-designing-with-css3/YA5FEOJP

2 https://css-tricks.com/snippets/css/complete-guide-grid/

3 https://www.classcentral.com/course/responsive-web-design-4200

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain the evolution of CSS3, its features, and its importance in modern web development.

CO2 Apply CSS3 selectors and properties to style web pages effectively.

CO3 Apply CSS Box Model and positioning techniques for structured layouts.

CO4 Design complex page layouts using CSS3 frameworks, media queries, and advanced layout customization techniques.

CO5 Create responsive web pages with CSS3 to enhance user experience and interface design.

CO – PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	-	-	-	-	-
CO2	3	2	1	2	-	-	-	-	-	-	-	-
CO3	3	2	1	2	-	-	-	-	-	-	-	-
CO4	3	3	3	3	1	-	-	1	-	-	-	1
CO5	3	3	3	3	1	-	-	1	-	-	-	1

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U23MDMC103 JAVASCRIPT ESSENTIALS: ADVANCED APP DEVELOPMENT **L T P C**
3 0 0 3

COURSE OBJECTIVES:

- To provide a comprehensive understanding of JavaScript fundamentals.
- To explore advanced JavaScript techniques to create interactive web applications
- To learn modern JavaScript frameworks for building front-end and server-side applications.

UNIT I **JAVASCRIPT FUNDAMENTALS** **9**

Introduction to JavaScript - History and Evolution of JavaScript - JavaScript in Web Development- Understanding ECMAScript Versions- Basics of Document Object Model (DOM)- JavaScript Functions-Understanding Functions: Declarations, Expressions, Arrow Functions - Scope and Closure: Managing Data Privacy and Function State - Variable Declarations- Using var, let, and const: Differences and Use Cases.

UNIT II **BROWSER SCRIPTING AND EVENTS** **9**

Client-Side Scripting - Scripting for Web Pages- Interacting with the DOM- Managing Browser Windows and Frames- Cookies and Web Storage Management- Dynamic Content Creation.

UNIT III **ADVANCED JAVASCRIPT TECHNIQUES** **9**

Object-Oriented JavaScript- Introduction to Objects and Classes- Creating and Using JavaScript Classes- Object Prototypes- Inheritance Patterns- Encapsulation Techniques- Polymorphism and Code Reusability. Advanced Function Handling- Asynchronous Functions: Async/Await, Promises.

UNIT IV **JAVASCRIPT FRAMEWORKS AND LIBRARIES** **9**

Frontend Frameworks - Introduction to Angular, React, and Vue- Component-Based Architecture- Single Page Application (SPA) Development- Building and Managing Front-End Routing- Introduction to TypeScript

UNIT V **SERVER-SIDE JAVASCRIPT** **9**

Introduction to Node.js and npm- Creating and Managing Modules - Understanding the Event Loop- Building a Simple Web Server- Using Databases with Node.js (MongoDB, SQL).

TOTAL: 45 PERIODS

TEXT BOOKS:

1 David Flanagan, "JavaScript: The Definitive Guide", 7th Edition, O'Reilly Media, 2020
2 Nicolas Cloud, Sufyan bin Uzayr, Tim Ambler, "JavaScript Frameworks for Modern Web Development: The Essential Frameworks, Libraries, and Tools to Learn Right Now", Apress, 2019.

REFERENCES:

1 Matt Frisbie, "Professional JavaScript for Web Developers", 5th Edition, John Wiley & Sons, 2023.
2 Keith J Grant; "CSS in Depth", Manning Publications, 1st Edition, 2018
3 Bethany Griggs, Manuel Spigolon, "Node.js Cookbook", 5th Edition, Packt Publishing, 2024.

ONLINE RESOURCES

1 https://onlinecourses.swayam2.ac.in/nou24_cs09/preview

2 https://www.coursera.org/learn/programming-with-javascript

3 https://www.javascriptinstitute.org/javascript-tutorial/server-side-javascript/

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Describe the evolution and significance of JavaScript in App development.

CO2 Explain Document Object Model (DOM) to manipulate web page elements and create dynamic content.

CO3 Analyze advanced JavaScript techniques such as closures, object-oriented programming, and asynchronous programming.

CO4 Apply modern front-end frameworks to develop component-based single-page applications (SPAs).

CO5 Create server-side applications using Node.js and integrating databases for data persistence.

CO – PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	-	-	-	-	-
CO2	2	2	1	1	-	-	-	-	-	-	-	-
CO3	3	3	2	2	-	-	-	-	-	-	-	1
CO4	3	2	1	2	1	-	-	-	-	-	-	1
CO5	3	3	3	3	1	-	-	1	-	-	-	1

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U23MDMC104 XML AND WEB SERVICES: FOUNDATIONS, ARCHITECTURE, AND APPLICATIONS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To understand the fundamental knowledge of xml and schema
- To learn the XML transformation and querying
- To explore different web service technologies

UNIT I INTRODUCTION TO XML 9

XML –Introduction –Document Type Definition or DTD – uses of DTD – Tags – Elements – Attributes – PCDATA – CDATA – Basics of entities – XML Elements – Elements Declaration – usage of #REQUIRED – usage of #IMPLIED – usage of #FIXED – Internal Entities – External Entities – Defining, Accessing XML Document.

UNIT II XML SCHEMA AND VALIDATION 9

XML Schema - XML Schema Definition (XSD) - Elements, attributes, and data types in XSD – Namespace in XML and XSD - Validation of XML documents using XSD - Advanced schema concepts - complex types, groups.

UNIT III XML TRANSFORMATION AND QUERYING 9

XSLT (Extensible Stylesheet Language Transformations) - XSLT syntax and patterns - Transforming XML documents using XSLT - XPath (XML Path Language) expressions - Introduction to XQuery.

UNIT IV WEB SERVICES 9

Web Services Overview - Web Service Architecture – Web service and APIs – Types of Web Services –Web Service protocols – Web Service Standards- Web Services Technologies.

UNIT V WSDL, SOAP and UDDI 9

WSDL - Overview Of SOAP – HTTP – XML-RPC – SOAP: Protocol – Message Structure – Intermediaries – Actors – Design Patterns And Faults – SOAP With Attachments – UDDI.

TOTAL: 45 PERIODS

TEXT BOOKS:

1 S. Banzal, "XML Basics", 1st Edition, Mercury Learning & Information, 2020.

2 Priscilla Walmsley, "XQuery: Search Across a Variety of XML Data", 2nd Edition, O'Reilly Media, 2023.

REFERENCES:

1 Clifford B. Anderson, "XQuery for Humanists", 1st Edition, Texas Agricultural & Mechanical University Press, 2020.

2 Mark Richards, Neal Ford, "Fundamentals of Software Architecture: A Modern Engineering Approach", 2nd Edition, O'Reilly Media, 2025.

3 Mike Amundsen, "Restful Web API Patterns and Practices Cookbook", 1st Edition, O'Reilly Media, 2022.

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ONLINE RESOURCES

1 https://www.youtube.com/watch?v=itRkLa2kq6w

2 https://www.coursera.org/learn/juniper-automation-xml

3 https://www.udemy.com/course/xml-and-xml-schema-definition-in-easy-steps/?couponCode=ST19MT121224

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain the concepts of XML.

CO2 Describe the concepts of xml schema and its validation

CO3 Apply xml technologies like XSLT, XPATH and XQUERY to perform XML transformations.

CO4 Explain web services architecture and its types

CO5 Apply SOAP, HTTP and UDDI services in the web applications.

CO – PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	-	-	-	-	-
CO2	2	2	1	1	-	-	-	1	-	-	-	-
CO3	3	2	1	2	-	-	-	1	-	-	-	1
CO4	2	2	1	1	-	-	-	-	-	-	-	-
CO5	3	2	1	2	-	-	-	1	-	-	-	1

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U23MDMC105	MOBILE TECHNOLOGY AND APP DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn the fundamental differences between various mobile operating systems.
- To understand the principles of user-centered design to create intuitive and engaging user interfaces (UI) for mobile applications.
- To deploy cross-platform mobile applications using Flutter.

UNIT I INTRODUCTION TO ANDROID 9

Android: An Open Platform for Mobile Development - Native Android Applications - Android SDK features - Understanding the Android Software Stack - The Dalvik Virtual Machine - Android Application Architecture - Android Libraries - Creating the Android Application - Types of Android Applications – Android Development Tools - Externalizing the Resources - The Android Application Lifecycle.

UNIT II BUILDING USER INTERFACE 9

Fundamental Android UI design - Android User Interface fundamentals - Layouts - Linear - Relative - Grid Layouts - Fragments - Creating new fragments - The Fragments Lifecycle - Introducing the Fragment Manager - Adding Fragments to Activities - Interfacing between Fragments and Activities.

UNIT III INTRODUCTION TO FLUTTER 9

Features of Flutter- Advantages of Flutter- Disadvantages of Flutter. Flutter Installation- Installation in Windows- Installation in Mac OS- Creating Simple Application in Android Studio - Architecture of Flutter Applications.

UNIT IV FLUTTER BASICS 9

Widgets- Gestures- Concept of State- Layers- Introduction to Dart Programming-Variables and Data types- Decision Making and Loops. Functions- Object Oriented Programming. Introduction to Widgets- Widget Build Visualization.

UNIT V ANIMATION ON FLUTTER 9

Introduction to Animation Based Classes-Work flow of the Flutter Animation- Working Application- Android Specific Code on Flutter- Introduction to Package- Types of Packages Using a Dart Package- Develop a Flutter Plugin Package- Accessing Rest API- Basic Concepts- Accessing Product service API.

TOTAL: 45 PERIODS

TEXT BOOKS:

1 Rap Payne, "Flutter App Development: How to Write for IOS and Android at Once", 2nd Edition, Apress, 2024.

2 Simone Alessandria, "Flutter Cookbook: 100+ Step-by-Step Recipes for Building Cross-Platform, Professional-G", 2nd Edition, Packt Publishing, 2023.

REFERENCES:

1 Dawn Griffiths, David Griffiths, "Head First Android Development: A Learner's Guide to Building Android Apps with Kotlin", 3rd Edition, O'Reilly Media, 2023.

2 Zigurd Mednieks, Laird Dornin, G. Blake Meike, Masumi Nakamura, "Programming Android", 2nd Edition, O'Reilly Media, 2021.
3 Barry Burd, John Paul Mueller, "Android Application Development All-in-One For Dummies", 3rd Edition, John Wiley & Sons, 2020.

ONLINE RESOURCES

1 https://onlinecourses.nptel.ac.in/noc20_cs52/preview
2 https://www.udemy.com/course/learn-flutter-dart-to-build-ios-android-apps/?couponCode=BFCPSALE24
3 https://docs.flutter.dev/resources/courses

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain the working principles of sensors using various measurement methods.

CO2 Analyze the actuation of sensors using their fundamental principles.

CO3 Describe the velocity and acceleration of accelerometers and gyroscopes.

CO4 Apply various measurement methods of physical and electrical parameters.

CO5 Apply the calibration methods for sensors attached with real time systems.

CO – PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	1	-	-	-	-
CO2	3	3	2	2	-	-	-	1	-	-	-	1
CO3	2	2	1	1	-	-	-	1	-	-	-	-
CO4	3	2	1	2	-	-	-	1	-	-	-	1
CO5	3	2	1	2	-	-	-	1	-	-	-	1

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U23MDMC106	AI FOR APP DEVELOPERS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To provide foundational knowledge of Artificial Intelligence (AI) and its significance in modern industries and applications.
- To explain core concepts of supervised, unsupervised and advanced learning techniques with practical implementation
- To explore various AI tools, libraries, and platforms for developing and deploying AI applications.

UNIT I INTRODUCTION TO ARTIFICIAL INTELLIGENCE 9

Foundations for AI – Types of AI – Role of AI in Modern Applications and Industries - AI in Mobile App Development: Opportunities and Challenges - AI Techniques: Machine Learning, NLP, and Computer Vision – Data Collection and Preprocessing for AI Systems – AI Tools, Frameworks, and Libraries – Ethical AI and Responsible Use of AI in Apps.

UNIT II BASICS OF MACHINE LEARNING 9

Machine Learning - Importance of Machine Learning – Types of Machine Learning – Approaches of Machine Learning - Applications Languages/Tools - Issues - Machine Learning Algorithm – Programming Languages.

UNIT III SUPERVISED AND UNSUPERVISED LEARNING ALGORITHMS 9

Linear Regression: Concept, Equation, and Implementation – Logistic Regression – Decision Tree – Support Vector Machines (SVM) – K-Nearest Neighbors (KNN) – Clustering Algorithms: K-Means Clustering, Hierarchical Clustering – PCA (Principal Component Analysis).

UNIT IV ADVANCED LEARNING TECHNIQUES 9

Fundamentals of Reinforcement Learning – State and action space – Reward function – Discounting – Action selection – Policy – Markov decision process – Q-learning Algorithm - Applications of RL: Robotics, Gaming, and Autonomous Systems.

UNIT V AI TOOLS AND PLATFORMS 9

AI Tools: Google AI, AWS AI, and Microsoft Azure - Importance of AI Libraries: TensorFlow, PyTorch, scikit-learn - AI in Mobile Apps: ML Kit - AI Models - Developing AI Applications - Deploying AI Models - Real-Life Applications of AI Problem-Solving.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Russell, Norwig "Artificial Intelligence: A Modern Approach", 4th Edition, Pearson Education, 2022.
2. Ethem Alpaydin, "Introduction to Machine Learning", 4th Edition, Massachusetts Institute of Technology Press, 2020.

REFERENCES:

1. Saptarsi Goswami, Amit Kumar Das, Amlan Chakrabarti, "AI for Everyone: A Beginner's Handbook for Artificial Intelligence", Pearson Education, 2024.
2. Tom M. Mitchell, "Machine Learning", 1st Edition, McGraw Hill Education, 2017.

3 Sebastian Raschka, "Machine Learning with PyTorch and Scikit-Learn: Develop machine learning and deep learning models with Python", Packt Publishing, 2022.

ONLINE RESOURCES

1 https://www.coursera.org/learn/foundations-of-ai-and-machine-learning#modules

2 https://nptel.ac.in/courses/106102220

3 https://onlinecourses.nptel.ac.in/noc23_ge40/preview

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Describe the fundamental principles of AI and identify its applications in industries and modern systems

CO2 Explain the importance of Machine Learning and differentiate its types, approaches, and tools.

CO3 Apply supervised and unsupervised learning algorithms in different fields.

CO4 Apply advanced learning techniques to solve real-world problems.

CO5 Apply modern AI tools and libraries to develop and deploy AI applications.

CO – PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	-	-	-	-	-
CO2	2	2	1	1	1	-	-	-	-	-	-	-
CO3	3	2	1	2	1	-	-	1	-	-	-	1
CO4	3	2	1	2	1	-	-	1	-	-	-	1
CO5	3	2	1	2	1	-	-	1	-	-	-	1

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Curriculum and Syllabus for Minor Degree Programme

Name of the Minor Degree	**FinTech & Entrepreneurship (FTE)**
Minor Degree Offering Department	**Management Studies**
Eligible Departments	**ECE, EEE, CSE, IT, Mech, Civil, AIDS, Cyber Security**

Sl. No.	Course Code	Course Title	L	T	P	Total Contact Periods	Credits
1	U23MDMS01	Entrepreneurship Essentials	2	0	2	4	3
2	U23MDMS02	Financial Technology Fundamentals	2	0	2	4	3
3	U23MDMS03	Start-Up Ecosystem	2	0	2	4	3
4	U23MDMS04	Managerial Applications of Blockchain	2	0	2	4	3
5	U23MDMS05	MSME Financing	2	0	2	4	3
6	U23MDMS06	Social Entrepreneurship	2	0	2	4	3
TOTAL CREDITS							**18**

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U23MDMS01	ENTREPRENEURSHIP ESSENTIALS	L	T	P	C
Prerequisites: Nil		2	0	2	3

COURSE OBJECTIVES:

- To understand the qualities and success metrics of an entrepreneur.
- To be acquainted with the skill-sets needed for a successful entrepreneur.
- To identify various entrepreneurial resources available in India.

UNIT I **INTRODUCTION** **6**

Entrepreneurship – Entrepreneur – Intrapreneur – Personal Qualities: Resilience – Passion – Risk-Taking – Vision – Self-Discipline – Leadership – Problem-Solving Skills – Networking Ability – Financial Acumen – Integrity. Success Metrics: Financial Performance – Market Position – Customer Satisfaction – Product and Service Quality – Operational Efficiency – Employee Engagement – Personal Fulfilment – Social Impact.

UNIT II **BUSINESS FUNDAMENTALS** **6**

Business Planning: Business Idea – Business Plan. Market Research: Market Analysis – Competitive Analysis. Financial Management: Budgeting – Funding Sources – Financial Statements. Marketing and Sales: Marketing Strategy – Branding – Sales Techniques. Operations Management: Operational Plan – Quality Control.

UNIT III **ENTREPRENEURIAL SKILLS** **6**

Creative Thinking and Innovation: Idea Generation – Problem-Solving. Leadership and Management: Team Building – Decision-Making. Financial Literacy: Budgeting – Financial Analysis. Sales and Marketing: Sales Techniques – Marketing Strategy. Networking: Building Relationships – Negotiation. Time Management and Organization: Prioritizing Tasks – Organizational Skills.

UNIT IV **ENTREPRENEURIAL MINDSET** **6**

Opportunity Recognition – Innovation – Risk-Taking – Resilience – Self-Motivation – Growth Mindset – Proactiveness – Customer Focus – Networking – Ethical Behaviour.

UNIT V **ENTREPRENEURIAL RESOURCES** **6**

Educational Resources: Online courses – Business School Programs. Mentorship and Networking: Mentorship Programs – Networking Events. Funding and Financial Resources: Crowd funding Platforms – Venture Capital – Small Business Loans. Marketing and Sales Tools: Digital Marketing Resources – social media. Support Networks: Entrepreneurial Committees – Online Forums. Books and Publications: Entrepreneurship Books – Industry Journals. Workshops and Seminars: Local Workshops – Online Webinars.

30 PERIODS

PRACTICALEXERCISES (any TWO to be completed, each in 15 periods).

1 Brainstorm 10 business ideas and prepare a brief report on them.

2 Write a Business Plan (Executive Summary, Market Analysis, Financial Projections)

3 Develop a marketing plan (target audience, channels, budget)

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4 Create a presentation for a start-up competition.

5 Identify potential business risks and draw a tentative risk management plan.

30 PERIODS
TOTAL: 60 PERIODS

TEXT BOOKS:

1 B.UdayaBhaskara Ganesh, PB Narendra Kiran, Shaiku Shahida Saheb, "Essentials Of Entrepreneurship Development", 1st Edition, Redshine Publication, 2023.

2 AnnaMariaBliven, "Entrepreneurship Essentials You Always Wanted To Know", 1st Edition, Vibrant Publishers, 2023.

REFERENCES:

1 Manmeet Kaur, Wasim Ahmad, K.S. Hari, Ruth Kattumuri, "FinTech Entrepreneurial Ecosystem in India: Role of Incubators and Accelerators", 1st Edition, Global Finance Journal, 2024.

2 Prakash Kumar, Ramesh Yadava, "Book Entrepreneurship 2024-25", 1st Edition, BIT Sindri Press, 2024.

3 Dr. Aarti Sharma, Mr. MaulikChandnani, "Essentials of Social Entrepreneurship: Building Better Future", 1st Edition, Redshine Publication, 2024.

ONLINE RESOURCES

1 https://www.vijaynicole.co.in/book/isbn/9789393161918

2 http://www.canadabusiness.ca/eng/page/2819/

3 http://www.ic.gc.ca/eic/site/cipointernet-internetopic.nsf/eng/h_wr02360.html

COURSEOUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain the personal qualities and success metrics of an entrepreneur.

CO2 Explain the various business fundamentals necessary for entrepreneurship.

CO3 Describe the entrepreneurial skills needed for the success of an entrepreneur.

CO4 Explain the entrepreneurial mind-set of a successful entrepreneur.

CO5 Summarize more appropriate of the various entrepreneurial resources.

CO / PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	1	-	1	2	2	2	1
CO2	2	2	1	1	-	1	-	1	2	2	2	1
CO3	2	2	1	1	-	1	-	1	2	2	2	1
CO4	2	2	1	1	-	1	-	1	2	2	2	1
CO5	2	2	1	1	-	1	-	1	2	2	2	1

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U23MDMS02 **FINANCIAL TECHNOLOGY FUNDAMENTALS** **L T P C**

Prerequisites: Nil **2 0 2 3**

COURSE OBJECTIVES:

- To familiarize the students with fundamental concepts of FinTech
- To acquaint them with the awareness on FinTech Payments and Lending
- To make them aware of recent developments and future trends in FinTech

UNIT I INTRODUCTION **6**

Financial Technology – Meaning and Definitions – Scope – Benefits – Challenges. FinTech Fundamentals: Digital Payments – Blockchain and Cryptocurrencies – Financial Inclusion – Big Data – Digital Identity Verification.

UNITII FINTECH PAYMENTS AND TRANSFERS **6**

Digital Payments – Peer-to-Peer (P2P) Payments – Cross-Border Payments – ACH Transfers – Real-Time Transfers (RTP) – Payment Processing Companies – Buy Now, Pay Later (BNPL)

UNIT III FINTECH LENDING AND BORROWING **6**

Digital Lending Platforms – Peer-to-Peer Lending – Automated Underwriting – Faster Access to Funds – Financial Inclusion – Enhanced Customer Experience – Security and Fraud Prevention – Competitive Interest Rates.

UNIT IV REGTECH, INSURTECH, WEALTHTECH **6**

RegTech (Regulatory Technology): Regulatory Monitoring – Reporting and Compliance – Risk Management – Transparency and Efficiency – Collaboration with Regulators. InsurTech (Insurance Technology): Big Data Analytics – IoT – Blockchain. Benefits of InsurTech. WealthTech (Wealth Technology): Robo-Advisors – Digital Brokers – Micro-Investing – Social Trading – Personal Financial Management – Big Data and AI – Blockchain.

UNIT V FUTURE TRENDS AND CAREER PATHS IN FINTECH **6**

Decentralized Finance – Digital-Only Banks – Sustainable Finance – B2B Collaboration. Career Paths in FinTech: Financial Analyst – Data Analyst – Data Scientist – UI/UX Designer – Customer Success Professional – Compliance Officer – Cybersecurity Specialist – Blockchain Developer – Investment Analyst.

30 PERIODS

PRACTICAL EXERCISES (any TWO to be completed, each in about 15 periods)

1 Develop a digital wallet for online transactions.

2 Build a Regulatory Reporting tool (for RegTech).

3 Create a simple Digital Lending Platform,

4 Implement a simple usage-based Insurance Model in FinTech.

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5 Prepare a brief report on the Growth of Mobile Payments in rural India.

30 PERIODS
TOTAL: 60 PERIODS

TEXT BOOKS:

1 Sanjay Phadke, "FinTech Future: The Digital DNA of Finance", 1st Edition, SAGE Publications Pvt Ltd, 2020.

2 Jaspal Singh, "Financial Technology (FinTech) and Digital Banking in India", 1st Edition, New Century Publications, 2022.

REFERENCES:

1 Sumeet Gupta and Adarsh Agrawal, "Analytical Study of FinTech in India: Pre & Post Pandemic COVID-19", 1st Edition, Ashwin Anokha Publications & Distributions, 2021.

2 Agusin Rubini, "Fintech Founders: Inspiring Tales from the Entrepreneurs that are Changing Finance", 1st Edition, FSPal.com, 2021.

3 Platform Revolution: How Networked Markets Are Transforming the Economy — and Susanne Chishti, Tony Craddock, BhagvanKommadi , "The PayTech Book", 1st Edition, Wiley, 2020.

ONLINE RESOURCES

1 https://www.vijaynicole.co.in/book/isbn/9788119243426

2 https://www.nobledesktop.com/learn/fintech/free-resources-and-tutorials

3 https://www.oreilly.com/library/view/-/9781637422489/

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain the building blocks of Financial Technology.

CO2 Describe the various options for FinTech Payments and Transfers

CO3 Summarize the various FinTech lending and borrowing platforms

CO4 Explain the concepts of RegTech, InsurTech and WealthTech

CO5 Summarize the various career paths available in FinTech

CO / PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	1	-	1	1	2	2	1
CO2	2	2	1	1	-	1	-	1	1	2	2	1
CO3	2	2	1	1	-	1	-	1	1	2	2	1
CO4	2	2	1	1	-	1	-	1	1	2	2	1
CO5	2	2	1	1	-	1	-	1	1	2	2	1

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U23MDMS03	START-UP ECOSYSTEM	L	T	P	C
Prerequisites: Nil		2	0	2	3

COURSE OBJECTIVES:

- To understand the start-up ecosystem and its key components
- To recognise various stages in start-up life cycle
- To be acquainted with the roles played by various players in start-up ecosystem

UNIT I INTRODUCTION 6

Start-Up – Meaning and Definition – Start-Up Ecosystem – Benefits – Challenges – Metrics of Success: Financial Metrics (Revenue Growth, Profitability, Burn Rate, Runway) – Customer Metrics (CAC, LTV, CRR, NPS) – Operational Metrics (Product Development Cycle, Monthly Active Users, Churn Rate) – Market Metrics (Market Share, Growth Rate, Brand Awareness).

UNITII START-UP ECOSYSTEM KEY COMPONENTS 6

Key Components of Start-Up Ecosystem: Funding Sources (Angel Investors, Venture Capitalists, Crowdfunding Platforms) – Mentors and Advisors (Experienced Entrepreneurs, Industry Experts) – Incubators and Accelerators – Educational Institutions – Service Providers – Government and Regulatory Support – Coworking Spaces – Culture and Community.

UNIT III START-UP STAGES 6

Start-Up Lifecycle: Idea Stage (Concept Development, Market Research, Feasibility Analysis) - Pre-Seed Stage (Validation, Founding Team, Initial Funding) – Seed Stage (Product Development, Market Testing, Seed Funding) – Early Stage (Product-Market Fit, Scaling Operations, Revenue Generation, Series A Funding) – Growth Stage (Market Expansion, Scaling Up, Team Expansion, Series B and Beyond) – Late Stage (Market Leadership, Profitability, Strategic Partnerships, Preparation for Exit) – Exit Stage (Acquisition, Merger, IPO).

UNIT IV ECOSYSTEM ROLES 6

Players in a Start-Up Ecosystem – Start-Ups and Entrepreneurs – Investors – Incubators and Accelerators – Educational Institutions – Government and Regulatory Bodies – Service Providers – Coworking Spaces – Mentors and Advisors – Networking Organisations – Media and Public Relations – Customers – R & D Facilities.

UNIT V START-UP ECOSYSTEM MODELS 6

Triple Helix Model – Quadruple Helix Model – Regional Cluster Model – Platform Ecosystem Model – Innovation District Model – Open Innovation Model – Hub-and-Spoke Model – Lean Start-Up Model.

30 PERIODS

PRACTICAL EXERCISES (any TWO to be completed, each in 15 periods).

1 Build a financial model for a start-up using Microsoft Excel

2 Conduct a Break-Even Analysis for a start-up enterprise.

3 Design a Company Culture and Values.

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4 Prepare a report after analysing at least 3 successful start-ups.

5 Evaluate Failed Start-ups and identify lessons learned from their failures.

30 PERIODS
TOTAL: 60 PERIODS

TEXT BOOKS:

1 Nitu Saxena and Sweta Siddharth, "Startups in India: Ecosystem, Best Practices, and Global Benchmarks", First Edition, IUP Publications, 2025.

2 IIBF's Micro, Small and Medium Enterprises – Covering all important aspects of Himalaya Publishing House Editorial Board, "Startup Ecosystem in India: Text & Cases", First Edition, Himalaya Publishing House, 2023.

REFERENCES:

1 Soum Paul, "Flight of the Unicorns", 1st Edition, HarperCollins India, 2021.

2 Eric Ries, "The Lean Startup", 1st Edition, Crown Business, 2021.

3 Shiv Khera, "You Can Win", 1st Edition, Bloomsbury India, 2021

ONLINE RESOURCES

1 https://books.google.co.in/books?id=tFNAYRBjsuIC&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

2 http://www.ventureblog.com/

3 http://onstartups.com/

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain the meaning and metrics of success for start-ups.

CO2 Discuss the key components of start-up ecosystem.

CO3 Summarize the various stages of Start-Up Life Cycle.

CO4 Describe the roles played by various players in a start-up ecosystem.

CO5 Summarize various start-up ecosystem models.

CO / PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	1	-	2	2	1	2	1
CO2	2	2	1	1	-	1	-	2	2	1	2	1
CO3	2	2	1	1	-	1	-	2	2	1	2	1
CO4	2	2	1	1	-	1	-	2	2	1	2	1
CO5	2	2	1	1	-	1	-	2	2	1	2	1

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U23MDMS04 MANAGERIAL APPLICATIONS OF BLOCKCHAIN **L T P C**

Prerequisites: Nil **2 0 2 3**

COURSE OBJECTIVES:

- To enable the students to understand the emerging concepts of blockchain technology
- To familiarize them with the operational aspects of cryptocurrencies
- To enlighten them with blockchain applications in healthcare and finance

UNIT I INTRODUCTION **6**

Meaning of Block chain – Origin of Block chain, Types of Block chain Networks – Centralized and Decentralized, Core Components of Block chain, Features of Block chain, Cryptography, Wallet, Digital Signature, Shared Ledger, Ledger database, World state database, Proof of work (PoW), Proof of stake (PoS), Practical Byzantine fault tolerance (PBFT), Proof of elapsed time (PoET)

UNITII WORKING OF BLOCKCHAIN **6**

Blockchain Architecture, Block chain technologies and concepts, Transaction Process, Blockchain Decentralization, Blockchain Transparency, Decentralized security, Bitcoin vs. Blockchain, Blockchain vs. Banks, Uses of Blockchain, Benefits of Blockchains, Drawbacks of Blockchains.

UNIT III BLOCKCHAIN APPLICATIONS: CRYPTO CURRENCIES **6**

Payment processing and financial transactions, Recording property records and real estate transactions, Securing patient information, Streamlining the supply chain, Tracking voting records, Merits and Demerits of blockchain with respect to cryptocurrency application.

UNIT IV BLOCKCHAIN APPLICATIONS: HEALTHCARE **6**

Blockchain transaction processing, Blockchain medical records, Patient data management, Privacy preference center, Telemedicine and remote monitoring, Protection of Healthcare Data, Managing Electronic Medical Record Data, Electronics Health Record data Management, Interoperable Electronics Health Records, Point of Care Genomics Management, Breakthroughs in genomics, Safeguarding genomics.

UNIT V BLOCKCHAIN APPLICATIONS: FINANCE & BANKING **6**

Cost reductions, Instant settlements, Smart contracts, Auditing, Cross border payments, Digital identity management, Stock exchange, Trade finance, Fund investment, Fraud prevention and security, Crypto staking, Invoice factoring, Types of B2B networks used for financial settlement.

30 PERIODS

PRACTICAL EXERCISES (any TWO to be completed, each in about 15 periods).

1 Analyse various Career opportunities available in block chain and submit a report

2 Identify popular Components of a Blockchain Ecosystem and make a presentation

3 Examine how Blockchain Technology is used in Cryptocurrency and prepare a report

4 Analyse how Blockchain Technology is used in healthcare and prepare a report

5 Analyse how Blockchain Technology is used in finance and banking and make a presentation

30 PERIODS
TOTAL: 60 PERIODS

TEXT BOOKS:

1 Bina Ramamurthy, "Blockchain in Action", 1st Edition, Manning Publications, 2025.

2 Shrivastava Gulshan, Le Dac-Nhuong, Sharma Kavita, "Cryptocurrencies and Blockchain Technology Applications", 1st Edition, Wiley, 2020.

REFERENCES:

1 NITI Aayog, "Blockchain: The India Strategy", 1st Edition, NITI Aayog, 2020.

2 S. L. Gupta, "Applications, Challenges, and Opportunities of Blockchain Technology in Banking and Insurance", 1st Edition, IGI Global, 2021.

3 Daniel Drescher, "Blockchain Basics: A Non-Technical Introduction in 25 Steps", 1st Edition, Apress, 2020.

ONLINE RESOURCES

1 Prof. Sandip Chakraborty, Dr. Praveen Jayachandran, "Blockchain Architecture Design and Use Cases" [MOOC], NPTEL: https://nptel.ac.in/courses/106/105/106105184/

2 https://lnk.ink/ErUUk

3 https://www.investopedia.com/terms/b/blockchain.asp

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Describe the basic concepts and technology used for blockchain.

CO2 Explain the concepts of Bitcoin and their usage.

CO3 Explain the primitives of the cryptocurrency related to blockchain.

CO4 Analyse the primitives of the healthcare related to blockchain

CO5 Summarize the primitives of the finance & banking related to blockchain

CO / PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	1	-	1	-	-	1	2
CO2	2	2	1	1	-	1	-	1	-	-	1	2
CO3	2	2	1	1	-	1	-	1	-	-	1	2
CO4	3	3	2	2	-	1	-	1	-	-	1	2
CO5	2	2	1	1	-	1	-	1	-	-	1	2

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U23MDMS05	MSME FINANCING	L	T	P	C
Prerequisites: Nil		2	0	2	3

COURSE OBJECTIVES:

- To understand the concepts and types of MSME financing in India.
- To examine the various sources of MSME Financing
- To be aware of various Initiatives of Governments in MSME financing.

UNIT I CONCEPT AND TYPES OF MSME FINANCING 6

MSMEs in India – Concept and Evolution – Role and Importance of MSMEs in Indian Economy – Key Challenges in MSME Financing: Access to Credit – Limited Financial Literacy – Documentation and Compliance – Lack of Credit History – Risk Perception – Informal Sector Challenges – Technological Barriers. Types of MSME Financing: Term Loans, Working Capital Loans, Invoice Financing, Equity Financing, Equipment Financing, Trade Credit, Business Credit Cards, and Overdraft Facilities.

UNITII SOURCES OF MSME FINANCING 6

Sources of MSME Financing: Commercial Banks, Small Finance Banks, Non-Banking Financial Companies – Microfinance Institutions, Venture Capital and Private Equity – Angel Investors - Crowdfunding – Peer-to-Peer Lending – Trade Credit – Factoring and Invoice Discounting – Development Financial Institutions - International Funding Agencies.

UNIT III GOVERNMENT INITIATIVES IN MSME FINANCING 6

Government Initiatives in MSME Financing: Credit Guarantee Fund Scheme for Micro and Small Enterprises (CGTMSE) – MUDRA Loans – Stand-up India Scheme – Technology Upgradation Fund (TUF) – MSME SAMBANDH – MSME SAMADHAAN – E-Commerce Export Hubs – SIDBI Branches in MSME Clusters – Financial Support for Food Irradiation and Quality Testing – New Assessment Model for MSME Credit.

UNIT IV DIGITAL MSME FINANCING SOLUTIONS 6

Digital Financing Solutions for MSMEs: UPI Integrated Platforms – Open Credit Enablement Network (OCEN) – FinTech Solutions (tailored for MSME Fund Requirements) – Government-backed Platforms (like MUDRA) – Peer-to-Peer Lending Platforms – Crowdfunding Platforms – State Bank of India's MSME-Sahaj – Digital Lending by Banks.

UNIT V PROS, CONS AND CAREER PATHS IN MSME FINANCING 6

Pros of MSME Financing: Access to Capital – Business Growth and Expansion – Improved Cash Flow – Flexibility – Credit History and Reputation. Cons of MSME Financing: High Interest Rates – Stringent Requirements – Repayment Obligations – Equity Dilution –

Complexity of Application Process – Short-term Focus. Career Paths in MSME Financing: Financial Analyst – Loan Officer – Credit Manager – Financial Advisor – Microfinance Specialist – Financial Controller.

30 PERIODS

PRACTICAL EXERCISES (any TWO to be completed, each in 15 periods).

1. Examine any two types of MSME Financing, after a field study, and submit a report.
2. Identify and evaluate any two types of sources of MSME financing and present your findings.
3. Make a presentation with details of eligibility and documentation on one of the Government Initiatives in MSME Financing.
4. Examine the financial solutions offered by FinTech Companies to MSMEs and prepare a report of your findings.
5. After studying various career paths available in MSME Financing, identify the one that suits your personal traits and submit a report of pros and cons of embracing that career by you.

30 PERIODS

TOTAL: 60 PERIODS

TEXT BOOKS:

1. Ministry of Micro, Small and Medium Enterprises, Government of India, "E-Book of Schemes for Micro, Small and Medium Enterprises (MSMEs)", 1st Edition, Ministry of MSME, 2022.
2. Sanjiv Layek, "Access to Credit for Indian MSMEs", 1st Edition, WASME, 2022.

REFERENCES:

1. Institute of Company Secretaries of India, "Handbook for MSME Entrepreneurs", 1st Edition, ICSI, 2023.
2. International Finance Corporation, "Micro, Small and Medium Enterprise Finance in India: A Research Study on Needs, Gaps and Way Forward", 1st Edition, International Finance Corporation, 2023.
3. Charan Singh and Kishinchand Poornima Wasdani, "Finance for Micro, Small, and Medium-Sized Enterprises in India: Sources and Challenges", 1st Edition, Asian Development Bank Institute, 2020.

ONLINE RESOURCES

1. https://documents1.worldbank.org/curated/en/759261548828982149/pdf/134150-WP-IN-Financing-India-s-MSMEs-Estimation-of-Debt-Requirement-of-MSMEs-PUBLIC.pdf
2. https://www.pwc.in/assets/pdfs/publications/2013/msme.pdf
3. https://msme.gov.in/sites/default/files/MSMESchemebooklet2024.pdf

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COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Understanding the types of MSME Financing.

CO2 Explain various sources of MSME Financing available in India.

CO3 Describe various Government Initiatives in MSME Financing.

CO4 Explain various Digital MSME Financing Solutions.

CO5 Summarize various options available in MSME Financing Career.

CO / PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	1	1	1	2	1	1	1
CO2	2	2	1	1	-	1	1	1	2	1	1	1
CO3	2	2	1	1	-	1	1	1	2	1	1	1
CO4	2	2	1	1	-	1	1	1	2	1	1	1
CO5	2	2	1	1	-	1	1	1	2	1	1	1

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U23MDMS06	SOCIAL ENTREPRENEURSHIP	L	T	P	C
Prerequisites: Nil		2	0	2	3

COURSE OBJECTIVES:

- To understand the concept and characteristics of social entrepreneurships
- To identify various forms of social entrepreneurships
- To study various social entrepreneurs of reputed operations in India

UNIT I INTRODUCTION 6

Social Entrepreneurship - Definition – Key Characteristics: Social Mission, Innovation, Sustainability, Scalability. Challenges: Funding, Balancing Mission and Profit, Scalability, and Measuring Impact. Examples of Social Entrepreneurship: Grameen Bank, TOMS Shoes, Teach For All.

UNITII FORMS OR TYPES OF SOCIAL ENTREPRENEURS 6

Forms or Types of Social Entrepreneurs: The Innovator – The Advocate – The Community Builder – The Social Engineer – The Environmentalist – The Policy Reformer – The Corporate Social Entrepreneur – The Social Business Leader – The Education Pioneer – The Health Innovator.

UNIT III FUNDING SOCIAL ENTREPRENEURSHIP 6

Social Entrepreneurship Funding Options: Grants, Impact Investing, Crowdfunding, Venture Philanthropy, Social Impact Bonds, Corporate Sponsorships, Microfinance, Donations and Fundraising, Government Programs, and Angel Investors and Venture Capital.

UNIT IV SOCIAL ENTREPRENEURSHIP MODELS 6

Non-Profit Model, Social Business Model, Hybrid Model, Cooperative Model, Fair Trade Model, Community Development Model, Employment Model, B Corp Model, Social Impact Investing Model, Environmental Sustainability Model.

UNIT V SOCIAL ENTREPRENEURSHIP IN INDIA 6

Notable Social Entrepreneurs in India: Jeroo Billimoria (Childline India Found8ation), Ria Sharma (Make Love Not Scars), Shaheen Mistri (Akanksha Foundation), Harish Hand8e (SELCO India), Anshu Gupta (Goonj), Ajaita Shah (Frontier Markets), Urvashi Sahni (Study Hall Education Foundation), and Hanumappa Sudarshan (Vivekananda Girijana Kalyana Kendra).

30 PERIODS

PRACTICAL EXERCISES (any TWO to be completed, each in 15 periods).

1 Develop a brief report on the works of a Social Entrepreneur in your vicinity

2 Identify a social issue in your vicinity, and develop a business plan to address the issue practically.

3 Design a social enterprise addressing a specific SDG (Sustainable Development Goal)

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4 Conduct a Needs Assessment for a Marginalised Community in your vicinity.

5 Develop a Social Media Campaign for a Social Enterprise.

30 PERIODS
TOTAL: 60 PERIODS

TEXT BOOKS:

1 Madhukar Shukla, "Social Entrepreneurship in India: Quarter Idealism and a Pound of Pragmatism", 1st Edition, SAGE Publications Pvt Ltd, 2020.

2 Meena Raghunathan, "Social Entrepreneurship in India", 1st Edition, Routledge India, 2024.

REFERENCES:

1 Duening, T. N. (2010). Five minds for the entrepreneurial future: Cognitive skills as the intellectual foundation for next generation entrepreneurship curricula. Journal of Entrepreneurship, 19(1), 1-22. doi:10.1177/097135570901900101

2 Kuratko, D. F. (2005). The emergence of entrepreneurship education: development, trends, and challenges. Entrepreneurship Theory and Practice, 29(5), 577-597.

3 Lindsay, N. J. (2005). Toward a cultural model of Indigenous entrepreneurial attitude. Academy of Marketing Science Review, 5, 1-17.

ONLINE RESOURCES

1 http://www.merriam-webster.com/dictionary/intrapreneur

2 http://www.caseatduke.org/documents/dees_sedef.pdf

3 http://www.caseatduke.org/documents/dees_sedef.pdf

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

CO1 Explain key characteristics of social entrepreneurship.

CO2 Describe various forms of Social Entrepreneurship and analyse them.

CO3 Explain various funding options for social enterprises.

CO4 Comprehend different models on social entrepreneurship.

CO5 Summarize notable social entrepreneurs and their works in India

CO / PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	1	1	1	2	1	1	1
CO2	2	2	1	1	-	1	1	1	2	1	1	1
CO3	2	2	1	1	-	1	1	1	2	1	1	1
CO4	2	2	1	1	-	1	1	1	2	1	1	1
CO5	2	2	1	1	-	1	1	1	2	1	1	1

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