Lokmanya Tilak Jankalyan Shikshan Santha's

Lokmanya Tilak College of Engineering

Sector 4, Vikas Nagar, Koparkhairane, Navi Mumbai 400709

An Autonomous Institute Affiliated to University of Mumbai

Honours/ Minor Degree (18 Credits)

CURRICULUM STRUCTURE

For

THIRD YEAR ENGINEERING

(BASED ON NEP 2020)

w.e.f. A.Y. 2026-27

Approved by Academic Council on 22/05/2026

Preface

In alignment with the vision of the National Education Policy (NEP) 2020, engineering education in India is undergoing a transformative shift toward greater flexibility, interdisciplinarity, and learner-centric design. A key feature of this transformation is the integration of the Honours and Minor program into the undergraduate engineering curriculum. This document outlines the framework and rationale behind the Honours/Minor structure, which aims to empower students to pursue academic excellence in their core engineering discipline while exploring emerging and complementary fields. The Honours track offers depth through advanced courses and practical-based learning in the student's major area, whereas the Minor provides breadth by enabling structured learning in a secondary area of interest. By encouraging cross-disciplinary engagement, the program is designed to cultivate well-rounded engineers who are not only technically sound but also adaptable, innovative, and responsive to the needs of a rapidly changing world. This curriculum model seeks to bridge the gap between academia and industry, while also fostering critical thinking, creativity, and lifelong learning. This preface introduces the detailed structure, credit requirements, and intended outcomes of the Honours/Minor offerings in the engineering curriculum, and serves as a guide for students, faculty, and academic administrators involved in its implementation and continual development.

The Government of Maharashtra has instructed autonomous colleges to update their curriculum and begin implementing the National Education Policy (NEP) 2020. We are fully committed to ensuring the effective and meaningful adoption of NEP 2020 in its true essence. At "Lokmanya Tilak College of Engineering", the holistic development of learners has always been our top priority and central focus. LTCE embraced the NEP philosophy as early as 2022 wherein we have introduced the concept of Honours and Minors programs on emerging fields as per the guidelines of University of Mumbai and in 2024, we proudly graduated our first batch under this holistic curriculum. The autonomous curriculum for 2024-28 is structured in line with the recommendations of NEP 2020, AICTE, and UGC. The Honours and Minor Degree programs offer students the flexibility to explore emerging fields like Blockchain Technology, Cyber Security, Artificial Intelligence, Data Science, 3D printing, Electric Vehicles, etc. and build specialized skills beyond their core curriculum. By integrating these options, LTCE aims to prepare well-rounded graduates ready to meet the evolving demands of industry and research.

Sd/-

Dr. Sheeba P. S.
Dean, Academics & Research

Sd/-

Dr. Subhash K. Shinde
Principal

Honours/ Minor Degree Program Mapping with Engineering Programs

In alignment with AICTE and MH Govt. guidelines, the Honours and Minor degree programs have been introduced by the institute to enable students to pursue additional specialized courses in emerging areas of their interest, thereby enhancing their competence in those domains. Honours or Minor Degree will cumulatively require additional **18 credits** in the specified area in addition to the credits essential for obtaining the Under Graduate Degree in Major Discipline.

Minor/ Honours' degree program in emerging technology to be chosen by eligible students studying in second year of various engineering programs are elaborated in following table to bring clarity to all stakeholders including students and faculty members. Each eligible student can opt for maximum one minor/ honour's program at a time.

Eligible Programs for Honours/ Minor:

Sr. No.	Name of Honours/ Minor Degree Programs	Eligible Programs for Honours	Eligible Programs for Minor
1	**Blockchain Technology**	Computer Engineering/ CSE (AI & ML)/ CSE (DS)/ Electronics & Telecommunication Engineering	Electrical Engineering/ Mechanical Engineering
2	**Artificial Intelligence & Data Science**	Computer Engineering/ CSE (IoT & CSBT) / Electronics & Telecommunication Engineering	Electrical Engineering/ Mechanical Engineering
3	**Cyber Security**	Computer Engineering/ CSE (AI & ML)/ CSE (DS)/ Electronics & Telecommunication Engineering	Electrical Engineering/ Mechanical Engineering
4	**3D Printing**	Mechanical Engineering	Computer Engineering/ CSE (AI & ML)/ CSE (DS)/ CSE (IoT & CSBT)/ Electronics & Telecommunication/ Electrical Engineering
5	**Electric Vehicles**	Electrical Engineering / Mechanical Engineering	Computer Engineering/ CSE (AI&ML)/ CSE (DS)/ CSE (IoT & CSBT)/ Electronics & Telecommunication

Eligibility Criteria for Students:

- Students with no backlog in Semester I, II, and III.
- The CGPI (based on semester I, II, and III) of the students must be 7.50 and above.

- For Direct Second Year (DSE) admitted students - No backlog in semester III and CGPI must be 6.75 and above.
- The Honours/ Minor degree program can be opted only during regular engineering studies.
- The student shall complete the Honours/ Minor degree program in stipulated four semesters only.

Honours/ Minor Courses* (18 Credits)

Semester	Course Code	Course Name	Teaching Scheme		Credit Assigned		Total Credits	Examination Scheme					
			L	P	L	P		Internal Assessment		End Semester Exam		Oral / Practical	Total
								Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)	Marks	Duration (Hrs)		
IV	XXMC401	Honour/ Minor Course 1	4		4		4	20	20	60	2	-	100
V	XXMC501	Honour/ Minor Course 2	4		4		4	20	20	60	2	-	100
VI	XXMC601	Honour/ Minor Course 3	3		3		3	20	20	60	2	-	100
VI	XXMCL601	Honour/ Minor Lab Course 3		2		1	1	-	25	-		25	50
VII	XXMC701	Honour/ Minor Course 4	4		4		4	20	20	60	2		100
VII	XXCP701	Capstone Project		4		2	2		50			50	100
	Total		**15**	**6**	**15**	**3**	**18**	**80**	**155**	**240**	**8**	**75**	**550**

* **Eligibility:** Students with no backlog in Semester I, II, and III and the CGPI must be 7.50 and above. For Direct Second Year (DSE) admitted students: No backlog in semester III and CGPI must be 6.75 and above.

Honours/ Minor Courses

Honours/Minor Degree		Blockchain Technology (BT)	Artificial Intelligence & Data Science (AD)	Cyber Security (CS)	3D Printing (DP)	Electric Vehicles (EV)
Semester	**Credits**	**Course Name**				
IV	**4**	**BTMC401:** Blockchain & Crypto Currencies	**ADMC401:** Mathematics for AI & Data Science	**CSMC401:** Network Security & Ethical Hacking	**DPMC401:** Introduction to CAD	**EVMC401:** Vehicular Systems and Dynamics
V	**4**	**BTMC501:** Smart Contracts & Use Cases	**ADMC501:** Data Science for Business Intelligence	**CSMC501:** Digital Forensic	**DPMC501:** 3D Printing: Introduction & Processes	**EVMC501:** Electric Vehicle System Design
VI	**3**	**BTMC601:** Blockchain Applications	**ADMC601:** Machine Learning	**CSMC601:** Information Security Management	**DPMC601:** Applications of 3D Printing	**EVMC601:** Automotive Controller and Auxiliary Systems
	1	**BTMCL601:** Blockchain Programming Lab	**ADMCL601:** Machine Learning Lab	**CSMCL601:** Vulnerability Assessment & Penetration Testing Lab	**DPMCL601:** Digital Fabrication Lab	**EVMCL601:** Electric Vehicle Lab
VII	**4**	**BTMC701:** NFT and Decentralised Finance	**ADMC701:** Deep learning and Gen AI	**CSMC701:** Application Security & Laws	**DPMC701:** 3D Printing in Medical Technology	**EVMC701:** EV Drive and Energy Sources
VII	**2**	**BTCP701:** Capstone Project	**ADCP701:** Capstone Project	**CSCP701:** Capstone Project	**DPCP701:** Capstone Project	**EVCP701:** Capstone Project

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Sector-04, Koparkhairane, Navi Mumbai - 400 709

Third Year Engineering Curriculum: Semester V

Honours/ Minor: Blockchain Technology

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	4 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					4
BTMC501	Smart Contracts & Use Cases	20	20	60	1	2	100	

Prerequisite: Blockchain & Cryptocurrency, Blockchain Platform, Blockchain Development	
Course Objectives: The course aims to	
1	To understand the fundamentals of smart contracts and blockchain-based automation.
2	To study Ethereum architecture, EVM, and programming with Solidity.
3	To explore token standards, decentralized applications (DApps), and real-world blockchain use cases.
4	To analyze challenges, risks, and opportunities in smart contract deployment.
Course Outcomes: Learners will be able to	
1	Explain the fundamentals and architecture of smart contracts.
2	Understand Ethereum architecture and the working of EVM.
3	To implement smart contracts in Ethereum using solidity.
4	Develop and deploy secure smart contracts using Solidity.
5	Evaluate smart contract applications across domains.
6	Apply blockchain solutions to real-world use cases.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Introduction to Smart Contracts** Overview of Blockchain and Distributed Ledger Technology, Concept and Definition of Smart Contracts, Traditional vs Smart Contracts, Advantages, Characteristics, and Limitations.	6	CO1

	Smart Contract Lifecycle – Creation, Deployment, Execution, Termination Platforms supporting Smart Contracts		
	Self-Learning Topic: Tools Overview – Remix IDE, Truffle, Hardhat		
02	**Smart Contract Architecture and Components**	10	**CO2**
	Structure of a smart contract (state variables, functions, modifiers, events) Compilation and deployment process, Ethereum Virtual Machine (EVM) overview, Gas, transaction fees, and optimization concepts Security concerns: re-entrancy, overflow, and access control Execution Model and State Transition, Contract Deployment and Interaction, MetaMask and Wallet Interfacing, Types of test-networks used in Ethereum, Transferring Ethers Using MetaMask, Ethereum 2 , Concept of Beacon chain		
	Self-Learning Topic: Case study of Decentralized Crowdfunding Platform on Ethereum		
03	**Solidity Programming Basics**	10	**CO3**
	Introduction to Solidity language syntax and data types, Variables, arrays, functions, Conditional Statements and Loops, Events and Modifiers, Error Handling and Require/Assert, Writing, compiling, and deploying contracts using Remix IDE. Smart Contract programming using solidity, mapper function, Control structures, inheritance, and libraries and Interfaces, Structs, Mappings Events and logging, Gas Optimization and Efficiency, Interacting with smart contracts through Web3.js or ethers.js Contract Structure and Compilation, Testing and Debugging with Remix.		
	Self-Learning Topic: Cryptocurrencies and their security issues, Consensus mechanisms, Digital Signatures		
04	**Advanced Smart Contract Development**	8	**CO4**
	ERC20 and ERC721 Tokens, comparison between ERC20 & ERC721, ICO, STOMetamask (Ethereum Wallet), setting up development environment, use cases of smart contract, smart Contracts: Opportunities, Risks. Smart Contract Security – Re-entrancy, Overflow, Dos, Time and Randomness Handling, Contract Upgradability Patterns.		
05	**Tokens and Decentralized Applications**	10	**CO5**
	Tokenization and Digital Assets, Definition and concept of tokens, Difference between **coins** and **tokens,** Use cases of tokens, Overview of tokenization — digital representation of assets on		

	blockchain. **T**oken Types and Classifications: Fungible vs. Non-Fungible Tokens (NFTs), Token Economy and ICOs, Introduction to Decentralized Applications (DApps): Definition and architecture of DApps, Differences between centralized apps and DApps , Layers of a DApp, Benefits and Limitations of DApps. DApp Platforms, Integration with Web3.js, DeFi Protocols and DAOs, Dapps Scalability, testing.		
	Self-Learning Topic: Simple Voting or Token Transfer DApp		
06	**Smart Contract Use Cases and Future Trends**	8	**CO6**
	Real-world Applications: Supply Chain, Real Estate, Healthcare. Identity Management and Decentralized Identity (DID). Gaming, NFTs, and Metaverse Use Cases, Challenges – Scalability, Interoperability, and Legal Aspects. Smart Contract Auditing and Compliance, Future Trends in Smart Contracts		
	Self-Learning Topic: Compare different blockchain platforms		
	Total	**52**	

Textbooks:

1. Mastering Ethereum, Building Smart Contract and Dapps, Andreas M. Antonopoulos Dr. Gavin Wood, O'reilly.
2. Blockchain Technology, Chandramouli Subramanian, Asha A George, Abhillash K. A and Meena Karthikeyen, Universities press

References:

1. Blockchain enabled Applications, Vikram Dhillon, Devid Metcalf, Max Hooper, A press
2. Building Blockchain Projects, Narayan Prusty, Packt
3. Mastering Bitcoin, PROGRAMMING THE OPEN BLOCKCHAIN, 2nd Edition by Andreas M. Antonopoulos, June 2017, Publisher(s): O'Reilly Media, Inc. ISBN: 9781491954386.
4. Blockchain Applications: A Hands-On Approach, by Arshdeep Bahga, Vijay Madisetti, Paperback – 31 January 2017.
5. Mastering Blockchain, Imran Bashir, Packt Publication.

Online References:

Sr. No.	Website Name
1	https://ethereum.org/en/
2	https://www.blockchain.com/
3	https://docs.soliditylang.org/en/v0.7.4/
4	https://hyperledger-fabric.readthedocs.io/en/release-2.2/whatis.html
5	https://onlinecourses.nptel.ac.in/noc19_cs47/preview

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

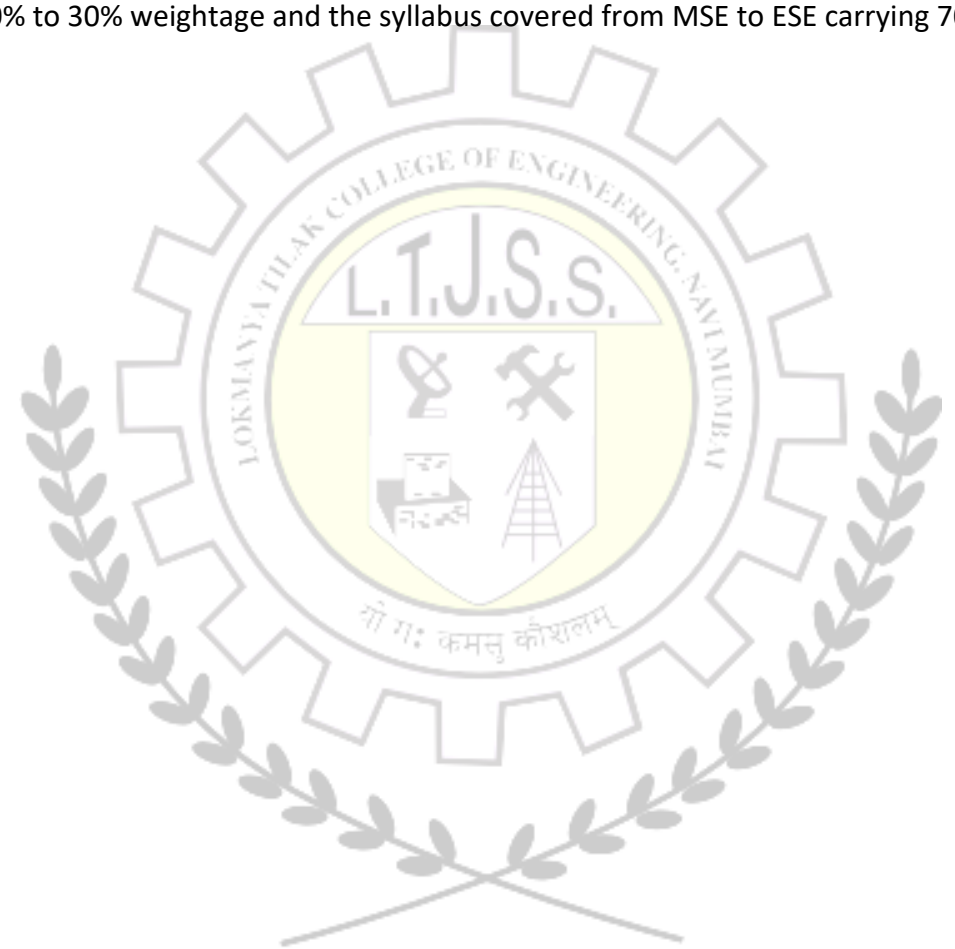
Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.



Honours/ Minor: Artificial Intelligence & Data Science

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	4 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					4
ADMC501	Data Science for Business Intelligence	20	20	60	1	2	100	

Prerequisite: Mathematics for Data Science, Database management system	
Course Objectives: The course aims to	
1	Introduce the fundamental concepts and components of Data Science and Business Intelligence.
2	Explain data warehousing, data mining, and visualization techniques for analytical decision-making.
3	Develop skills for exploratory data analysis and statistical reasoning for business datasets.
4	Apply machine learning models to real-world business problems.
5	Explore modern BI applications, tools, and ethical aspects in data-driven enterprises
Course Outcomes: Learners will be able to	
1	Understand the role and process of Data Science and its applications in business intelligence.
2	Design and implement data warehousing and data mining techniques for structured analysis.
3	Apply principles of effective data visualization to represent business data using appropriate tools.
4	Perform Exploratory Data Analysis (EDA) and statistical analysis to identify patterns, outliers, and key insights from business datasets.
5	Implement predictive analytics models such as classification and clustering, and evaluate their performance for business decision-making.
6	Analyze business applications and emerging trends in BI and Data Science, emphasizing ethical, AI-driven, and cloud-based analytical practices.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Introduction to Data Science** What is Data Science? Why Data Science? Components of Data Science Difference between Business Intelligence and Data Science	6	CO1

	Role of Machine Learning in Data Science Applications of Data Science		
02	**Fundamentals of Data Warehousing and Data Mining** Introduction to Data Warehouse and Data Mining Differences between Operational Database Systems and Data Warehouses Data Warehouse: Characteristics and Architecture Fact and Dimension Tables. OLAP Cube and OLAP Operations (Roll-up, Drill-down, Slice, Dice) Introduction to Data Mining, knowledge discovery process. Data Preprocessing.	10	**CO2**
03	**Data Visualization** Data Exploration: types of attributes, Introduction to Data Visualization Importance and Need for Data Visualization Principles of Effective Visualization (Simplicity, Accuracy, Clarity) Types of Visualizations: Charts, Graphs, Heatmaps, Histograms, Tree Maps Data Visualization Tools and Platforms (Power BI, Tableau, Python Libraries) Interactive Dashboards and Storytelling with Data	12	**CO3**
04	**Exploratory Data Analysis (EDA) and Statistical Analysis** Role of EDA in Data Science and BI Descriptive Statistics and Data Summarization Data Distribution, Outliers, Correlation, and Covariance Case Study: Customer Segmentation using EDA	6	**CO4**
05	**Data mining Models for Business** Classification Techniques: Naive Bayes, K nearest neighbour (KNN) Clustering Techniques: Distance measures, K-Means and Hierarchical Clustering Model Evaluation: Confusion Matrix, Accuracy, Precision, Recall, F1 Score Association rule mining: Apriori Business Use Cases: Demand Forecasting, Churn Prediction, and Risk Analysis	12	**CO5**
06	**Business Applications and Trends in Data Science** Applications of BI and Data Science in: Retail and Marketing Analytics, Banking and Financial Analytics, Healthcare and Supply Chain Analytics Role of AI in Modern Business Intelligence (Augmented Analytics) Cloud and Big Data Platforms for BI (AWS, Azure, Google Cloud) Ethical and Privacy Considerations in Data Analytics	10	**CO6**

Text Books:

1. Data Mining: Concepts and Techniques By Jiawei Han, Micheline Kamber, and Jian Pei, Morgan Kaufmann Publisher.
2. Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking By Foster Provost and Tom Fawcett, O'Reilly Media
3. Data Warehousing Fundamentals for IT Professionals By Paulraj Ponniah, Wiley India
4. Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking By Foster Provost and Tom Fawcett, O'Reilly Media

References:

1. Business Intelligence Guidebook: From Data Integration to Analytics By Rick Sherman, Morgan Kaufmann
2. Storytelling with Data: A Data Visualization Guide for Business Professionals By Cole Nussbaumer Knaflic, Wiley
3. Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Matplotlib By Wes McKinney, O'Reilly Media
4. https://onlinecourses.nptel.ac.in/noc24_cs65/preview

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Honours/ Minor: Cyber Security

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	4 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					4
CSMC501	Digital Forensic	20	20	60	1	2	100	

Prerequisites: Computer Hardware: Motherboard, CPU, Memory: RAM, Hard Disk Drive (HDD), Solid State Drive (SSD), Optical drive Computer Networks: Introduction CN Terminology: Router, Gateway, OSI and TCP/IP Layers Operating Systems: Role of OS in file management, Memory management utilities, Fundamentals of file systems used in Windows and Linux.	
Course Objectives: The course aims to	
1	Describe the various computer and cyber-crimes in the digital world.
2	Determine the significance of digital forensics life cycle, underlying forensics principles and investigation process.
3	Understand the importance of File system management with respect to computer forensics.
4	Able to identify the live data in case of any incident handling and application of appropriate tools and practices for the same.
Course Outcomes: Learners will be able to	
1	Identify and define the class for various computer and cyber-crimes in the digital world.
2	Determine the need of digital forensics and the role of digital evidence.
3	Define and analyze the role of File systems in computer forensics.
4	Demonstrate the incident response methodology with best practices for incidence response with forensic tools.
5	Generate/Write reports on the application of appropriate computer forensic tools for investigation.
6	Identify and investigate threats in network and mobile.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Introduction to Cybercrime and Computer-crime** Definition and classification of cybercrimes: Definition, Hacking, DoS Attacks, Trojan Attacks, Credit Card Frauds, Cyber Terrorism, Cyber Stalking.	6	**CO1**

	Definition and classification of computer crimes: Computer Viruses, Computer Worms. Prevention of Cybercrime: Steps that can be followed to prevent cybercrime, Hackers, Crackers, Phreakers.		
	Self-learning Topics: Steps performed by Hacker.		
02	**Introduction to Digital Forensics and Digital Evidences**	7	**CO2**
	Introduction to Digital Forensics: Introduction to Digital Forensics and lifecycle, Principles of Digital Forensic. Introduction to Digital Evidences: Challenging Aspects of Digital Evidence, Scientific Evidence, Presenting Digital Evidence. Digital Investigation Process Models: Physical Model, Staircase Model, Evidence Flow Model.		
	Self-Learning Topic: Digital Investigation Process Models comparison and its application, Rules of Digital Evidence.		
03	**Computer Forensics**	7	**CO3**
	OS File Systems Review: Windows Systems- FAT32 and NTFS, UNIX File Systems, MAC File Systems. Windows OS Artifacts: Registry, Event Logs. Memory Forensics : RAM Forensic Analysis, Creating a RAM Memory Image, Volatility framework, Extracting Information. Computer Forensic Tools: Need of Computer Forensic Tools, Types of Computer Forensic Tools, Tasks performed by Computer Forensic Tools.		
	Self-Learning Topic: Study of 'The Sleuth Kit' Autopsy tool for Digital Forensics.		
04	**Incident Response Management, Live Data Collection and Forensic Duplication**	12	**CO4**
	Incidence Response Methodology: Goals of Incident Response, Finding and Hiring IR Talent. IR Process: Initial Response, Investigation, Remediation, Tracking of Significant Investigative Information. Live Data Collection: Live Data Collection on Microsoft Windows. Forensic Duplication: Forensic Duplicates as Admissible Evidence, Forensic Duplication Tools: Creating a Forensic evidence, Duplicate/Qualified Forensic Duplicate of a Hard Drive.		
	Self-learning Topics: Live Data Collection on Unix-Based Systems.		

05	**Forensic Tools and Report Writing** Forensic Image Acquisition in Linux: Acquire an Image with dd Tools, Acquire an Image with Forensic Formats, Preserve Digital Evidence with Cryptography, Image Acquisition over a Network, Acquire Removable Media Forensic Investigation Report Writing: Reporting Standards, Report Style and Formatting, Report Content and Organization. **Self-Learning Topic:** Case study on Report Writing	10	**CO5**
06	**Network Forensics and Mobile Forensics** Network Forensics: Sources of Network Based Evidence, Principles of Internetworking, Internet Protocol Suite, Evidence Acquisition, Analyzing Network Traffic: Packet Flow and Statistical Flow, Network Intrusion Detection and Analysis, Investigation of Routers, Investigation of Firewalls. Mobile Forensics: Mobile Phone Challenges, Mobile phone evidence extraction process, Android OS Architecture, Android File Systems basics, Types of Investigation, Procedure for Handling an Android Device, Imaging Android USB Mass Storage Devices. **Self-Learning Topic**: Elcomsoft iOS Forensic Toolkit, Remo Recover tool for Android Data recovery	14	**CO6**
	Total	**56**	

Text Books:

1. Forensics by Dr. Dhananjay R. Kalbande Dr. Nilakshi Jain, Wiley Publications, First Edition, 2019.
2. Digital Evidence and Computer Crime by Eoghan Casey, Elsevier Academic Press, Third Edition, 2011.
3. Incident Response & Computer Forensics by Jason T. Luttgens, Matthew Pepe and Kevin Mandia, McGraw-Hill Education, Third Edition (2014).
4. Network Forensics: Tracking Hackers through Cyberspace by Sherri Davidoff and Jonathan Ham, Pearson Edu, 2012.
5. Practical Mobile Forensic by Satish Bommisetty, Rohit Tamma, Heather Mahalik, PACKT publication, Open source publication, 2014 ISBN 978-1-78328-831-1 .
6. The Art of Memory Forensics: Detecting Malware and Threats in Windows, Linux, and Mac Memory by Michael Hale Ligh (Author), Andrew Case (Author), Jamie Levy (Author), AAron Walters (Author), Publisher: Wiley; 1st edition (3 October 2014).

References:

1. Scene of the Cybercrime: Computer Forensics by Debra Littlejohn Shinder, Syngress Publication, First Edition, 2002.
2. Digital Forensics with Open Source Tools by Cory Altheide and Harlan Carvey, Syngress

Publication, First Edition, 2011.
3. Practical Forensic Imaging Securing Digital Evidence with Linux Tools by Bruce Nikkel,NoStarch Press, San Francisco, (2016).
4. Android Forensics: Investigation, Analysis, and Mobile Security for Google Android by Andrew Hogg, Elsevier Publication,2011.

Online References:

1. https://www.pearsonitcertification.com/articles/article.aspx?p=462199&seqNum=2
2. https://flylib.com/books/en/3.394.1.51/1/
3. https://www.sleuthkit.org/autopsy/
4. http://md5deep.sourceforge.net/md5deep.html
5. https://tools.kali.org/
6. https://kalilinuxtutorials.com/
7. https://accessdata.com/product-download/ftk-imager-version-4-3-0
8. https://www.amazon.in/Art-Memory-Forensics-Detecting-Malware/dp/1118825098

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Honours/ Minor: 3D Printing

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	4 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					4
DPMC501	3D Printing: Introduction & Processes	20	20	60	1	2	100	

Course Objectives: The course aims to	
1	To familiarise with the importance of Rapid Prototyping.
2	To study programming aspects of subtractive manufacturing process.
3	To familiarize with the basic process of additive manufacturing in particular 3D printing.
Course Outcomes: Learners will be able to	
1	Illustrate understanding of various cost-effective alternatives for manufacturing products and select the feasible RP process for specific technical applications
2	Build and create data for 3D printing of any given object using liquid based rapid prototyping and tooling processes
3	Build and create data for 3D printing of any given object using solid based rapid prototyping and tooling processes
4	Build and create data for 3D printing of any given object using powder based rapid prototyping and tooling processes
5	Select an appropriate material and tools to develop a given product using rapid prototyping machine
6	Select proper rapid prototyping and reverse engineering techniques for specific technical applications.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Additive Manufacturing:**	8	C01
	Introduction to AM, Classification of AM Processes, Advantages & disadvantages, AM Applications; in Design, Concept Models, Form & fit checking, Functional testing, CAD data verification, Rapid Tooling, and bio fabrication.		
	Self-Learning: Historical evolution of 3D printing technologies.		
02	**Liquid based systems:**		

	Stereo lithography apparatus (SLA): Models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages, case studies. **Solid ground curing (SGC):** Models and specifications, process, working, principle, applications, advantages and disadvantages, case studies.	10	**CO2**
03	**Solid based systems:** **Laminated object manufacturing (LOM):** Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies. **Fused Deposition Modeling (FDM):** Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies.	10	**CO3**
04	**Powder Based Systems:** **Selective laser sintering (SLS):** Models and specifications, process, working principle, applications, advantages and disadvantages, case studies. **Three-dimensional printing (3DP):** Models and specification, process, working principle, applications, advantages and disadvantages, case studies. **Electron Beam Melting (EBM):** Models and specification, process, working principle, applications, advantages and disadvantages, case studies.	12	**CO4**
05	**Materials for Additive manufacturing:** Types of material: polymers, metals, ceramics and composites, liquid-based materials, photo polymer development, solid based materials, powder-based materials. **Material properties** Colour, dimensional accuracy, stability, surface finish, machinability, environmental resistance, operational properties.	8	**CO5**
06	**Reverse Engineering:**		

	Introduction to Digitizing Methods, Contact type and Non-contact type, Brief introduction to the types of medical imaging. **Virtual reality**: Definition, features of VR, Technologies used in VR, Introduction to Augmented reality	8	**CO6**

Text Books:

1. Rapid Prototyping, Principles and Applications by Rafiq I. Noorani, Wiley & Sons
2. Rapid Prototyping: Principles and Applications by Chua C.K, Leong K.F and Lim C.S, 2nd Edition, World Scientific
3. Rapid Manufacturing – An Industrial revolution for the digital age by N.Hopkinson, R.J. M. Huge, P M, Dickens, Wiley
4. Advanced Manufacturing Technology for Medical applications: Reverse Engineering, Software conversion and Rapid Prototyping by Ian Gibson, Wiley
5. Rapid Prototyping and Manufacturing: Fundamentals of Stereolithography by Paul F. Jacobs, McGraw Hill
6. Rapid Manufacturing by Pham D T and Dimov S S, Springer Verlog
7. "Rapid Prototyping" Chee Kai Chua, World Scientific Publishing

References:

1. Rapid Manufacturing, By Prof. J. Ramkumar, Prof. Amandeep Singh, IITKanpur, https://onlinecourses.nptel.ac.in/noc20_me50/preview
2. Fundamentals of Additive Manufacturing Technologies, By Prof. Sajan Kapil, IIT Guwahati, https://onlinecourses.nptel.ac.in/noc21_me115/preview

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Honours/ Minor: Electric Vehicles

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	4 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					4
EVMC501	**Electric Vehicle System Design**	20	20	60	1	2	100	

Prerequisite: Sustainability and environment, Electrical Machine.	
Course Objectives: The course aims to	
1	Illustrate the design philosophies used in the EV domain.
2	Explore the selection of power and control architecture of EV drives
3	Study the design aspects of EV battery packs and other auxiliary systems
Course Outcomes: Learners will be able to	
1	Select and size the electric motor for a particular EV application and performance criteria
2	Select and size the battery pack to meet desired EV performance and
3	Design the EV drive system with functional safety considerations.
4	Illustrate the use of hybrid energy source for EV performance improvement
5	Illustrate the design aspects of Automotive Subsystem
6	Design the EV chargers and charging infrastructure

Module	Contents	Hours	CO Mapping
1.	**Selection/ Sizing of EV Electric Motors:** Electric Vehicle modelling, Tractive force calculations, Design considerations for 2W, 3W and 4W EVs; Torque, power and Speed requirement, Traction Limit, Maximum Acceleration Limit, Maximum Grade Limit, Vehicle Power Demand Vehicle Performance Envelope, and Vehicle Power Envelope; Vehicle Power Demand during Driving Cycles. Design considerations for EV motors and their cooling system. Application Examples of EV/HEV motors with vehicles and motor specifications.	08	**CO1**
2.	**Selection/ Sizing of Battery pack and other Energy Resource:** Selection of type of Battery pack for 2W, 3W and 4W EVs; Battery pack sizing: Design considerations: Range per charge, range anxiety, EV motor power requirement; Impact of road conditions, environmental conditions and traffic conditions. High-Voltage Cabling and Disconnects, Safety in Battery Design, Testing for safety. Accelerated Reliability Testing of Electric Vehicles, Battery Cycle Life versus Peak Power and Rest Period. Selection and sizing of Fuel cell for FCEV, design considerations; Battery-ultra-capacitor hybrid combination sizing, performance analysis. Design considerations for Ultra-capacitor based EV, requirement of charging infra. Flywheel selection and sizing for EV/HEV applications.	12	**CO2**

3.	**Automotive Subsystem Design:** Electronic Control Unit (ECU) and its Control Features, Communications between ECUs, Control Software Development: Software-in-the-Loop (SIL) Simulation and Hardware-in-the- Loop (HIL) Simulation. Acceleration and braking control, regenerative braking; Automotive Steering Systems.	8	**CO3**
4.	**EV System integration:** EMC design on ECU level, EMC design on system level and in special subsystems, Radiated emissions and Conducted emissions, EMI EMC measurements.	6	**CO4**
5.	**Design of Charging Infrastructure:** Design considerations for AC charger: vehicle interface and charging protocol design. applicable charging standards Design of On-Board Charger (OBC)-Schematic, power topology and control, Power capacities, regenerative braking control. Design considerations of DC fast charger: vehicle interface and charging protocol design. Connectivity and applicable charging standards. Installation guidelines and grid requirement for charger installations.	12	**CO5**
6.	**Design with Functional Safety of Automotive Electronics:** Functional Safety requirements of Automotive Electronics; ASIL identification and safety goal finalization, ISO 26262. Energy Storage integrity / protection: rupture and toxic gas management; low energy stranding, Unintended vehicle movement, shock protection, and Elimination of potential thermal/ explosive event. Hazard and Risk Analysis (HARA) for different situations, Testing of vehicles for compliance of safety norms. Acceleration and braking control, regenerative braking; Automotive Steering Systems. Design considerations of HVAC controller	10	**CO6**

Text/Reference Books:-

1. Design and Control of Automotive Propulsion Systems by Zongxuan Sun and Guoming Zhu, CRC Press, 2015
2. Electric Vehicle Machines And Drives Design, Analysis and Application by K. T. Chau, IEEE Press, and Wiley, 2015
3. EMC and Functional Safety of Automotive Electronics by Kai Borgeest, IET, 2018

Website Reference / Video Courses:

1. NPTEL Web Course: Electric Vehicles - Part 1 by PROF. AMIT KUMAR JAIN Department of Electrical Engineering IIT Delhi; https://nptel.ac.in/courses/108/102/108102121/
2. NPTEL Web Course: Fundamentals of Electric vehicles: Technology & Economics, by Prof. Ashok Jhunjhunwala, Prof. Prabhjot Kaur, Prof. Kaushal Kumar Jha and Prof. L Kannan, IIT Madras, https://nptel.ac.in/courses/108/106/108106170/
3. NPTEL Web Course: Introduction to Hybrid and Electric Vehicles by Dr. Praveen Kumar and Prof. S. Majhi, IIT Guwahati, https://nptel.ac.in/courses/108/103/108103009/

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Third Year Engineering Curriculum: Semester VI

Honours/ Minor: Blockchain Technology

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
BTMC601	**Blockchain Applications**	20	20	60	1	2	100	

Prerequisite: Basic understanding of Blockchain fundamentals, Smart Contracts, and Distributed Ledger Technology (DLT).	
Course Objectives: The course aims to	
1	To explore the applications of blockchain technology across various sectors.
2	To understand blockchain integration with existing systems and processes.
3	To analyze real-world use cases and their implementation challenges.
4	To develop insights into blockchain trends such as DeFi, NFTs, DAOs, and CBDCs.
5	To encourage students to identify innovative blockchain-based solutions for industry problems.
Course Outcomes: Learners will be able to	
1	Explain blockchain architecture and its role in different sectors.
2	Analyze the design and deployment of blockchain applications.
3	Evaluate various blockchain platforms and their interoperability.
4	Develop use case models using blockchain tools.
5	Assess challenges, scalability issues, and future trends in blockchain adoption.
6	To use Blockchain on Mobile App and on Cloud.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Introduction to Blockchain Applications**	4	**CO1**
	Evolution from Cryptocurrency to Blockchain Applications, Blockchain Architecture Review, Public, Private, and Consortium Blockchains, Permissioned vs Permissionless Systems, Blockchain Layers and Interoperability, Challenges in Adoption and Scalability		
	Self-Learning Topic: Layer-2 Solutions (Polygon, Optimism, Arbi		

	Trum)		
02	**Finance and Banking Applications** Blockchain in Financial Services, Decentralized Finance (DeFi) and Lending Platforms, Stablecoins and CBDCs (Central Bank Digital Currencies), Cross-border Payments and Remittances, Asset Tokenization and Smart Securities, Blockchain in Insurance **Self-Learning Topic:** Zero-Knowledge Proofs and Privacy Coins	8	**CO2**
03	**Supply Chain and Logistics** Transparency and Traceability with Blockchain, Provenance Tracking and Anti-counterfeiting, Cold Chain Monitoring using IoT and Blockchain, Smart Contracts for Supplier Management, Blockchain Platforms: IBM Food Trust, VeChain, Integration with ERP Systems **Self-Learning Topic:** Blockchain Interoperability Protocols (Polkadot, Cosmos)	8	**CO3**
04	**Government, Identity, and Public Sector Applications** Blockchain for Digital Identity and Authentication, Land and Property Registration Systems, Voting Systems using Blockchain E-Governance and Data Integrity, Blockchain for Record Management and Certification. Case Studies: Estonia, India, and Dubai Blockchain Initiatives	7	**CO4**
05	**Healthcare, Education, and IoT Applications** Blockchain in Healthcare Data Management, Patient Records and Consent Management, Blockchain for Academic Credential Verification, Blockchain and IoT Integration and their role in Smart Cities and Energy Management. Use Cases: Medical Chain, BurstIQ, EduBlock **Self-Learning Topic:** Web3.0 Tools for Decentralized Development	7	**CO5**
06	**Emerging Trends and Future of Blockchain** Web3 and Decentralized Applications, NFTs and Metaverse, DAOs and Governance Mechanisms, and Cross-chain Solutions Blockchain Security, Auditing, and Compliance Future Directions: AI, Quantum, and Green Blockchain **Self-Learning Topic:** Blockchain in Environmental Sustainability and Carbon Credits	8	**CO6**
	Total	**42**	

Textbooks:

1. Mastering Ethereum: Building Smart Contracts and Dapps, Andreas Antonopoulos,

Gavin Wood, O'Reilly Publication
2. Mastering Blockchain, Second Edition: Distributed ledger technology, decentralization, and smart contracts explained,2nd Edition, Imran Bashir
3. Solidity Programming Essentials: A beginner's Guide to Build Smart Contracts for Ethereum and Blockchain, RiteshModi,Packt publication
4. Mastering Blockchain, Imran Bashir, Second Edition, Packt Publication.
5. Blockchain Technology, Chandramouli Subramanian, Asha A. George, Abhillash K. A and Meena Karthikeyen, Universities Press.

References:

1. Blockchain disruption and decentralized finance: The rise of decentralized business models-Yan Chen, Cristiano Bellavitis
2. SoK: Decentralized Finance (DeFi)-Sam M. Werner, Daniel Perez, Lewis Gudgeon,Ariah Klages-Mundt,Dominik Harz∗‡, William J. Knottenbelt,Imperial College London, † Cornell University, Interlay
3. Decentralized Finance (DeFi) –A new Fintech Revolution?
4. https://makerdao.com/da/whitepaper/
5. https://uniswap.org/
6. https://compound.finance/documents/Compound.Whitepaper.pdf
7. https://wbtc.network/assets/wrapped-tokens-whitepaper.pdf

Online References:

Sr. No.	Website Name
1	https://ethereum.org/en/
2	https://www.udemy.com/
3	https://geth.ethereum.org/docs/dapp/
4	https://www.coursera.org/
5	https://onlinecourses.nptel.ac.in/noc19_cs47/preview
6	https://metamask.io

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
BTMCL601	Blockchain Programming Lab	-	25	25	-	-	50	

Prerequisite: Basic understanding of computer networks, data structures, and programming concepts. Familiarity with Python or JavaScript is desirable. Basic knowledge of blockchain technology is preferred.	
Course Objectives: The course aims to	
1	Understand blockchain architecture and working principles.
2	Set up and use blockchain development tools like Ganache, MetaMask, and Remix IDE
3	Develop and deploy smart contracts and DApps using Solidity.
4	Apply blockchain solutions to real-world domains such as healthcare and education.
5	Analyze, secure, and simulate decentralized systems using smart contract auditing and DAO mechanisms.
Course Outcomes: Learners will be able to	
1	Understand the architecture, components, and working principles of blockchain technology.
2	Install, configure, and use Ethereum tools such as Ganache, MetaMask, and Remix IDE for blockchain development.
3	Develop, deploy, and test smart contracts using Solidity on a local or test blockchain network.
4	Design and simulate decentralized applications (DApps) integrated with MetaMask for user interaction.
5	Apply blockchain for real-world use cases such as healthcare data management and academic certificate verification.
6	Analyze and secure smart contracts using Remix Static Analysis and simulate DAO voting for decentralized governance.

Suggested Experiments: Blockchain Programming Lab		
Sr. No.	**Suggested Experiments**	**CO Mapping**
1.	Study of Blockchain architecture and working principles.	**CO1**
2.	Installation and configuration of Ethereum tools (Ganache, MetaMask, Remix IDE).	**CO2**
3.	Develop and deploy a simple Smart Contract using Solidity.	**CO3**
4.	Build a simple Decentralized Application (DApp) integrated with MetaMask.	**CO4**
5.	Blockchain in Healthcare Data Management & Patient Records	**CO5**
6.	To implement a smart contract that issues and verifies academic certificates on the blockchain.	**CO5**
7.	Study of IPFS and storing/retrieving data using the IPFS network.	**CO5**
8.	Analyze Smart Contract Vulnerabilities using Remix Static Analysis Tool	**CO6**
9.	Simulation of a DAO (Decentralized Autonomous Organization) Voting Smart Contract	**CO6**
10.	**Mini Project:** Develop an end-to-end blockchain-based use case (e.g., supply chain, voting, or healthcare system).	**CO1- CO6**

Text Books:

1. Mastering Ethereum: Building Smart Contracts and Dapps, Andreas Antonopoulos, Gavin Wood, O'Reilly Publication
2. Mastering Blockchain, Second Edition: Distributed ledger technology, decentralization, and smart contracts explained,2nd Edition, Imran Bashir
3. Solidity Programming Essentials: A beginner's Guide to Build Smart Contracts for Ethereum and Blockchain, RiteshModi, Packt publication
4. Mastering Blockchain, Imran Bashir, Second Edition, Packt Publication.

References Books:

1. Mastering Bitcoin, PROGRAMMING THE OPEN BLOCKCHAIN, 2nd Edition by Andreas M. Antonopoulos, June 2017,Publisher(s): O'Reilly Media, Inc. ISBN: 9781491954386.
2. Blockchain Applications: A Hands-On Approach, by ArshdeepBahga, Vijay Madisetti, Paperback – 31 January 2017.Mastering Blockchain, Imran Bashir, Packt Publication.

Online References:

Sr. No.	Website Name
1	https://geth.ethereum.org/downloads/
2	https://medium.com/@agrawalmanas09/how-to-setup-private-ethereum-blockchain-on-windows-10-machine-ab497e03d6b8
3	https://docs.aws.amazon.com/blockchain-templates/latest/developerguide/blockchain-templatescreate-stack.html
4	https://www.edureka.co/blog/ethereum-private-network-tutorial
5	https://docs.soliditylang.org/en/develop/index.html
7	https://medium.com/publicaio/a-complete-guide-to-using-metamask-updated-version-cd0d6f8c338f

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Oral & Practical Exam (25 Marks)

An Oral & Practical exam will be held based on entire syllabus.

Honours/ Minor: Artificial Intelligence & Data Science

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
ADMC601	Machine Learning	20	20	60	1	2	100	

Prerequisite:	
Course Objectives: The course aims to	
1	To introduce the fundamental concepts, types, and development process of Machine Learning along with the required mathematical and statistical foundations.
2	To enable students to apply supervised and unsupervised learning algorithms for solving real-world data analysis and pattern recognition problems.
3	To develop the ability to design, train, and optimize advanced learning models including ensemble techniques and neural networks for accurate and efficient predictions.
Course Outcomes: Learners will be able to	
1	Explain the fundamental concepts, applications, and development steps of Machine Learning models
2	Apply mathematical and statistical foundations such as linear algebra and probability to design and analyze ML algorithms.
3	Implement supervised learning techniques for regression and classification problems and evaluate their performance.
4	Analyze and apply unsupervised learning methods including clustering, Gaussian Mixture Models, and outlier detection techniques.
5	Utilize ensemble learning approaches such as bagging, boosting, and stacking to improve model accuracy and robustness
6	Design and train simple neural networks using perceptron and multilayer perceptron architectures with backpropagation learning.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Introduction to Machine Learning** Introduction to Machine Learning,Application of Machine Learning, Steps of developing a Machine Learning Application. Machine Learning types: Supervised and Unsupervised Learning,Training, Testing and validation dataset, cross validation, overfitting and underfitting of model	5	**CO1**
02	**Mathematical Foundation for ML** Linear Algebra: Vectors, Matrices, Norms, Subspaces,	6	**CO2**

	Projections, SVD,Descriptive Statistics Basic Probability Concepts:Events, sample spaces, oint Probability Distribution,conditional probability, Bayes' theorem, Discrete and Continuous Random Variables		
03	**Supervised Learning:Regression** Classification: Decision tree Regression: Simple linear regression, Multiple linear regression, Multivariate linear regression, Logistic regression, Support Vector Machines Error calculation and performance measures	7	**CO3**
04	**Unsupervised Learning** Gaussian Mixture Models, Expectation -Maximization algorithm, DBSCAN What are outliers? Types, Challenges; Outlier Detection Methods: Supervised, Semi Supervised, Unsupervised, Proximity based, Clustering Based	7	**CO4**
05	**Ensemble learning** Introduction to Ensemble Methods. Bagging and random forests, Boosting algorithms : AdaBoost Stacking and blending models, Extreme Gradient Boosting (XGBoost): XGBoost Regression and classification.	7	**CO5**
06	**Neural Network** Introduction, Fundamental concept, Evolution of Neural Networks, Biological Neuron, Artificial Neural Networks, NN architecture, McCulloch-Pitts Model. Designing a simple network, Non-separable patterns, Perceptron model with Bias. Activation functions, Binary, Bipolar, continuous, Ramp. Limitations of Perceptron. Perceptron Learning Rule. Delta Learning Rule (LMS-Widrow Hoff), Multi-layer perceptron network. Adjusting weights of hidden layers. Error back propagation algorithm.	10	**CO6**

Text Books:

1. Nathalie Japkowicz & Mohak Shah, —Evaluating Learning Algorithms: A Classification Perspective, Cambridge.
2. Marc Peter Deisenroth, Aldo Faisal, Cheng Soon Ong, —Mathematics for machine learning

3. Samir Roy and Chakraborty, —Introduction to soft computing‖, Pearson Edition.
4. Ethem Alpaydın, —Introduction to Machine Learning‖, MIT Press McGraw-Hill Higher Education
5. Peter Flach, —Machine Learning‖, Cambridge University Press

References:

1. Tom M. Mitchell, —Machine Learning‖, McGraw Hill
2. Kevin P. Murphy, —Machine Learning — A Probabilistic Perspective‖, MIT Press
3. Stephen Marsland, —Machine Learning an Algorithmic Perspective‖, CRC Press
4. Shai Shalev-Shwartz, Shai Ben-David, —Understanding Machine Learning‖, Cambridge University Press
5. Peter Harrington, —Machine Learning in Action‖, DreamTech Press
6. https://nptel.ac.in/courses/106106139

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
ADMCL601	Machine Learning Lab	-	25	25	-	-	50	

Prerequisite: Python Programming	
Lab Objectives: The course aims to	
1	familiarize students with machine learning environments and commonly used libraries.
2	Implement supervised learning algorithms and interpret their performance.
3	Apply unsupervised learning algorithms to uncover hidden patterns and data grouping
4	Build, Optimize and compare ensemble learning models for improving models performance.
5	Implement and train neural network model for classification problems
Lab Outcomes: Learners will be able to	
1	Set up and operate machine learning environments and utilize standard Python ML libraries.
2	implement and evaluate supervised learning models using real-world datasets.
3	Apply and analyze unsupervised learning methods to identify data patterns.
4	Develop and evaluate ensemble learning methods to enhance models accuracy and robust predictions.
5	To develop and evaluate Neural Network odels

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
01	Introduction to platforms such as Anaconda, COLAB	CO1
02	Study of Machine Learning Libraries and tools (Python library, tensorflow, keras,...)	CO1
03	Implementation of Linear Regression for a given example data set	CO2
04	Implementation of Logistic regression for a given example data set	CO2
05	Implementation of Support Vector Machines for a given example data set	CO2
06	Implementation of Gaussian Mixture Models, for a given example data set	CO3
07	Implementation of Expectation -Maximization for a given example data set	CO3
08	Implementation of Bagging and Random Forest classifier	CO4
09	Implementation of Boosting algorithm for classification	CO4
10	Implementation of McCulloch Pitts Model for a given example data set	CO5

11	Implementation of Single Layer Perceptron for a given example data set	CO5
12	Implementation of Error Backpropagation Perceptron Training Algorithm for a given example data set	CO5

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Oral & Practical Exam (25 Marks)

An Oral & Practical exam will be held based on entire syllabus.

Honours/ Minor: Cyber Security

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
CSMC601	**Information Security Management**	20	20	60	1	2	100	

Prerequisite: Operating Systems, Cryptography and Networking Principles, Basic of Web Technologies	
Course Objectives: The course aims to	
1	Understand the fundamentals and importance of information security management.
2	Explore security standards, frameworks and current trends in information security.
3	Distinguish various threats modelling, risk assessment and access control methods.
4	Understand incident management, disaster recovery and auditing for system protection.
Course Outcomes: Learners will be able to	
1	Discuss Fundamentals and principles of Information Security.
2	Analyze cloud security issues and major information security standards.
3	Apply threat modelling risk assessment methodology.
4	Apply the role of access control for Identity management.
5	Explain the concept of incident management, disaster recovery and business continuity.
6	Identify common issues in web application and server security.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Basics of Information Security** What is Information Security & Why do you need it? Basics Principles of Confidentiality, Integrity, Availability, Information Security Governance: Policies, Procedures, Standards, Guidelines, Administrative & Technical Controls, People-Process-Technology Framework.	6	**CO1**
02	**Cloud Computing & Information Security Standards** Cloud Computing Overview: IaaS, PaaS, SaaS, Benefits & Security Issues in Cloud Environments, Security Standards & Frameworks: ISO 27001, ISO 27002, NIST Cybersecurity Framework, COBIT, SOC2, OSSTMM, OWASP, Certifiable Standards: What, Why, How, When, Who	7	**CO2**
	Threat, Vulnerability & Risk Management		

03	Threat Modelling: Threat, Threat-Source, Attacks Vectors, Vulnerabilities and Exploits, Risk Assessment Frameworks: ISO 31010, NIST-SP-800-30, OCTAVE, Risk Assessment and Analysis: Risk Team Formation, Identifying Threat and Vulnerability, Quantification of Risk, Calculating Total Risk and Residual Risk & Risk mitigation Controls, Monitoring & Documentation: Risk Register, Reporting.	7	**CO3**
04	**Identity Access Management & Zero Trust** Concepts of Identification, Authentication, Authorization and Accountability. Access Control Models: DAC, MAC, RBAC, Rule-Based, ABAC, Access Control Techniques: Access control Matrix, Content-dependent & Context – dependent access. Access Control Methods: Administrative, Physical, Technical Controls, Privileged Access Management (PAM), Zero Trust Architecture: Principles & Implementation, Access Control Monitoring: IDS and IPS and Anomaly Detection, Accountability: Event Monitoring, Log reviews, Log Protection, Threats to Access Control: Various Attacks on the Authentication systems.	8	**CO4**
05	**Operational Security** Concept of Availability: High Availability, Redundancy and Backup. Calculating Availability, Mean Time Between Failure (MTBF), Mean Time to Repair (MTTR), Incident Management Lifecycle: Detection, Response, Mitigation, Reporting, Recovery and Remediation, Disaster Recovery: Metric for Disaster Recovery, Recovery Time Objective (RTO), Recovery Point Objective (RPO), Work Recovery Time (WRT), Maximum Tolerable Downtime (MTD), Business Process Recovery, Facility Recovery (Hot site, Warm site, Cold site, Redundant site), Backup & Restoration, Security Operations Centre (SOC) : Functions & Tools.	7	**CO5**
06	**System, Network & Web Application Security** Window Security : Types of Audits, Server Security, Active Directory Basics (Group Policy), Anti-Virus, Mails, Malware Protection, Linux Security: Endpoint Protection, Shadow Passwords, SUDO users, Web Application Security: OWASP, Common Issues in Web Apps, what is XSS, SQL injection, CSRF, Password Vulnerabilities, SSL/TLS Basics, CAPTCHA, Session Hijacking, Local and Remote File Inclusion, Audit Trails, Web Server Security Issues, Network Security Principles: Firewalls, IDS/IPS,NAC.	7	**CO6**
	Total	**42**	

Text books:

1. Shon Harris, Fernando Maymi, CISSP All-in-One Exam Guide, McGraw Hill Education, 7th Edition, 2016.
2. Andrei Miroshnikov, Introduction to Information Security - I, Wiley, 2018
3. Ron Lepofsky, The Manager's Guide to Web Application Security, Apress; 1st ed. edition, 2014

Reference books:

1. Rich-Schiesser, IT Systems Management: Designing, Implementing and Managing World - Class Infrastructures, Prentice Hall; 2 edition, January 2010.
2. NPTEL Course: - Introduction to Information Security (URL: https://nptel.ac.in/noc/courses/noc15/SEM1/noc15-cs03/)
3. Dr. David Lanter – ISACA COBIT – 2019 Framework -Introduction and Methodology
4. Pete Herzog, OSSTMM 3, ISECOM
5. NIST Special Publication 800-30, Guide for Conducting Risk Assessments, September 2012.
6. https://www.ultimatewindowssecurity.com/securitylog/book/Default.aspx
7. https://advisera.com/27001academy/what-is-iso-27001/
8. https://nvlpubs.nist.gov/nistpubs/legacy/sp/nistspecialpublication800-30r1.pdf
9. http://www.diva-portal.org/smash/get/diva2:1117263/FULLTEXT01.pdf

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					
CSMCL601	Vulnerability Assessment & Penetration Testing Lab	--	25	25	--	--	50	1

Prerequisite: Computer Networks	
Course Objectives: The course aims to	
1	Discuss security vulnerabilities and weaknesses in the target applications.
2	Describe potential vulnerabilities which are present in the system in network using vulnerability assessment tools.
3	Explain threats by exploiting them using penetration test attempt by utilizing the vulnerabilities in a system
4	Recognize how security controls can be improved to prevent hackers gaining access controls to database.
Course Outcomes: Learners will be able to	
1	Understand the structure where vulnerability assessment is to be performed.
2	Apply assessment tools to identify vulnerabilities present in the system in network.
3	Evaluate attacks by executing penetration tests on the system or network.
4	Analyse a secure environment by improving security controls and applying prevention mechanisms for unauthorised access to database.
5	Create security by testing and exploit systems using various tools and remove the impact of hacking in system.
6	Determine of documents as per applying the steps of vulnerabilities of assessment and penetration testing.

Module	Detailed Contents	CO Mapping
01	**Human Security (Social Engineering) Assessment**	CO1
	Visibility Audit: Collecting information through social media and internet. Collecting contact details (like phone number, email ID, What's App ID, etc) **Active Detection Verification**: Test if the phone number, email id etc are real by test message. Test whether the information is filtered at point of reception. Test if operator / another person assistance can be obtained. **Device Information:** IP Address, Port details, Accessibility, Permissions, Role in business **Trust Verification:** Test whether the information can be planted in form of note / email / Message (Phishing) **Test Subjects:** College Staff, Reception, PA to Director / Principal. To conduct information gathering to conduct social engineering audit on	

	various sections in your college.	
02	**Network & Wireless Security Assessment**	**CO2**
	Network Discovery: Using various tools to discover the various connected devices, to get device name, IP Address, relation of the device in network, Detection of Active port, OS Fingerprinting, Network port and active service discovery **Tools:** IP Scanner, Nmap etc **Network Packet Sniffing:** Packet Sniffing to detect the traffic pattern, Packet capturing to detect protocol specific traffic pattern, Packet capturing to reassemble packet to reveal unencrypted password **Tools:** Wireshark	
03	**Setting up Pentester lab**	**CO3**
	Including an attacker machine preferably Kali and in the same subnet victim machines either DVWA/ SEEDlabs/ multiple 9 LO3 140 VULNHUB machines as and when required. Understanding Categories of pentest and legalities/ ethics. Installed Kali machine on VM environment with some VULNHUB machines and find out vulnerability of Level 1-VULNHUB machine like deleted system files, permissions of files.	
04	**Database and Access Control Security Assessment**	**CO4**
	Database Password Audit: Tool based audit has to be performed for strength of password and hashes. **Tools:** DBPw Audit **Blind SQL Injection:** Test the security of the Database for SQL Injection Tools: BSQL Hacker **Password Audit**: Perform the password audit on the Linux / Windows based system **Tools:** Cain & Able, John the ripper, LCP Password Auditing tools for Windows. **Active Directory and Privileges Audit**: Conduct a review of the Active Directory and the Group Policy to assess the level of access privileges allocated. **Tools**: SolarWinds	
05	**Log Analysis**	**CO5**
	Conduct a log analysis on Server Event Log / Firewall Logs / Server Security Log to review and obtain insights **Tools**: graylog, Open Audit Module.	
06	**Compliance and Observation Reporting**	**CO6**
	License Inventory Compliance: Identify the number of licenses and its deployment in your organization. **Tools:** Belarc Advisor, Open Audit Report Writing: NESSUS tool **Report should contain:** a. Vulnerability discovered. b. The date of discovery.	

	c. Common Vulnerabilities and Exposure (CVE) database reference and score; those vulnerabilities found with a medium or high CVE score should be addressed immediately. d. A list of systems and devices found vulnerable. e. Detailed steps to correct the vulnerability, which can include patching and/or reconfiguration of operating systems or applications. f. Mitigation steps (like putting automatic OS updates in place) to keep the same type of issue from happening again. **Purpose of Reporting:** Reporting provides an organization with a full understanding of their current security posture and what work is necessary to both fix the potential threat and to mitigate the same source of vulnerabilities in the future.	

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
1	Discuss on OSINT — Public Info Collector Objective**:** automatically collect publicly available info about a target org/person (webpages, LinkedIn/Twitter public pages, basic WHOIS).	CO1
2	Perform a controlled phishing simulation and trust-verification test using SET and email clients.	CO1
3	Capture and analyse network traffic using Wireshark to identify unencrypted credentials and protocols.	CO2
4	Evaluate Simple Port Scanner Objective: scan a target IP for open TCP ports using pure Python (socket).	CO2
5	Illustrate Nmap automation wrapper (Network discovery) Objective**:** call Nmap from Python to get device/service fingerprints and parse results.	CO2
6	Scan and enumerate a Level-1 VulnHub machine to identify file/permission and service weaknesses.	CO3
7	Perform blind SQL injection testing on a lab web app using BSQL-Hacker and DVWA.	CO4
8	Conduct password audits on Windows / Linux hosts using Cain & Abel, John the Ripper, and LCP.	CO4
9	Collect and analyse server and firewall logs using Graylog or Open-Audit to identify anomalies.	CO5
10	Review Active Directory and Group Policy to audit privileges and role assignments using SolarWinds.	CO5
11	Show Packet capture & basic protocol analysis Objective: capture packets and identify plaintext credentials or insecure traffic patterns on lab network.	CO6
12	Run a vulnerability scan (OpenVAS / Nessus) and prepare a compliance report with CVE references and remediation steps.	CO6

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Oral & Practical Exam (25 Marks)

An Oral & Practical exam will be held based on entire syllabus.

Honours/ Minor: 3D Printing

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
DPMC601	Applications of 3D Printing	20	20	60	1	2	100	

Course Objectives: The course aims to	
1	To familiarise with the importance of Rapid Prototyping.
2	To study programming aspects of the subtractive manufacturing process.
3	To familiarize with the basic process of additive manufacturing in particular 3D printing.
Course Outcomes: Learners will be able to	
1	Illustrate understanding of various cost-effective alternatives for manufacturing products and select the feasible RP process for specific technical applications
2	Build and create data for 3D printing of any given object using liquid based rapid prototyping and tooling processes
3	Build and create data for 3D printing of any given object using solid based rapid prototyping and tooling processes
4	Build and create data for 3D printing of any given object using powder based rapid prototyping and tooling processes
5	Select an appropriate material and tools to develop a given product using rapid prototyping machine
6	Select proper rapid prototyping and reverse engineering techniques for specific technical applications.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Introduction** **Applications in Jewellery Industries** **Introduction to 3D Printing Jewellery:** Steps Involved in Jewellery 3D Printing, why 3D Printing for Jewellery Making, Techniques Involved in Jewellery 3D Printing, 3D Printing Processes for Jewellery	8	CO1

	Designing, Challenges with Jewellery 3D Printing, 3D Printing vs Traditional Methods, Types of Jewellery can be 3D Printed, **3D Printers for Jewellery Making –** How They Work & Which to Choose **Self-Learning Topic:** Traditional Methods for Jewellery making		
02	**Module Title: Medical Applications in Additive manufacturing** **Medical Applications in Additive manufacturing** Presurgical Planning Models, Mechanical Bone Replicas, Teaching Aids and Simulators, Customized Surgical Implants, Prosthetics and Orthotics', Anthropology, Forensics **Self-Learning Topic:** Research one paper or case study on 3D printed bone models and summarize its findings.	8	**CO2**
03	**Applications in Aerospace Industries** Use of AM in Aerospace, Metal AM in Aerospace, Super alloys, Non-Destructive Evaluation, Space technology	6	**CO3**
04	**Applications in Tooling** **Methods of Rapid tooling:** Direct Soft Tooling, Indirect Soft Tooling, Direct Hard Tooling, Indirect Hard Tooling.	6	**CO4**
05	**Applications in various industries** Automotive, Defence, Coin industries, Household appliance, Toy industry, Ship building, Un-manned Aerial Vehicles (UAV), Furniture, Construction and food. **Self-Learning Topic: Material limitations and quality control.**	8	**CO5**
06	**Applications in Design** Design for Additive Manufacturing (DFAM), Topology optimization for AM, Generative design Applications in Engineering, Analysis and Planning	6	**CO6**

Text Books:

1. Makers: The New Industrial Revolution (Telord 1403), by Chris Anderson
2. Medical Modelling The Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Richard Bibb, Dominic Eggbeer and Abby Paterson, Woodhead Publishing Series in Biomaterials: Number 91, Elsevier Ltd.
3. 3D Printing in Aerospace and Defense Standard Requirements, by Gerardus Blokdyk
4. Additive Manufacturing for the Aerospace Industry, by Francis Froes, Rodney Boyer
5. 3D Printing in Medicine, 1st Edition - April 1, 2017, by Deepak Kalaskar
6. An Update on Medical 3D Printing Hardcover – 1 January 2019, by Dr Raju Vaishya, Dr Abid Haleem, Dr Lalit Maini
7. 3D Printing in Medicine: A Practical Guide for Medical Professionals

Hardcover – Import, 12 October 2017, by Frank J. Rybicki, Gerald T. Grant
8. Rapid Prototyping, Principles and Applications by Rafiq I. Noorani, Wiley & Sons
9. Rapid Prototyping: Principles and Applications by Chua C.K, Leong K.F and Lim C.S, 2nd Edition, World Scientific
10. Rapid Manufacturing – An Industrial revolution for the digital age by N.Hopkinson, R.J. M. Hauge, P M, Dickens, Wiley
11. Advanced Manufacturing Technology for Medical applications: Reverse Engineering, Software conversion and Rapid Prototyping by Ian Gibson, Wiley

References:

1. Rapid Manufacturing, By Prof. J. Ramkumar, Prof. Amandeep Singh, IIT Kanpur https://onlinecourses.nptel.ac.in/noc20_me50/preview
2. Fundamentals of Additive Manufacturing Technologies, By Prof. Sajan Kapil, IIT Guwahati
3. https://onlinecourses.nptel.ac.in/noc21_me115/preview

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
DPMCL601	**Digital Fabrication Lab**	-	25	25	-	-	50	

Prerequisite:	
Course Objectives: The course aims to	
1	To impart the geometric modelling skills for development of 3D models of engineering components.
2	To familiarize with production drawings with important features like GD &T, surface finish, heat treatments etc.
3	To familiarize with additive manufacturing process
4	To acquaint with basic process of 3D modelling using biomedical data.
Course Outcomes: Learners will be able to	
1	**Upon successful completion of this course, the learner will be able to:** Illustrate basic understanding of types of CAD model creation.
2	Build geometric model of a given object using 3D modelling software
3	Generate assembly models of given objects using assembly tools of a modelling software
4	Apply 3D scanning techniques to create accurate digital models for reverse engineering or product design applications
5	Demonstrate CAM Tool path and prepare NC- G code
6	Develop 3D model using available biomedical data
7	Build any given real life object using 3D printing process

Suggested List of Experiments

Perform Any 8 Experiment from given list

Sr. No.	List of Experiments	CO Mapping
01	Geometric modelling of an Engineering component, demonstrating skills in sketching commands of creation (line, arc, circle etc.) modification (Trim, move, rotate etc.) and viewing using (Pan, Zoom, Rotate etc.)	**CO1, CO2**
02	Demonstrating modelling skills using commands like Extrude, Revolve, Sweep, Blend, Loft etc. Mesh of curves, free form surfaces etc. Feature manipulation using Copy, Edit, Pattern, Suppress, History operations etc.	**CO1, CO2**
03	Assembly: Constraints, Exploded views, interference check. Drafting (Layouts, Standard & Sectional Views, Detailing & Plotting).	**CO3**
04	Solid modelling of any engineering component using any 3D modelling software.	**CO3**

05	Non - Contact Scanning – Generation of CAD model using 3D scanning equipment.	**CO4**
06	Reverse Engineering of a legacy component – Selection of components, 3D scanning, CAD model verification, 3D print of CAD model.	**C04**
07	Modelling of a component using 3D modelling software and development of G – Code output using Fractal Software.	**CO5**
08	Design an object with free form surface using Autodesk Fusion 360 and development of G – Code output using Fractal Software.	**CO5**
09	Segmentation in Slicer's Segment Editor module for the purpose of 3D printing.	**CO6**
10	Creation of 3D model from 2D images using any image processing software and printing it. (3D Slicer open source) (Application: Any body organ like Heart, Gallbladder etc. as per available Dicom files)	**CO6**
11	Development of physical 3D mechanical structure using any one of the Additive manufacturing processes – Material to be used Metal	**CO7**
12	Development of physical 3D mechanical structure using any one of the Additive manufacturing processes - Material to be used Plastic	**CO7**

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Oral & Practical Exam (25 Marks)

An Oral & Practical exam will be held based on entire syllabus.

Honours/ Minor: Electric Vehicles

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
EVMC601	**Automotive Controller and Auxiliary Systems**	20	20	60	1	2	100	

Prerequisite: Sustainability and environment, Electrical Machine.	
Course Objectives: The course aims to	
1	To Identify functionalities of various automotive controllers and auxiliary systems
2	To study various automotive sensors and actuators
3	To explore details of energy sources management system, thermal management system and overall
Course Outcomes: Learners will be able to	
1	To illustrate functionality of various auxiliary subsystems used EVs
2	To demonstrate the use of VCUS and ECUS in automobile
3	To describe the need and functionality of automotive sensors / actuators and networking
4	To illustrate the design and management aspects of EV energy sources
5	To describe the various heat losses, and thermal management systems incorporated in EVs
6	To elaborate on System Integration and resource optimization in EVs

Module	Content	Hours	CO Mapping
1.	**Introduction:** Review of Automotive electrical, electronic, communication and thermal subsystems; Review of Energy Storage (Power Plant) system, Main Traction Inverter, On-Board Charger (OBC), LV Auxiliary Power Source, HV Battery Disconnect; Vehicle Control Unit (VCU) and ECUs. Braking Systems: Energy Consumption in Braking, Braking Power and Energy on Front and Rear Wheels, Brake System of EVs and HEVs, Series Brake-Optimal Feel, Series Brake-Optimal Energy Recovery; Parallel Brake; Antilock Brake System (ABS); Fundamentals of Regenerative Braking. Steering System: In-car system networking, Steering ratio characteristic, Steering Stabilization, Over-steer, understeer, Electric-Power-Assisted Steering (EPAS); Autonomous vehicles, Principle of object detection.	8	**CO1**

2.	**Vehicle Control Unit and Electronic Control Unit:** VCU functionality: Inverter control, battery management, charging control, vehicle functions in transmission and engine control; Advanced Driver Assistance System (ADAS); Electronic control units (ECUs): Various Section ECUs and their networking; Body and Lighting ECU (Key-less Entry, Sonar, HID, LED Lamps), Body ECU (Airbag).	08	**CO2**
3.	**Automotive sensors / actuators and networking:** Radar Sensor Detectors for Vehicle Safety Systems; Airborne Ultrasonic Imaging: SONAR Based Image Generation for Autonomous Vehicles, Motor angle sensor, Steering angle sensor, Tyre Pressure Monitoring Systems (TPMS); In Vehicle communication system: CAN, LIN, Ethernet, Flexray	6	**CO3**
4.	**Energy Storage (Power Plant) Management system:** Battery cell packaging, Battery Management System (BMS), Design of battery pack and safety considerations; High voltage cabling and cut-outs; Battery pack installation. Use of Battery-UC Hybrid source; Fuel Cell (FC): FC management and Hydrogen storage in EV.	8	**CO4**
5.	**Thermal Management System:** Heat Calculation in various subsystems; HVAC system: HVAC compressor drive; Liquid cooling system for Battery, Electric drive and On board charger. Design considerations for thermal management system	06	**CO5**
6.	**System Integration and Implementation:** Vehicular Power Control Strategy and Energy Management: A Generic Framework, Definition, and Needs, Methodologies for Optimization, Cost Function Optimization, Benefits of Energy Management.	06	**CO6**

Text/Reference Books:-

1. Electric Powertrain Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles by John G. Hayes and G. Abas Goodarzi, Wiley, 2018.
2. Handbook of Automotive Power Electronics and Motor Drive Edited by Ali Emadi, CRC Press, 2005
3. Encyclopaedia of Automotive Engineering edited by David Crolla *et al.*, Wiley, 2014
4. Electric and Hybrid Vehicles Technologies, Modeling and Control: A Mechatronic Approach by Amir Khajepour, Saber Fallah and Avesta Goodarzi, Wiley, 2014.
5. Hybrid Electric Vehicles Principles and Applications with Practical Perspectives, Second Edition Chris Mi and M. Abul Masrur, Wiley 2018.
6. Autonomous Vehicles Intelligent Transport Systems And Smart Technologies edited by Nicu Bizon, Lucian Dascalescu and Naser Mahdavi Tabatabaei, Nova Publishers, 2014
7. Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles by Sheldon S. Williamson, Springer, 2013
8. Electric and Hybrid Buses for Urban Transport Energy Efficiency Strategies, by Bogdan Ovidiu Varga, Calin Iclodean and Florin Mariasiu, Springer, 2016

Website Reference / Video Courses:

1. NPTEL Web Course: Electric Vehicles - Part 1 by PROF. AMIT KUMAR JAIN Department of Electrical Engineering IIT Delhi; https://nptel.ac.in/courses/108/102/108102121/
2. NPTEL Web Course: by Fundamentals of Electric vehicles: Technology & Economics: Prof. Ashok Jhunjhunwala, Prof. Prabhjot Kaur,Prof. Kaushal Kumar Jha andProf. L Kannan, IIT Madras, https://nptel.ac.in/courses/108/106/108106170/
3. NPTEL Web Course: Introduction to Hybrid and Electric Vehicles by Dr. Praveen Kumar and Prof. S. Majhi, IIT Guwahati, https://nptel.ac.in/courses/108/103/108103009/

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
EVMCL601	**Electric Vehicle Lab**	-	25	25	-	-	50	

Course Objectives: The course aims to	
1	To provide hands-on with various major components used in EV/HEVs
2	To explore EV drives & control implementation along with analysis using simulation tool or with hardware.
3	To study various auxiliary systems commonly used in EV.
Course Outcomes: Upon successful completion of this course, the learner will be able to:	
1	Compare and contrast conventional vehicles and EV/HEVs.
2	Illustrate operations and features of Conventional, hybrid electric vehicle and electrical vehicle Power trains.
3	Describe the working of EV drives used for different kinds of electric motors.
4	Illustrate battery characteristics and working of BMS.
5	Describe the operation of On-board and Off-board EV chargers
6	Demonstrate the use of simulations tools along with hardware implementation for evaluation of EV subsystems.

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
01	Conventional and electrical vehicle sub-systems and components	**CO1**
02	Conventional, hybrid electric vehicle and electrical vehicle Powertrains	**CO2**
03	Motor performance test - for BLDC /PMSM/ IM/SRM motors	**CO3**
04	EV drive for BLDC/PMSM/IM /SRM motors	**CO3**
05	Battery cell and module- characterization	**CO4**
06	Battery Management System (BMS)	**C04**
07	On-board and Off-board charger for EV	**CO5**
08	Study of Automotive Electronics- HVAC control, Steering Control, VCU; 2/3 or 4 Wheeler EV.	**CO4**
Use of software tools: Use of tools like ADVISOR, MATLAB, SEMIKRON SEMISEL, Python, C, Java platforms (or similar) etc. for the following		
1	Design and testing of controlled rectifier circuit for battery charging Simulation/ Emulation of Vehicle performance analysis for Conventional and Electrical Vehicle	**CO6**
2	Design simulation of a battery pack with given specifications and constraints.	**CO6**
3	Simulation/ Emulation of BLDC motor drive for performance analysis	**CO6**
4	Simulation/ Emulation of PMSM motor drive for performance analysis	**CO6**
5	Simulation/ Emulation of IM motor drive for performance analysis	**CO6**

6	Simulation/ Emulation of SRM motor drive for performance analysis	**CO6**
7	Simulation/ Emulation of On board and Off board charger.	**CO6**
8	Simulation/ Emulation of regenerative breaking.	**CO6**
10	1.Case study of any EV / HEV on road in India 2.Case study of Government policy related to green transportation and EV manufacturing. 3. Case study of Government policy on pollution control	**All COs**
11	Visit to EV/Battery/Motor/Capacitor manufacturing Plant	**All COs**

Any experiment or simulation related to EV and HEV that helps the students understand the course should be included and added other than the suggested list.

Plant Visit:
Visit to existing EV charging station/ battery manufacturing unit/ EV manufacturing unit

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Oral Examination: (25 Marks)
Oral examination will be of 25 marks based on the entire lab work of **EVMCL 601 Electric Vehicles Lab.**