MANUAL FOR DEGREE OPTIONS

1. MULTIDISCIPLINARY MINOR (EMBEDDED WITH BASIC DEGREE)

2. DOUBLE MINOR (DM) (OPTIONAL MINOR IN EMERGING AREAS)

3. HONOURS WITH RESEARCH (OPTIONAL)

First to Final Year Engineering
(Sem. III to Sem. VIII)

REVISION: FRCRCE-2-25

Effective from Academic Year 2025-26
Board of Studies Approval: **28/02/2025**
Academic Council Approval: **14/02/2025 & 8/3/2025**

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Preamble:

Government of Maharashtra has directed Autonomous Colleges to revise their curriculum in line with National Education Policy (NEP) 2020 through Government Resolution dated 4th July 2023. Following degree options are given to the students admitted from academic year 2024-25 based on UGC circulars and *DTE guidelines ref no. 17/DTE/NEP-2020/2024/111 dated 4th June 2024* related to implementation of NEP.

Credit requirements for different options of the Degrees:

Degree/SEM	I	II	III	IV	V	VI	VII	VIII	Total
B.Tech with Multidisciplinary Minor	20	20	22	22	22	22	20	20	168
B.Tech with Double Minor (Multidisciplinary & Specialisation Minor)	20	20 +2*	22 +4*	22 +4*	22 +4*	22 +4*	20 +2$	20 +2$	188
B.Tech with Research and Multidisciplinary Minor	20	20 +2*	22 +4*	22 +4*	22 +4*	22 +4*	20 +2$	20 +2$	188

Optional Credits $ credits (2) an be earned in VII/VIII

1. Learners who earn a minimum of total **168 credits** will be awarded "**B.Tech in Engg. /Tech. with Multidisciplinary Minor (MDM)**" degree.

2. Learners will have the following options to earn **B. Tech. in Engg. /Tech. degree in**

a. Major Engg./Tech Discipline with Double Minor (Multidisciplinary and Specialization Minor)

b. Honors with Research and Multidisciplinary Minor

There is 2 credit course 'Introduction to Emerging Technologies' in SEM-II introducing various emerging technologies along with basics of various tracks under multidisciplinary, minor and research domain helping student in decision making for further options of learning.

a) Major Engg./Tech Discipline with Double Minor (Multidisciplinary and Specialization Minor) (additional 20 credits): 168 +18+2 (SEM-II)=188 Min Credits.

There will be four courses (4 credits each), one in each semester starting from the 3rd semester which will be from emerging areas of specialisation. In 7th or 8th semester students will complete 2 credits seminar/project. **Admission eligibility min CGPA=7.5 after First year**

b) B.Tech in Engg./ Tech.- Honors with Research and Multidisciplinary Minor (additional 20 credits by research): 168 +18+2 (SEM-II)=188 Min Credits. (Admission eligibility min CGPA=7.5 after First and should maintain CGPA=7.5 after Third year)

3. Learner can earn the certificate/Diploma/Degree based on his/her exit from the program as follows. College shall explore feasibility to offer NSDC aligned skill based courses to the learners:

a. UG Certificate: After a one-year (40 credits to be earned) and 8-credits summer workshop/vocational courses/internship

b. UG Diploma: After two-years (80 credits to be earned) and 8-credits summer workshop/vocational courses/internship/Project

c. B. Voc.: After three-years (120 credits to be earned) and 8-credits summer workshop/vocational courses/internship/Project

Guidelines for 'Honours with Research' Degree Option:

- Admission eligibility min CGPA=7.5 after First year
- Need to maintain CGPA=7.5 after Third year
- Optional additional 20 credits by research project to be completed
- SEM-II: 2 Credits, SEM-III to SEM-VI: 4 in each SEM, Final Year: 2 Credits Seminar
- Basic MDM degree along with honors with research: Total=188 Min Credits
- Student need to identify the domain of research at the start of SEM-III and work in the same domain for entire year
- Change in domain will be allowed only after one year
- Research Project need to be in the **Basic (Core) Branch of degree or Specialisation in basic degree.** However, emerging technology can be used as a tool/methodology for doing the research.
- Following are the expected **milestones or outcomes** at the **end of academic year:**

  1. Second Year:

  Two papers presented by student (One in Each Sem) in International Conference of repute

  2. Third Year:

  One Journal paper in reputed International Journal/ One patent published

  One paper presented by student in International Conference of repute

  3. Fourth Year:

  Participation in University/State/National/International Level Research Colloquium or Project Competition or Product Exhibition
- If expected milestones are not achieved then student will be discontinued in next semester from the 'Honours with Research' Degree option.
- Every student will have an **independent Research Project** and milestones to be achieved
- **Department teachers shall float the Research Projects** outlining the scope and work. These Research Projects need to follow the below mentioned approval mechanism

  1. Student shall discuss with Research Project Supervisor and get approval in writing
  2. Research supervisor shall take approval of HoD for all research projects under him/her.
- HoD must take care of proper distribution of research projects among faculty. If 'Research Project' demands multidisciplinary concept then **Co-supervisor** from same or other department can be opted.
- HoD shall arrange common presentation by student in front of department faculty on the research idea selected by student before allotment.
- Approval from **Dean Research & Development** shall be taken HoD for all the allotted projects. Research Project reports written by student and outcomes achieved at the end of each semester shall compulsorily be submitted by **Research Supervisor to Dean R&D**. Dean R&D shall maintain the data for the same.
- Every week student shall submit progress to Research Supervisor and at the end of the semester student shall give presentation in front of all department faculty. If necessary then External Expert/Alumni can be invited for mentoring and judging the project.
- Rubrics for assessment of projects shall be developed, informed to all students & supervisors and must be followed in each department.

Guidelines for 'MDM and DM Degree Option'

UG Basic Degree	MDM Options included in Basic Degree	Double Minor (Emerging Areas) Options
Computer Engineering	1.Communication Engineering 2.Mechanical Engineering 3.Business Management 4.Healthcare Management 5.Design	1. VLSI Design & Verification 2. Internet of Things 3. Automation a Robotics 4. Sustainability
Computer Science & Engineering		
Electronics & Computer Science		1. Data Science 2. Automation & Robotics 3. Blockchain Technology 4. Cyber Security 5. Sustainability
Mechanical Engineering	1.Computer Engineering 2.Electronics Engineering 3.Business Management 4.Healthcare Management 5.Design	1. Data Science 2. AI & ML 3. Internet of Things 4. Sustainability

Minor in Communication Engineering: (Offered to Comp, CSE & ECS)

Course Code	Communication Engineering Minor Courses	Credits
25MDMCM1	Signals and System	2
25MDMCM2	Analog and Digital Communication	2
25MDMCM3	Microcontrollers and Applications	2
25MDMCM4	Communication and Computer Networks	2
25MDMCM5	Mobile Communication and Computing	2

Minor in Mechanical Engineering: (Offered to Comp, CSE & ECS)

Course Code	Mechanical Engineering Minor Courses	Credits
25MDMME1	Elements of Mechanical Engineering	2
25MDMME2	Manufacturing Engineering	2
25MDMME3	Product Design and Development	2
25MDMME4	Industrial Engineering	2
25MDMME5	Supply Chain Management	2

Minor in Computer Engineering: (Offered to Mech)

Course Code	Computer Engineering Minor Courses	Credits
25MDMCE1	Data Structures and Algorithms	2
25MDMCE2	Database Management System	2
25MDMCE3	Microcontrollers and Applications	2
25MDMCE4	AI and Applications	2
25MDMCE5	Human Machine Interface	2

Minor in Electronics Engineering: (Offered to Mech)

Course Code	Electronics Engineering Minor Courses	Credits
25MDMEL1	Signals and System	2
25MDMEL2	Digital Electronics	2
25MDMEL3	Microcontrollers and Applications	2
25MDMEL4	Linear Integrated Circuits	2
25MDMEL5	Industrial Electronics	2

Minor in Business Management: (Offered to all branches)

Course Code	Business Management Minor Courses	Credits
25MDMBM1	Financial Accounting	2
25MDMBM2	Economics for Business	2
25MDMBM3	Business Administration	2
25MDMBM4	Human Resource Management	2
25MDMBM5	Digital Marketing	2

Minor in Healthcare Management: (Offered to all branches)

Course Code	Healthcare Management Minor Courses	Credits
25MDMHM1	Biomedical Instrumentation & Imaging	2
25MDMHM2	Hospital Administration Fundamentals	2
25MDMHM3	Operations Management for Healthcare Systems	2
25MDMHM4	Digital Transformation in HealthCare	2
25MDMHM5	Bioinformatics and Computational Biology	2

Minor in Design: (Offered to all branches)

Course Code	Design Minor Courses	Credits
25MDMDE1	Industrial and Product Design	2
25MDMDE2	Communication Design	2
25MDMDE3	Graphic Design and Animation	2
25MDMDE4	Interaction Design	2
25MDMDE5	Mobility and Vehicle Design	2

List of Track related to Double Minor Degree in 'Emerging Areas' :

1. Name: VLSI Design and Verification (offered to Comp and CSE)

1. **25DM11:** VLSI Design Flow
2. **25DM12:** FPGA Programming
3. **25DM13:** Verification using System Verilog
4. **25DM14:** AI and ML for VLSI

2. Name: Internet of Things (offered to Comp, CSE and Mech)

1. **25DM21:** Sensors and Actuators
2. **25DM22:** Fundamentals of IoT
3. **25DM23:** Embedded System and RTOS
4. **25DM24:** System Design

3. Name: Automation and Robotics (offered to Comp, CSE and ECS)

1. **25DM31:** Introduction to CAD/CAM
2. **25DM32:** 3D Printing
3. **25DM33:** Mechatronics
4. **25DM34:** Industrial Robotics and Automation

4. Name: Sustainability (offered to all)

1. **25DM41:** Design Thinking for Sustainability
2. **25DM42:** Green Computing
3. **25DM43:** Emerging Technologies for Sustainability
4. **25DM44:** Sustainable Product Design

5. Name: **Data Science (offered to ECS, Mech)**

1. **25DM51:** Statistics for Data Science
2. **25DM52:** Data Analytics and Visualisation
3. **25DM53:** Game Theory
4. **25DM54:** Web and Social Media Analytics

6. Name: Artificial Intelligence and Machine Learning (offered to Mech)

1. **25DM61:** Statistics for Data Science
2. **25DM62:** Fundamentals of AI & ML
3. **25DM63:** Natural Language Processing
4. **25DM64:** Artificial Intelligence for Mechanical Engineering

7. Name: **Blockchain Technology (offered to ECS)**

1. **25DM71:** Blockchain Basics
2. **25DM72:** Bitcoin and Cryptocurrency
3. **25DM73:** Blockchain Security
4. **25DM74:** Industrial Blockchain

8. Name: **Cyber Security (offered to ECS)**

1. **25DM81:** Cyber Security Essentials
2. **25DM82:** Web Application, Penetration Testing and Ethical Hacking
3. **25DM83:** Digital Forensic
4. **25DM84:** Cloud and IoT Security

MULTIDISCIPLINARY MINOR (EMBEDDED WITH BASIC DEGREE)

Minor in Communication Engineering: (Offered to CE, CSE and ECS)

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25MDMCM1	Signals and Systems	L	T	P	L	T	P	Total
		2	--	--	2	--	--	2
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	

Pre-requisite Course Codes	Basic concepts of Mathematics	
Course Outcomes	CO1	Identify and differentiate between continuous and discrete time signals and systems
	CO2	Develop input output relationship for LTI systems
	CO3	Apply the concept of Laplace transform and understand conversion from time domain to frequency domain for continuous time systems.
	CO4	Apply the concept of Z transform and comprehend conversion from time domain to frequency domain for discrete time systems.
	CO5	Discuss various applications of signals and system

Module No.	Unit No.	Topics	Ref.	Hrs.
		Introduction to Signals and Systems	1,2,3,4	4
1	1.1	**Introduction to Signals:** Definition, Basic Elementary signals - exponential, sine, step, impulse, ramp, rectangular, triangular. Operations on signals. **Classification of Signals: A**nalog and discrete time signals, even and odd signals, periodic and non-periodic signals , deterministic and non-deterministic signals, energy and power signals. Arithmetic Operations on Signals, Time Shifting, Time Scaling, Time Reversal of Signals		
	1.2	**Systems and Classification of systems:** System Representation, continuous time and discrete systems, system with and without memory, causal and non-causal system, linear and nonlinear system, time invariant and time variant system, stable system		
		Time Domain Analysis of Continuous and Discrete Systems	1,2,3,4	6
2	2.1	Properties of Linear Time Invariant (LTI) systems, Impulse and Step Response		

	2.2	Use of Convolution Integral and Convolution Sum and Correlation for Analysis of LTI Systems		
	2.3	Properties of Convolution Integral/Sum		
		Laplace Transform and Continuous time LTI systems	1,2,3,4	6
3	**3.1**	Need of Laplace Transform, Concept of Region of Convergence,Properties of Laplace Transform, , unilateral Laplace Transform, inverse Laplace Transform.		
	3.2	**Analysis of continuous time LTI systems using Laplace Transform: C**ausality and stability of systems in *s*-domain, Total response of a system.		
		***z*-Transform and Discrete time LTI systems**	1,2,3,4	6
4	**4.1**	Need of *z*-Transform, *z*-Transform of finite and infinite duration sequences, Concept of Region of Convergence, *z*-Transform properties, Standard z-transform pairs, one sided z-Transform. Inverse z-Transform: Partial Fraction method only.		
	4.2	**Analysis of discrete time LTI systems using *z*-Transform**: Transfer Function, plotting Poles and Zeros of a transfer function , causality and stability of systems, Total response of a system		
		Applications of Signals and System		4
5	**5.1**	Electrical and Electronics Engineering Applications		
	5.2	Computer Science and IT Applications		
	5.3	Mechanical and Civil Engineering Applications		
	5.4	Robotics and IoT Applications		
			Total	**26**

Course Assessment:

Theory:

ISE-1:
Activity: Quiz and assignments 20 Marks
ISE-2:
Activity: Quiz and Assignments 20 Marks

MSE: 30 Marks written examination based on 50% syllabus (Duration:90 minutes)
ESE: 30 Marks written examination based on remaining syllabus after MSE (Duration:90 minutes)

Recommended Books:

1. Tarun Kumar Rawat, "Signals and Systems", Oxford University Press, 2016.
2. A. Nagoor Kani, "Signals and Systems", Tata McGraw-Hill Education, 2014.
3. Alan V. Oppenhiem, Alan S. Willsky and S. Hamid Nawab, Signals and Systems, Prentice-Hall of India, Second Edition, 2002.
4. Simon Haykin and Barry Van Veen, Signals and Systems, John Wiley and Sons, Second Edition, 2004.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25MDMCM2	Analog and Digital Communication	L	T	P	L	T	P	Total
		2	--	--	2	--	--	2
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	

Pre-requisite Course Codes	PCC11EC03 (Digital Electronics), MDMXX1(Signals & systems), PCC12EC05 (Electronic Devices)	
Course Outcomes	CO1	Explain types and parameters of noise and the need for modulation.
	CO2	Analyze various amplitude and angle modulation techniques.
	CO3	Discuss the operation of radio receivers and demodulators.
	CO4	Generate and detect pulse modulation techniques.
	CO5	Derive performance parameters of Digital modulation methods
	CO6	Simulate/implement various analog and digital modulation techniques.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to Communication**	2,6	3
	1.1	Types of Noise, Signal-to-noise ratio, Noise factor, Noise Figure, Noise Temperature		
	1.2	Need for modulation		
2		**Amplitude Modulation**		6
	2.1	**Amplitude Modulation:** Representation of AM wave (Mathematical & Graphical), Frequency spectrum of AM wave, AM Power Distribution, AM for a Complex Modulating Signal: modulation index, power distribution, and Current Distribution	1,2, 3,6	
	2.2	**Types of AM**: Generation of DSB-SC using diode based balanced modulator, Generation of SSB using phase shift method		
3		**Angle modulation**	1,2, 3,6	6
	3.1	Theory of Frequency Modulation (FM) & Phase Modulation (PM) - Basic Concepts, Spectrum Analysis of FM Wave, Noise triangle, Pre-emphasis, De-emphasis, Comparison of AM, FM and PM		

	3.2	**Radio receivers:** Superheterodyne Receiver, Receiver Characteristics: Sensitivity, Selectivity, Fidelity and Image frequency rejection ratio, choice of Intermediate frequency, Diode detector for AM, Frequency discriminator and Phase discriminator methods for FM		
4		**Pulse Modulation**	1,2, 3,6	6
	4.1	Sampling theorem, aperture effect and aliasing		
	4.2	Generation and Detection of Pulse Amplitude Modulation (PAM)		
	4.3	Pulse Code Modulation (PCM), Delta Modulation (DM), Advanced Delta Modulation (ADM)		
	4.4	**Multiplexing Techniques:** Time Division Multiplexing (TDM): T1 carrier system, Frequency Division Multiplexing (FDM)		
5		**Digital Modulation Techniques**	1,3, 4,5, 6	5
	5.1	**Generation, detection, signal space diagram, power spectral density and bandwidth of:** Binary Phase Shift Keying (BPSK), Quaternary Phase Shift Keying (QPSK), M-ary PSK, Binary Amplitude Shift Keying (BASK), Quadrature Amplitude Modulation (QAM), Binary Frequency Shift Keying (BFSK), Minimum Shift Keying (MSK).		
			Total	**26**

Course Assessment:

Theory:

ISE-1 (20M):

Activity: Practical assignment on DSB-FC (AM), SSB, DSB-SC, FM.

ISE-2 (20M):

Activity: Practical assignment on sampling theorem, pulse modulation, TDM, FDM, and digital modulation techniques.

MSE: 90 minutes 30 Marks written examination based on 50% syllabus

ESE: 90 minutes 30 Marks written examination based on the remaining syllabus after MSE

Recommended Books:

1. Principles of Communication Systems, Taub Schilling & Saha, Tata Mc-Graw Hill, Third Ed
2. Electronics Communication System, George Kennedy, Bernard Davis and Prasanna, Tata McGraw Hill, 6th Ed, 2018
3. Analog and Digital Communication, T. L. Singal, Tata Mc-Graw Hill, New Delhi, First Edition, 2012.
4. Digital Communication: Fundamentals and Applications, Sklar B. & Ray P. K., Pearson, Dorling Kindersley (India), 2nd edition, 2006

5. Digital communication, Simon Haykin, John Wiley and sons, 2010
6. Electronics Communication Systems, Wayne Tomasi, Pearson Education, Third Edition, 2001.

Online Resources:

1. https://www.mathworks.com/help/comm/ug/analog-baseband-examples.html
2. https://www.mathworks.com/help/comm/ug/analog-passband-modulation-examples.html
3. https://github.com/Nikeshbajaj/ASK_PSK_FSK

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25MDMCM3	Microcontrollers and Applications	L	T	P	L	T	P	Total
		2	--	--	2	--	--	2
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	

Pre-requisite Course Codes	Digital Electronics, C programming	
	At the End of the course students will be able to:	
Course Outcomes (CO)	CO1	Explain the fundamental concepts of microcontrollers
	CO2	Develop programming skills for microcontrollers using Embedded C concepts
	CO3	Program various on-chip components of microcontrollers
	CO4	Interface various devices to the 8051 microcontroller
	CO5	Evaluate various enhancements in modern microcontrollers based on the ARM CORTEX cores

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**8051 Microcontroller Architecture**		6
	1.1	Introduction to the concepts of Microprocessors and Microcontrollers	1,2	
	1.2	Concept of Buses, Read/write operations, T state, Machine cycle and Instruction cycle	1,2	
	1.3	8051 Architecture	1,2	
	1.4	8051 Memory organization	1,2	
	1.4	RISC and CISC Concepts, Harvard and Von Neumann Architectures	1,2	
	1.5	Overview of various available Microcontrollers, Applications of Microcontrollers	1,2	
2		**Programming the 8051**		4
	2.1	Assembly language programming, Addressing modes	1,2	
	2.2	Embedded C programming concepts: Data types, Modifiers, Qualifiers, Functions, Macros, Interrupt service routines.	1,2	
3		**8051 Internal Hardware**		6
	3.1	I/O port programming	1,2	
	3.2	Timers/Counters programming	1,2	
	3.3	Serial port programming	1,2	
	3.4	Interrupts programming	1,2	
	3.5	Low power modes of the 8051	1,2	

4		**8051 Interfacing**		
	4.1	Display interfacing: LED, 16x2 generic alphanumeric LCD display.	1	6
	4.2	Analog devices interfacing: 8-bit ADC, 8-bit DAC, temperature sensor (LM35)	1	
	4.3	Motor interfacing: Relay, DC motor (speed control using PWM), Stepper motor and Servo motor.	1	
5		**ARM Cortex microcontrollers**		4
	5.1	Introduction to the ARM Cortex family	3	
	5.2	Salient features of ARM Cortex cores: RISC design, Operating modes and states, NVIC, Low power modes	3	
			Total	**26**

Course Assessment:

ISE-1:
Embedded C programming: Arithmetic /Logical operations, I/O port, Timer/Counter, Serial port [20 Marks]

ISE-2:
Embedded C programming: LCD Interfacing, Stepper motor interfacing, DC motor interfacing, Sensor Interfacing [20 Marks]

Note: In ISE 2, Interfacing with Arduino boards can be introduced

MSE: 30 Marks 90 minutes written examination based on 50% syllabus
ESE: 30 Marks 90 Minutes written examination based on remaining syllabus after MSE

Recommended Books

1.M.A.Mazidi, J.C.Mazidi, Rolin D. McKinlay,"The 8051 Microcontroller and Embedded Systems
Using Assembly and C", Pearson Education, Second Edition, 2007.
2. Kenneth J. Ayala, "The 8051 Microcontroller", Cengage Learning India Pvt. Ltd, Third Edition,
2005.
3.Joseph Yiu, "The Definitive guide to ARM CORTEX-M3 & CORTEX-M4 Processors", Elsevier, 2014, 3rd Edition.

Reference Books:
1.Raj Kamal, "Microcontrollers: Architecture, Programming, Interfacing and System Design", Pearson Education, 2009.
2. Manish K Patel, "The 8051 Microcontroller Based Embedded Systems", McGraw Hill, 2014.
3. Ajay V Deshmukh, "Microcontroller Theory And Applications ", Tata Mcgraw Hill, 2017

MULTIDISCIPLINARY MINOR (EMBEDDED WITH BASIC DEGREE)

Minor in Mechanical Engineering: (Offered to CE, CSE and ECS)

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25MDMME1	Elements of Mechanical Engineering	L	T	P	L	T	P	Total
		2	-	-	2	-	-	2
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	

Pre-requisite Course Codes	None	
Course Outcomes	CO1	Understand the basic concepts of force systems, resultant force, and equilibrium.
	CO2	Identify different types of engineering materials and their mechanical properties.
	CO3	Explain the fundamentals of thermodynamics and the first and second laws.
	CO4	Understand the modes of heat transfer and explain the working of boilers, their types, mountings, and accessories.
	CO5	Explain fluid properties and their significance in fluid mechanics.
	CO6	Explain the layout and working of thermal and hydel power plants, and the significance of renewable energy sources.

Module No.	Unit No.	Topics	Ref	Hrs.
1	1.1	Fundamentals of Engineering Mechanics, Force Systems, Resultant Force, Coplanar Concurrent Force System, Numerical on Concurrent Force System Only. Non-Concurrent Coplanar Force System: Moment of Force, Varignon's Theorem (Theory Only)	1	4
	1.2	Concept of Equilibrium, Free Body Diagram, Numerical on lamis theorem	1	2
2	2.1	Engineering Materials: Scope and Importance, Materials Overview, Mechanical Properties, Stress-Strain Diagram	2	4
3	3.1	Basics of Thermodynamics, Zeroth Law, First Laws: (No numerical)	3	2
	3.2	Second Law of Thermodynamics: Comparison of Carnot Cycle and Rankine Cycle	3	2
4	4.1	Introduction to Heat Transfer, Conduction, Convection, Radiation (Theory Only)	4	2
	4.2	Boilers: Types, Boiler Mountings and accessories	4	2
5	5.1	Fundamentals of Fluid Mechanics, Properties of Fluids, Bernoulli's Equation (Only Theory)	5	2

	5.2	Aerofoil theory	5	2
6	**6.1**	Introduction to Power Plant Engineering: Layouts of Thermal power plant, Hydel Plant and Gas Turbine Power Plant, Comparative Study	6	2
	6.2	Renewable Energy Sources: Solar, Wind, and Hydropower. Biomass & Geothermal: Energy from organic waste and Earth's heat	6	2
		Total		**26**

Course Assessment:

Theory:

ISE-1: Quiz (20 Marks)
ISE-2: Quiz (20 Marks)
MSE: 90 minutes of written examination based on 50% syllabus **(**30 Marks)
ESE: 90 minutes of written examination based on the remaining syllabus covered after MSE (30 Marks)

Recommended Textbooks:

1. *Engineering Mechanics – S. S. Bhavikatti, New Age International Publishers (For Module 1: Fundamentals of Engineering Mechanics)*
2. *Strength of Materials – R. K. Bansal, Laxmi Publications (For Module 2: Engineering Materials, Stress-Strain)*
3. *Fundamentals of Thermodynamics – Sonntag, Borgnakke, Van Wylen, Wiley India (For Module 3: Basics of Thermodynamics)*
4. *Heat and Mass Transfer – J.P. Holman, McGraw Hill (For Module 4: Heat Transfer & Boilers)*
5. *Fluid Mechanics and Hydraulic Machines – R. K. Bansal, Laxmi Publications (For Module 5: Fluid Mechanics & Aerofoil Theory)*
6. *Power Plant Engineering – P.K. Nag, McGraw Hill (For Module 6: Power Plant Engineering & Renewable Energy)*

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25MDMME2	Manufacturing Engineering	L	T	P	L	T	P	Total
		2	-	-	2	-	-	2
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	

Pre-requisite Course Codes	None	
Course Outcomes	CO1	Identify and differentiate between various manufacturing processes.
	CO2	Explain different types of cutting off machines and their applications.
	CO3	Understand the different parts of lathe machine and lathe machine operations.
	CO4	Have knowledge of different types of drilling machines and operations.
	CO5	Describe types of milling operations and their differences.
	CO6	Explain the principles of grinding operations.

Module No.	Topics	Ref	Hrs.
1	Definition and need of various manufacturing processes. Classification of various manufacturing processes based on chip-less and chip-removal processes.	1, 2	04
2	Types of circular saws, Band saw, Power hacksaw, Friction saw, Abrasive cutting off machines. Advantages, Limitations, and Applications of different types of cutting off machines.	1, 2	04
3	Descriptions and functions of lathe parts. Lathe specifications, Lathe operations, and Taper turning. Single point cutting tool nomenclature. Work and tool holding devices & accessories.	1, 2	06
4	Drilling operations. Types of Drilling machines. Drill nomenclature. Work and tool holding devices. Deep hole drilling and Boring machines.	1, 2	04
5	Types of milling operations and their difference. Milling parameters. Types of milling machines. Types of Milling cutters.	1, 2	04
6	Principle of grinding. Types of grinding machines and operations. Grit, grade, and structure of grinding wheels. Balancing of grinding wheels. Truing, dressing, and shaping of grinding wheels.	1, 2	04
	Total		**26**

Course Assessment:

Theory:

ISE-1: Quiz (20 Marks)
ISE-2: Quiz (20 Marks)
MSE: 90 minutes of written examination based on 50% syllabus **(**30 Marks)
ESE: 90 minutes of written examination based on the remaining syllabus covered after MSE (30 Marks)

Recommended Textbooks:

1. *Elements of Workshop Technology:* Machine Tools (Volume – 2) by S. K. Hajra Choudhary, A. K. Hajra Choudhary, Nirjhar Roy, Media promoters 15th Edition (2023).
2. *A Course in Workshop Technology Vol. II (Machine Tools)* by B. S. Raghuwanshi, Dhanpat Rai & Co. (2015).

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25MDMME3	Product Design and Development	L	T	P	L	T	P	Total
		2	-	-	2	-	-	2
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	

Pre-requisite Course Codes	Machine Design	
Course Outcomes	CO1	Describe the process of product design & development.
	CO2	Employ engineering, scientific, and mathematical principles to develop and execute a design project from a concept to a finished product.
	CO3	Apply the principles of DFMA and other DFX principles in product design.
	CO4	Analyze products based on ergonomics and aesthetic aspects.
	CO5	Apply value engineering and software solutions in product design.
	CO6	Illustrate various modern approaches like concurrent engineering, product life cycle management, robust design, rapid prototyping / rapid tooling.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction:** Definition of product design, Various phases in product development and Design, The Design Process, Considerations in product design	1-3	2
	1.2	**Planning for products**: Establishing markets - market segments - relevance of market research.	1-3	1
2	2.1	**Identifying customer needs:** Voice of Customer (VoC), Customer populations, Hierarchy of human needs, Need gathering methods, Establishing engineering characteristics, Competitive benchmarking, Quality Function Deployment (QFD), House of Quality (HoQ), Product design specification, Development of product design with specifications using QFD, Relevant case studies.	1-3	3
3	3.1	**The design processes:** Descriptive and prescriptive design models, Concept development & evaluation, Pugh's total design activity model	1-3	3

		Conceptual Design: Market research, Generation, Selection and Embodiment of concept, Product Architecture, Customer centric product designing		
	3.2	**Creativity:** Role of creativity in problem solving, Vertical and lateral thinking, Brain storming, Synectics, Group working dynamics, Adaptation to changing scenarios in economics, social, cultural and technological fronts, Anticipation of new needs and aspirations.		1
4	**4.1**	**Product Ergonomics:** Anthropometry, Environmental conditions, thermal, noise, vibration, displays, illusions, Psycho and psychological aspects in design, Man-machine information exchange.	1-3	2
	4.2	**Product Aesthetics:** Visual awareness, Form elements in context of product design, Concepts of size, shape and texture, Introduction to colour and colour as an element in design, Colour classifications and dimensions of colour, Colour combinations and colour dynamics, Interaction / communication of colours, Psychological aspects of colours, generation of products forms with analogies from nature	1-3	1
	4.3	**Product Graphics:** Graphics composition and layout, Use of grids in graphics composition, Study of product graphics and textures. Industrial Design aspects applied in electromechanical design and user interface design.	1-3	2
5	**5.1**	**Design for Manufacturing and Assembly:** Guidelines and Methodology, DFA Index, Analysis of assembly requirements, Standardization, Ease of Assembly and disassembly, Modular concepts Concept of Lean Manufacturing and Six Sigma	1-3	2
	5.4	**Other DFX Principles:** Designs for Maintainability, Safety, Reliability, Sustainable Design	1-3	1
6	**6.1**	**Value Engineering:** Product value and its importance, Value analysis job plan, Steps to problem solving and value analysis, Value analysis tests, Value Engineering idea generation check list, Material and process selection in value engineering, Cost reduction, case studies and exercises.	1-3	1
	6.2	**Software Solutions:** Use of Computers for drafting, modeling, assembly, detailing, CAM interfacing, Rapid tooling/rapid prototyping.	1-3	3
	6.3	**Modern Applications:** Concurrent Engineering, Robust Design, Additive Manufacturing/Rapid Prototyping, Product Life Cycle Management techniques and application areas.	1-3	4
Total				**26**

Course Assessment:

Theory:

ISE-1: Quiz (20 Marks)
ISE-2: Case Study presentation in a group related to any of the following topics: Customer centric product design, Value engineering, Industrial design, PLM, robust design, computer aided design (20 marks)
MSE: 90 minutes 30 Marks written examination based on 50% syllabus
ESE: 90 minutes 30 Marks written examination based on remaining syllabus covered after MSE

Recommended Books:

Text Books:

1. Anita Goyal, Karl T Ulrich, Steven D Eppinger, "Product Design and Development," 4th Edition, 2009, Tata McGraw-Hill Education, ISBN-10-007-14679-9.
2. Kevin Otto, Kristin Wood, "Product Design," Indian Reprint 2004, Pearson Education, ISBN 9788177588217.
3. Product Design and Manufacturing - R.C. Gupta, A.K. Chitale PHI, 2011

Reference Books:

1. Clive L.Dym, Patrick Little, "Engineering Design: A Project-based Introduction," 3rd Edition, John Wiley & Sons, 2009, ISBN 978-0-470-22596-7.
2. George E. Dieter, Linda C.Schmidt, "Engineering Design," 4th Edition, McGraw-Hill International Edition, 2009, ISBN 978-007-127189-9.
3. Yousef Haik, T. M. M. Shahin, "Engineering Design Process," 2nd Edition Reprint, Cengage Learning, 2010, ISBN 0495668141.

Links for online NPTEL/SWAYAM courses:

1. Product Design and Manufacturing by Prof. J. Ramkumar, Prof. Amandeep Singh | IIT Kanpur https://onlinecourses.nptel.ac.in/noc21_me66/preview
2. Product Design and Development by Prof. Inderdeep Singh, IIT Roorkee https://onlinecourses.nptel.ac.in/noc21_me83/preview

MULTIDISCIPLINARY MINOR (EMBEDDED WITH BASIC DEGREE)

Minor in Computer Engineering: (Offered to Mech)

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
25MDMCE1	Data Structures and Algorithms	1	- -	2	1	--	1	2
		Examination Scheme						
			ISE	MSE	ISE	ESE	Total	
		Theory	10	15	10	15	50	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes	ESC11EC03	
Course Outcomes	CO1	Explain the fundamental concepts of data structures, algorithm properties and complexity.
	CO2	Implement various operations of linear data structures.
	CO3	Implement various operations of non-linear data structures.
	CO4	Implement sorting algorithms and drive its complexity.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction to Data structure and Algorithms Complexity** Introduction to Data Structures, Concept of ADT, Types of Data Structures: Linear and Nonlinear Definition of an Algorithm, Properties of a Good Algorithm, Asymptotic Notations & Complexity Classes, Recursive algorithms	1,2,4	2
2	2.1	**Stack and Queue:** **Stack:** Introduction, Stack as ADT, Operations, Implementation using array, Applications of stack.	1,2,3	3
	2.2	**Queue:** Introduction, Queue as ADT, Operations, Implementation using array, Circular queue, Applications of queue	1,2,3	2
3	3.1	**Linked List:** Linked list as an ADT, Singly Linked List, Operation on Singly linked list, Applications of Linked List:	1,2,3	2
4	4.1	**Tree:** Basic Terminology, Linked Representation of Binary Tree ADT, Traversal of Binary Tree, Binary Search Tree and operations on it. Applications of these binary trees.	1,2, 3	3
5	5.1	**Graphs:** Basics Terminology, Adjacency List and Adjacency Matrix Representation, Graph traversals BFS and DFS. Applications of Graph	1,2, 3	2
6	6.1	**Sorting Techniques:** Insertion Sort, Selection sort,Quick sort, Merge sort, derivation of complexity of sorting algorithms	1,2, 4	3
			Total	**17**

Module No.		Name of the experiment
1	1 2	**Stack ADT** a. Implement Stack ADT using array b. Convert Infix to Postfix and evaluate the postfix using Stack ADT..
2	3 4	**Queue ADT** a. Implement Linear Queue ADT using an array. b. Implement Circular Queue ADT using an array.
3	5 6	**Linked List ADT** a. Implement Singly Linked List ADT. b. Implement stack and queue using linked list.
4	7	**Binary Search Tree** a. Implement Binary Search Tree ADT using Linked List
5	8	**Graph:** Implement a program to represent a graph using an adjacency list or adjacency matrix data structure. And perform breadth-first search (BFS) or depth-first search (DFS) traversal algorithms.
6	9	**Sorting Algorithm and its complexity** Implement Bubble, Selection, Insertion, Merge and Quick sort
	10	**Mini Project: (Suggested list of Mini Project Topics) (Any One)** a. Text Edition Application: Implement a text editor with an undo feature. Every time a change is made to the text, save the previous state. When the user performs an undo operation, last state should be reverted. b. Develop a print job scheduler. Users submit print jobs to the printer, and they are processed in the order they were received. c. Design and implement a music application to manage and organize playlists efficiently. The application should allow users to perform the following operations: Add, Edit, delete and play song, d. Develop a browser history manager using a doubly linked list to efficiently track and navigate through the user's browsing history. The application should facilitate the following functionalities: Navigation forward and backward, Add page, remove page, search page, display history etc. e. Develop a word dictionary application to efficiently store and retrieve words and their definitions. The application should provide the following functionalities: Insertion, deletion, search, update etc. f. Given a network of cities connected by roads with different weights representing distances. Visit each city exactly once and print the sequence of all the cities visited.

Course Assessment:

Theory:

ISE-1: (10 Marks)-Activity: Regular Quizzes of 10 Marks

ISE-2: (10 Marks)-Activity: Programming Assignment of 10 Marks

MSE: One hour **15 Marks** written examination based on 50% syllabus

ESE: One hour **15 Marks** written examination based on remaining 50% syllabus

Lab:

ISE-1: (20 Marks)-Practical Exam after completing first five experiments
ISE-2: Activity: Mini Project (**10 Marks**), Remaining Experiments Assessment **(10 marks)**

Reference Books:

1. Data Structures using C and C++ by Yedidyah Langsam, Moshe J. Augenstein, Aaron M.Tenenbaum, Second Edition.
2. Data Structures using C, Reema Thareja, Third Edition.
3. Data Structures and Program Design in C++, Robert L. Kruse, Alexander J. Ryba Prentice- Hall India.
4. Introduction to Algorithms, Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, The MIT Press, 4th Edition, 2022.

Further Reading:

1. Data Structures and Algorithm in Java, Goodrich and Tamassia, John Wiley and Sons, Sixth Edition 2014.
2. Data Structures and Pseudocode approach with C, 2nd Edition by Richard F. Gilberg & Behrouz A. Forouzan

Online Resources:

1. https://nptel.ac.in/courses/106/102/106102064/
2. https://www.coursera.org/specializations/data-structures-algorithms
3. https://visualgo.net
4. www.leetcode.com
5. www.hackerrank.com
6. https://www.youtube.com/playlist?list=PLDV1Zeh2NRsB6SWUrDFW2RmDotAfPbeHu

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25MDMCE2	Database Management Systems	L	T	P	L	T	P	Total
		1	--	2	1	--	1	2
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	10	15	10	15	50	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes		
Course Outcomes	CO1	Explain the basic concepts and the applications of database management systems.
	CO2	Design ER/EER diagrams for real-world scenario.
	CO3	Convert ER/EER diagram to relational model and write relational algebra queries.
	CO4	Formulate SQL queries to retrieve, manipulate, and analyze data stored in a relational database.
	CO5	Apply the concept of normalization to relational database to improve the database design.
	CO6	Describe the concepts of transaction and concurrency control.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Module 1: Introduction To Database Systems**	1,2,6	2
	1.1	Characteristics of Database systems		
	1.2	File System Vs. Database systems		
	1.3	Three Schema Architecture and Data Independence		
	1.4	DBMS Architecture, Applocations of DBMS		
2		**Module 2: Conceptual Data Modelling using Entity Relation Diagram**	1,2,6	2
	2.1	The Entity-Relationship (ER) Model: Entity types, Types of Attributes, Types of Keys		
	2.2	Relationships**:** Types of Relationships (Unary, Binary, Ternary, N-ary), Constraints on Relationship (Cardinality and Participation)		
	2.3	Extended ER Diagram**:** Generalization, Specialization, and Aggregation.		
3		**Module 3: Relational Model and Relational Algebra**	1,2,6	2
	3.1	Introduction to Relational Model: Relational Schema and Concepts of keys.		
	3.2	Mapping the ER and EER Model to the Relational Model		
	3.3	Relational Algebra**:** Operators and Relational Algebra Queries		
		Module 4: Structured Query Language	1,2	3

4	**4.1**	DDL commands**:** CREATE, ALTER, DROP, TRUNCATE, Integrity constraints**:** Key constraints, Domain constraints, Referential integrity constraints, and Check constraints		
	4.2	DML Commands: Insert, Update, Delete, WHERE clause, OrderBy clause.		
	4.3	Aggregate Functions, GroupBy – Having clause		
	4.4	SQL Joins, Set operations, Nested queries		
5		**Normalization**	1,2,4,6	2
	5.1	Pitfalls in Relational Database designs, Concept of Normalization, Function Dependencies.		
	5.2	1NF, 2NF, 3NF, BCNF		
6		**Transaction and Concurrency Control**	1,2	2
	6.1	Introduction to Transaction, Transaction States, ACID properties, Serial and Concurrent Schedules, Serializability**:** Conflict and View serializability. Transaction Control Commands (TCL)		
	6.2	Introduction to Concurrency Control**:** Lock-based protocols, Timestamp-based protocols.		
			Total	**13**

Sr.no	**Suggested List of experiments**	**Ref.**	**Hrs.**
1.	Identify the case study and formulate the detailed problem statement. Design Entity-Relationship (ER)/Extended Entity-Relationship (EER) Model for the same.	**1,2,6**	**1.**
2.	Map the ER/EER Diagram designed in Experiment 1 into relational model and write SQL queries to create all PRIMARY KEY TABLES using DDL commands (Apply the constraints like PRIMARY KEY, NOT NULL, and DOMAIN Constrains)	**1,2,6**	**2.**
3.	Create all FOREIGN KEY tables. Apply Referential Integrity constraints.	**1,2,5**	**3.**
4.	Perform operations involving ALTER, DELETE, and UPDATE commands on the tables created in Experiment 2 and 3.	**1,2,5**	**4.**
5.	Write SQL queries to implement JOINS and Nested queries for tables created in Experiment 2 and 3.	**1,2,5**	**5.**
6.	Write the query for implementing the aggregate functions MAX(), MIN(), AVG(), COUNT(), SUM() with Group by and Having clause for the previously created tables.	**1,2,5**	**6.**
7.	Implement PL/SQL and TRIGGERS for the previously created tables.	**1,2,5**	**7.**
8.	Create Views and Indices for the previously created tables.	**1,2,5**	**8.**
	Mini project/presentation/Group activity/ Simulation using modern tools		

Course Assessment:

Theory:

ISE-1:
Activity: Quiz and assignments 10 Marks
ISE-2: Two hours 10 Marks
Activity: Article Discussion, Quiz and Assignments
Outcome: Reflective Journal

MSE: One hour 15 Marks written examination based on 50% syllabus
ESE: One hour 15 Marks written examination based on remaining 50% syllabus

Lab:

ISE:
1. ISE-1 will be conducted for four or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2
a. Remaining Four experiments or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Simulation using modern tools to solve the given problem statement for 10 marks/Mini project

Recommended Books:

1. Korth, Slberchatz, Sudarshan, Database System Concepts, 6th Edition, McGraw Hill
2. Elmasri and Navathe, Fundamentals of Database Systems, 5th Edition, Pearson education.
3. Raghu Ramkrishnan and Johannes Gehrke, Database Management Systems, TMH.
4. G. K. Gupta, Database Management Systems, McGraw Hill., 2012.
5. SQL Tutorial (w3schools.com)
6. Course: Database Management System By Prof. Partha Pratim Das, Prof. Samiran Chattopadhyay IIT Kharagpur : https://onlinecourses.nptel.ac.in/noc22_cs91/preview

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25MDMCE3	Microcontrollers and Applications	L	T	P	L	T	P	Total
		2	--	--	2	--	--	2
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	

Pre-requisite Course Codes	Digital Electronics, C programming	
	At the End of the course students will be able to:	
Course Outcomes (CO)	CO1	Explain the fundamental concepts of microcontrollers
	CO2	Develop programming skills for microcontrollers using Embedded C concepts
	CO3	Program various on-chip components of microcontrollers
	CO4	Interface various devices to the 8051 microcontroller
	CO5	Evaluate various enhancements in modern microcontrollers based on the ARM CORTEX cores

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**8051 Microcontroller Architecture**		6
	1.1	Introduction to the concepts of Microprocessors and Microcontrollers	1,2	
	1.2	Concept of Buses, Read/write operations, T state, Machine cycle and Instruction cycle	1,2	
	1.3	8051 Architecture	1,2	
	1.4	8051 Memory organization	1,2	
	1.4	RISC and CISC Concepts, Harvard and Von Neumann Architectures	1,2	
	1.5	Overview of various available Microcontrollers, Applications of Microcontrollers	1,2	
2		**Programming the 8051**		4
	2.1	Assembly language programming, Addressing modes	1,2	
	2.2	Embedded C programming concepts: Data types, Modifiers, Qualifiers, Functions, Macros, Interrupt service routines.	1,2	
3		**8051 Internal Hardware**		6
	3.1	I/O port programming	1,2	
	3.2	Timers/Counters programming	1,2	
	3.3	Serial port programming	1,2	
	3.4	Interrupts programming	1,2	

	3.5	Low power modes of the 8051	1,2	
4		**8051 Interfacing**		
	4.1	Display interfacing: LED, 16x2 generic alphanumeric LCD display.	1	6
	4.2	Analog devices interfacing: 8-bit ADC, 8-bit DAC, temperature sensor (LM35)	1	
	4.3	Motor interfacing: Relay, DC motor (speed control using PWM), Stepper motor and Servo motor.	1	
5		**ARM Cortex microcontrollers**		4
	5.1	Introduction to the ARM Cortex family	3	
	5.2	Salient features of ARM Cortex cores: RISC design, Operating modes and states, NVIC, Low power modes	3	
			Total	**26**

Course Assessment:

ISE-1:
Embedded C programming: Arithmetic /Logical operations, I/O port, Timer/Counter, Serial port [20 Marks]

ISE-2:
Embedded C programming: LCD Interfacing, Stepper motor interfacing, DC motor interfacing, Sensor Interfacing [20 Marks]

Note: In ISE 2, Interfacing with Arduino boards can be introduced

MSE: 30 Marks 90 minutes written examination based on 50% syllabus
ESE: 30 Marks 90 Minutes written examination based on remaining syllabus after MSE

Recommended Books

1.M.A.Mazidi, J.C.Mazidi, Rolin D. McKinlay,"The 8051 Microcontroller and Embedded Systems
Using Assembly and C", Pearson Education, Second Edition, 2007.
2. Kenneth J. Ayala, "The 8051 Microcontroller", Cengage Learning India Pvt. Ltd, Third Edition,
2005.
3.Joseph Yiu, "The Definitive guide to ARM CORTEX-M3 & CORTEX-M4 Processors", Elsevier, 2014, 3rd Edition.

Reference Books:
1.Raj Kamal, "Microcontrollers: Architecture, Programming, Interfacing and System Design", Pearson Education, 2009.
2. Manish K Patel, "The 8051 Microcontroller Based Embedded Systems", McGraw Hill, 2014.
3. Ajay V Deshmukh, "Microcontroller Theory And Applications ", Tata Mcgraw Hill, 2017

MULTIDISCIPLINARY MINOR (EMBEDDED WITH BASIC DEGREE)

Minor in Electronics Engineering: (Offered to Mech)

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25MDMEL1	Signals and System	L	T	P	L	T	P	Total
		2	--	--	2	--	--	2
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	

Pre-requisite Course Codes	Basic concepts of Mathematics	
Course Outcomes	CO1	Identify and differentiate between continuous and discrete time signals and systems
	CO2	Develop input output relationship for LTI systems
	CO3	Apply the concept of Laplace transform and understand conversion from time domain to frequency domain for continuous time systems.
	CO4	Apply the concept of Z transform and comprehend conversion from time domain to frequency domain for discrete time systems.
	CO5	Discuss various applications of signals and system

Module No.	Unit No.	Topics	Ref.	Hrs.
		Introduction to Signals and Systems	1,2,3,4	4
1	1.1	**Introduction to Signals:** Definition, Basic Elementary signals - exponential, sine, step, impulse, ramp, rectangular, triangular. Operations on signals. **Classification of Signals: A**nalog and discrete time signals, even and odd signals, periodic and non-periodic signals , deterministic and non-deterministic signals, energy and power signals. Arithmetic Operations on Signals, Time Shifting, Time Scaling, Time Reversal of Signals		
	1.2	**Systems and Classification of systems:** System Representation, continuous time and discrete systems, system with and without memory, causal and non-causal system, linear and nonlinear system, time invariant and time variant system, stable system		
		Time Domain Analysis of Continuous and Discrete Systems	1,2,3,4	6
2	2.1	Properties of Linear Time Invariant (LTI) systems, Impulse and Step Response		

	2.2	Use of Convolution Integral and Convolution Sum and Correlation for Analysis of LTI Systems		
	2.3	Properties of Convolution Integral/Sum		
		Laplace Transform and Continuous time LTI systems	1,2,3,4	6
3	**3.1**	Need of Laplace Transform, Concept of Region of Convergence,Properties of Laplace Transform, , unilateral Laplace Transform, inverse Laplace Transform.		
	3.2	**Analysis of continuous time LTI systems using Laplace Transform: C**ausality and stability of systems in *s*-domain, Total response of a system.		
		***z*-Transform and Discrete time LTI systems**	1,2,3,4	6
4	**4.1**	Need of *z*-Transform, *z*-Transform of finite and infinite duration sequences, Concept of Region of Convergence, *z*-Transform properties, Standard z-transform pairs, one sided z-Transform. Inverse z-Transform: Partial Fraction method only.		
	4.2	**Analysis of discrete time LTI systems using *z*-Transform**: Transfer Function, plotting Poles and Zeros of a transfer function , causality and stability of systems, Total response of a system		
		Applications of Signals and System		4
5	**5.1**	Electrical and Electronics Engineering Applications		
	5.2	Computer Science and IT Applications		
	5.3	Mechanical and Civil Engineering Applications		
	5.4	Robotics and IoT Applications		
			Total	**26**

Course Assessment:

Theory:

ISE-1:
Activity: Quiz and assignments 20 Marks
ISE-2:
Activity: Quiz and Assignments 20 Marks

MSE: 30 Marks written examination based on 50% syllabus (Duration:90 minutes)
ESE: 30 Marks written examination based on remaining syllabus after MSE (Duration:90 minutes)

Recommended Books:

1. Tarun Kumar Rawat, "Signals and Systems", Oxford University Press, 2016.
2. A. Nagoor Kani, "Signals and Systems", Tata McGraw-Hill Education, 2014.
3. Alan V. Oppenhiem, Alan S. Willsky and S. Hamid Nawab, Signals and Systems, Prentice-Hall of India, Second Edition, 2002.
4. Simon Haykin and Barry Van Veen, Signals and Systems, John Wiley and Sons, Second Edition, 2004.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
25MDMEL2	Digital Electronics	2	--	2	2	--	1	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Lab	20	–	30	–	50	

Pre-requisite Course Codes		Binary number system and codes, binary arithmetic
Course Outcomes	After the successful completion students should be able to	
	CO1	Compare TTL and CMOS families w.r.t. their characteristic parameters
	CO2	Construct combinational circuits using given MSI devices.
	CO3	Apply the knowledge of flip-flops and MSI devices to design sequential circuits.
	CO4	Analyze the given sequential circuits to identify the state transitions and race conditions.
	CO5	Implement the given logic function using programmable logic devices.

Module No.	Unit No.	Topics	Ref	Hrs.
1		**Implementation of Logic functions**		
	1.1	Logic gates, Implementation of functions using basic gates and using Universal gates	1,2, 3,4	4
	1.2	Formulating a logic function, Sum of Products (SOP), Product of Sums (POS), Minimization using Boolean Algebra, De Morgan's Theorems, Minimization using Karnaugh map (upto 4 variables), Quine-McClusky Technique	1,2, 3,4	
2		**Logic Families**		
	2.1	Characteristic parameters of logic families: Voltage and Current parameters, Fan in, Fan out, Noise margin, Power Dissipation, Propagation Delay	1,2, 3,4	3
	2.2	TTL NAND gate and its transfer characteristics, CMOS inverter and transfer characteristics, comparison of TTL and CMOS logic families		
3.		**Combinational Circuit Design**		
	3.1	Full adders, ripple carry adders, Carry Look ahead Adders, Binary Subtractors	1,2, 3,4	5
	3.2	Multiplexer/ Demultiplexer, Encoders, Priority Encoders, Parity Generators, Code Converters, comparator, ALU		
	3.3	Static and dynamic hazards in combinational circuits		
4 .		**Elements of Sequential Circuit**		
	4.1	Storage elements: Latches and Flip-flops (S-R, J-K, D, T Flip- flop), Master Slave Flip-flop	1,2, 3,4	5
	4.2	Synchronous and Asynchronous counters, Shift registers and their	1,2,	
		applications	**3,4**	

	Analysis of Sequential circuits	
5.1	Analysis of Moore and Mealy type Finite State Machines (FSM), State Reduction	**1,2, 3,4**
5.2	Introduction to Asynchronous Sequential circuits, Essential hazards in asynchronous sequential circuits	**1,2, 3,4**
	Programmable devices	
	Structure of Programmable Logic Devices (PLDs), Function implementation with PAL and PLAs, Introduction to CPLD and FPGA	**1,2, 3,4**
		Total **26**

Laboratory Experiments:

Sr. No.	Title of experiment	Module	Ref
1.	To implement the combinational logic for a given function using basic gates and Universal gates.	1	1,2
2.	To simulate a CMOS inverter and to plot the transfer characteristics (using SPICE)	2	1,2
3.	a. To verify the function of 8 bit binary adder IC7483 b. To implement a BCD adder using IC7483	3	1,2
4.	a. To implement the function of 8 bit Multiplexer using IC74151 b. To implement a given 4 variable Boolean function using Multiplexer IC 74151	3	1,2
5.	To implement an 8 bit binary comparator using IC 7485	3	1,2
6.	a. To implement a Mod n asynchronous counter using flip-flops b. To implement a Mod n counter using IC 74163	4	1,2
7.	Implementation of a combinational circuit using reconfigurable devices a. To write an HDL code for the parity generator and simulate verify the operation by simulation. b. To implement the HDL code on FPGA and verify the operation.	6	7,8
8.	Implementation of a sequential circuit using reconfigurable devices a. To write an HDL code for a 4 bit shift register and verify the operation by simulation. b. To implement the HDL code on FPGA and verify the operation.	6	7,8

Course Assessment:

Theory:

ISE-1: 20 marks

1. Quiz/ crossword -10 Marks
2. Open book test -10 marks

ISE-2: 20 Marks

1. Case study -10 Marks
2. Oral examination -10 marks

MSE : 90 Minutes 30 Marks written examination based on 50% syllabus

ESE : 90 Minutes 30 Marks written examination based on remaining syllabus after MSE

Lab:

40 Marks (08 experiments of 05 marks each) + 10 Marks (activity based) = 50 Marks

1. **ISE-1** will be conducted for four experiments. Continuous pre-defined rubrics-based **evaluation for 20 marks.**
2. **ISE-2**
   a. Four experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
   b. Activity based: Testing and debugging activity for 10 marks

Recommended Books:

1. John F. Wakerly, "Digital Design Principles and Practice"- Pearson Publications, 4th edition
2. Morris Mano, Michael D. Ciletti, " Digital Design with introduction to Verilog HDL" Pearson, 5th edition
3. John M. Yarbrough, "Digital Logic Applications and Design" – Thomson Publications
4. Stephen Brown and ZvonkoVranesic, "Fundamentals of digital logic design with Verilog design", McGraw Hill, 3rd Edition
5. Roth and Kinney, "Fundamentals of Logic Design", Cengage learning,7th edition
6. William I.Fletcher, "An Engineering Approach to Digital Design", PrenticeHall of India
7. J. Bhaskar, A Verilog HDL Primer, Third Edition, Star Galaxy Publishing
8. Sameer Palnitkar, "Verilog HDL: A guide to digital design and synthesis"

Online References:

https://archive.nptel.ac.in/content/storage2/courses/106108099//Digital%20Systems.pdf

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25MDMEL3	Microcontrollers and Applications	L	T	P	L	T	P	Total
		2	--	--	2	--	--	2
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	

Pre-requisite Course Codes	Digital Electronics, C programming	
	At the End of the course students will be able to:	
Course Outcomes (CO)	CO1	Explain the fundamental concepts of microcontrollers
	CO2	Develop programming skills for microcontrollers using Embedded C concepts
	CO3	Program various on-chip components of microcontrollers
	CO4	Interface various devices to the 8051 microcontroller
	CO5	Evaluate various enhancements in modern microcontrollers based on the ARM CORTEX cores

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**8051 Microcontroller Architecture**		6
	1.1	Introduction to the concepts of Microprocessors and Microcontrollers	1,2	
	1.2	Concept of Buses, Read/write operations, T state, Machine cycle and Instruction cycle	1,2	
	1.3	8051 Architecture	1,2	
	1.4	8051 Memory organization	1,2	
	1.4	RISC and CISC Concepts, Harvard and Von Neumann Architectures	1,2	
	1.5	Overview of various available Microcontrollers, Applications of Microcontrollers	1,2	
2		**Programming the 8051**		4
	2.1	Assembly language programming, Addressing modes	1,2	
	2.2	Embedded C programming concepts: Data types, Modifiers, Qualifiers, Functions, Macros, Interrupt service routines.	1,2	
3		**8051 Internal Hardware**		6
	3.1	I/O port programming	1,2	
	3.2	Timers/Counters programming	1,2	
	3.3	Serial port programming	1,2	
	3.4	Interrupts programming	1,2	

	3.5	Low power modes of the 8051	1,2	
4		**8051 Interfacing**		
	4.1	Display interfacing: LED, 16x2 generic alphanumeric LCD display.	1	6
	4.2	Analog devices interfacing: 8-bit ADC, 8-bit DAC, temperature sensor (LM35)	1	
	4.3	Motor interfacing: Relay, DC motor (speed control using PWM), Stepper motor and Servo motor.	1	
5		**ARM Cortex microcontrollers**		4
	5.1	Introduction to the ARM Cortex family	3	
	5.2	Salient features of ARM Cortex cores: RISC design, Operating modes and states, NVIC, Low power modes	3	
			Total	**26**

Course Assessment:

ISE-1:
Embedded C programming: Arithmetic /Logical operations, I/O port, Timer/Counter, Serial port [20 Marks]

ISE-2:
Embedded C programming: LCD Interfacing, Stepper motor interfacing, DC motor interfacing, Sensor Interfacing [20 Marks]

Note: In ISE 2, Interfacing with Arduino boards can be introduced

MSE: 30 Marks 90 minutes written examination based on 50% syllabus
ESE: 30 Marks 90 Minutes written examination based on remaining syllabus after MSE

Recommended Books

1.M.A.Mazidi, J.C.Mazidi, Rolin D. McKinlay,"The 8051 Microcontroller and Embedded Systems
Using Assembly and C", Pearson Education, Second Edition, 2007.
2. Kenneth J. Ayala, "The 8051 Microcontroller", Cengage Learning India Pvt. Ltd, Third Edition,
2005.
3.Joseph Yiu, "The Definitive guide to ARM CORTEX-M3 & CORTEX-M4 Processors", Elsevier, 2014, 3rd Edition.

Reference Books:
1.Raj Kamal, "Microcontrollers: Architecture, Programming, Interfacing and System Design", Pearson Education, 2009.
2. Manish K Patel, "The 8051 Microcontroller Based Embedded Systems", McGraw Hill, 2014.
3. Ajay V Deshmukh, "Microcontroller Theory And Applications ", Tata Mcgraw Hill, 2017

DOUBLE MINOR (DM) (OPTIONAL MINOR IN EMERGING AREAS)

VLSI Design and Verification (offered to Computer Engg. and CSE)

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		2	2	--	2	2	--	4
25DM11	VLSI Design Flow	Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Tut	20	--	30	--	50	

Pre-requisite Course Codes		--
Course Outcomes	CO1	Explore evolution of VLSI and VLSI Design flow
	CO2	Explain MOSFET Characteristics and CMOS Technology
	CO3	Write Verilog code for Digital Circuits using Industry-Standard EDA tools
	CO4	Explore emerging trends in VLSI CAD

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to VLSI Technology**	1, 2	4
	1.1	Evolution of VLSI, Moore's Law, current trends, applications, VLSI Design flow, EDA tools		
	1.2	VLSI design methodologies: Full-custom, Semi-custom, Standard-cell		
	1.3	India Semiconductor Industry and GoI policies		
2		**MOS Transistor Theory**	1	9
	2.1	MOSFET structure and operation, threshold voltage, Scaling		
	2.2	Concept of Inverter and types CMOS Inverter: DC characteristics, voltage transfer characteristics CMOS NAND and NOR schematic		
	2.3	Noise margins, power dissipation in CMOS circuits		
3		**Verilog HDL Basics**	2	6
	3.1	Need of HDL, Types of HDL Concept of design module and testbench		
	3.2	Verilog Program Structure, Language constructs, Verilog datatypes, Operators etc.		
4		**Design Modeling Styles and Emerging Trends**	2	
	4.1	Design Abstractions, Behavioral, Data flow, Gate level and Switch level modeling		7
	4.1	Low-power VLSI design AI/ML-driven VLSI design automation		
			Total	**26**

Recommended Books:

1. Sung-Mo (Steve) Kang, Yusuf Leblebici, "*CMOS Digital Integrated Circuits Analysis & Design*", McGraw-Hill Education
2. Samir Palnitkar "*Verilog HDL: A Guide to Digital Design and Synthesis*", Pearson
3. J. Bhasker, "Verilog HDL Synthesis, A Practical Primer".
4. S. H. Gerez, "VLSI Physical Design Automation: Theory and Practice"
5. Michel D. Ciletti "*Advanced Digital Design with Verilog HDL*" ,2nd Ed., PHI, 2009
6. Douglas J. Smith, "Verilog Designer's Library"
7. Some useful websites: AMD Xilinx, EDA Playground and ASIC World
8. Online Resources: NPTEL course on CAD for VLSI-
   https://archive.nptel.ac.in/courses/106/106/106106088/
   https://www.coursera.org/learn/vlsi-cad-logic
   http://www.facweb.iitkgp.ac.in/~isg/CAD/

Theory Assessment:

ISE-1: Article Reflection: **20 Marks**
MSE: 90 minutes **30 Marks** written examination based on 50% syllabus
ISE-2: Quiz: **20 Marks**
ESE: 90 minutes **30 Marks** written examination based on remaining syllabus after MSE

Tutorial Assessment:

Simulation experiments using EDA Playground and MATLAB HDL Coder

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25DM12	FPGA Programming	L	T	P	L	T	P	Total
		2	2	--	2	2	--	4
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Tut	20	--	30	--	50	

Pre-requisite Course Codes		--
Course Outcomes	CO1	Explain FPGA and SoC AMD Architecture
	CO2	Write Verilog HDL code for the given FSM
	CO3	Apply logic synthesis, optimization techniques and perform timing analysis
	CO4	Develop Real-World FPGA Applications.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to FPGA Technology**	1, 6	6
	1.1	Overview of FPGA design flow Comparison with ASIC, FPGA and SoC		
	1.2	FPGA architecture: 7-Series and UltraScale AMD FPGA		
	1.3	Introduction to Zynq and Zybo SoC		
	1.4	Applications of FPGA and SoC		
2		**Verilog HDL for FSM**	3-5	7
	2.1	Blocking vs. Non-blocking assignments, Latch inference and unintended issues, Timing constraints, setup & hold time, clock skew, Synthesis-friendly coding practices		
	2.2	Designing finite state machines (FSMs)		
3		**Logic Synthesis, Optimization and Physical Design Automation**	3-5	8
	3.1	Introduction to logic Synthesis, Logic synthesis of Verilog Construct, Examples of synthesis.		
	3.2	Design constraints: Area, Delay and Power, Optimization in synthesis. Post Synthesis verification		
	3.3	Physical Design Automation: Partitioning, Placement, and Floorplanning. Routing algorithms, Clock tree synthesis (CTS), Power planning and optimization		
4		**Case Studies**	1-2	
	4.1	Use of FPGA in real world applications for various sectors e.g. product design, healthcare, automotive, test and measurement etc.		5
			Total	**26**

Recommended Books:

1. Wayne Wolf, "*FPGA-Based System Design*" Prentice Hall
2. David Romano, "*Make: FPGA: Programming and Interfacing*".
3. Samir Palnitkar "*Verilog HDL: A Guide to Digital Design and Synthesis*", Pearson
4. J. Bhasker, "*Verilog HDL Synthesis, A Practical Primer*".
5. Michel D. Ciletti "*Advanced Digital Design with Verilog HDL*", 2nd Ed., PHI, 2009
6. Some useful websites: AMD Xilinx, EDA Playground and ASIC World

Theory Assessment:

ISE-1: Article Reflection: **20 Marks**
MSE: 90 minutes **30 Marks** written examination based on 50% syllabus
ISE-2: Quiz: **20 Marks**
ESE: 90 minutes **30 Marks** written examination based on remaining syllabus after MSE

Tutorial Assessment:

1. Experiment-1: FPGA Implementation of FSM (10 Marks)
2. Experiment-2: On contents of Chapter-3 (10 Marks)
3. Experiment-3: On contents of Chapter-3 (10 Marks)
4. Mini-Project (20 Marks)

DOUBLE MINOR (DM) (OPTIONAL MINOR IN EMERGING AREAS)

Internet of Things (offered to Comp, CSE and Mech)

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25DM21	Sensors and Actuators	L	T	P	L	T	P	Total
		2	2	--	2	2	--	4
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Tut.	20	--	30	--	50	

Pre-requisite Course Codes	Electronic Devices, Analog Electronics, VLSI Design	
Course Outcomes	CO1	Understand the concept of sensors and actuators and their characteristics
	CO2	Understand the practical approach in design of technology based on different sensors and actuators
	CO3	Learn various sensor materials and technology used in designing sensors and actuators
	CO4	Implement a prototype for demonstrating the application of the sensors
	CO5	Demonstrate problem solving & troubleshooting skills in sensor and actuator applications

Module No.	Unit No.	Topics	Ref.	Hrs.
1 Fundamentals Sensors and Actuators	**1.1**	Sensor Classification – Physicals, Mechanical, Electrical, Chemical, electrochemical	1,2	5
	1.2	Functional unit of sensor: receptor and transducer; Units of Measurements	1,2	
	1.3	Sensor and actuator Characteristics, Physical Principles of Sensing Electric Charges, Fields, and Potentials; Capacitance; Magnetism; Induction; Resistance; Piezoelectric Effect; Hall Effect; Temperature and Thermal Properties of Material; Heat Transfer; Light; Dynamic Models of Sensor Elements	1,2	
2 Interface Electronic Circuits	**2.1**	Input Characteristics of Interface Circuits, Amplifiers, Excitation Circuits	1,2	5
	2.2	Analog to Digital Converters, Direct Digitization and Processing, Bridge Circuits, Data Transmission, Batteries for Low Power Sensors	1,2	
	2.3	Analog and digital filtering	1,2	
3 Sensors and actuators in Different Application	**3.1**	Area Occupancy and Motion Detectors; Position, Displacement, and Level; Velocity and Acceleration; Force, Strain, and Tactile Sensors; Pressure Sensors	1,2,3	6
	3.2	Temperature Sensors; Biosensors, Gas sensors, proximity sensor. (Correlation of output with the parameter being measured in engineering terms): Only Working principle of each type of sensors and transduction action (for example: detection of change in temperature and conversion to electrical quantity say resistance and corresponding correlation) , Few examples of actuators: Relay, Solenoid Valve, Motors etc.	1,2,3	
	3.3	Case study of Applications of sensors and actuators in automotive, manufacturing plants, digital devices such as mobile phone, house-hold instrument such as washing machine	1,2,3	

		(name of various sensors and their usability in each of these applications).		
4 Sensor and Actuators: Materials and Technologies	**4.1**	MEMS-cantilever based sensors and their types such as, accelerometer, gyroscopes: Structure, material used (polysilicon, Silicon etc), working principle, applications.	2,3	5
	4.2	Metal oxide semiconductor (nano-particles) based sensors such as gas sensors, biomedical sensors, chemical sensors (Structure, material used, working principle, applications)	2,3	
	4.3	MEMS-cantilever based sensors and their types such as, accelerometer, gyroscopes: Structure, material used working principle, Micromotors etc.	2,3	
5 Smart Sensors Industrial standards for the sensors /actuators and its calibration	**5.1**	4-20 mA Current Loop, Types of smart Sensors, Limitations of single sensor and applicability of Array-based sensor technology, Electronic-Nose sensors	2,4	5
	5.2	HART, Industrial buses such as Profibus, CAN bus, etc. ISA S82.01, NEMA standards, The International Electro-Technical Commission (IEC)	2,4	
	5.3	Different Standards, Calibration and compatibility. Knowledge of terms such as accuracy, full scale, hysteresis, resolution, gain error, offset error, SNR etc.	2,4	
			Total	**26**

Course Assessment:

Theory:

ISE-1:

Activity: Model making for Sensor/Actuators: 20 Marks

ISE-2:

Activity: 1. Standards based Quiz/ crosswords: 10 Marks

2. Article Discussion: Outcome: Reflective Journal: 10 Marks

MSE: 90 minutes 30 Marks written examination based on 50% syllabus

ESE: 90 minutes 30 Marks written examination based on remaining 50% syllabus

Recommended Books:

1. J. Fraden, Handbook of Modern Sensors: Physical, Designs, and Applications, AIP Press, Springer
2. D. Patranabis, Sensors and Transducers, PHI Publication, New Delhi
3. Mechatronics- Ganesh S. Hegde, Published by University Science Press (An imprint of Laxmi Publication Private Limited).
4. Metal Oxide Nanostructures as Gas Sensing Devices (Series in Sensors Book 7), G. Eranna (Author), Publisher: CRC Press

Online Resources:

1. Website link: www.nptel.ac.in

Tutorial

ISE 1:

1. Experiment no.1. Classification of different sensors (Analog / Digital)
2. Experiment no. 2. Actuators and drivers required
3. Experiment no.3. Design of KRC filters (Active 1st and 2nd order)
4. Experiment no.4. Design of 4-20mA Current loop.
5. Experiment no.3. Design of Instrumentation Amplifier for a given gain

ISE 2:

Activity based on Standards and Calibration.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25DM22	Fundamentals of IoT	L	T	P	L	T	P	Total
		2	2	-	2	2	-	4
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Tut	20	--	30	--	50	

Pre-requisite Course Codes		
Course Outcomes	CO1	Explain the IoT architecture, protocols, and communication technologies. *(Understand)*
	CO2	Identify and interface sensors, actuators, and microcontrollers for IoT applications. *(Apply)*
	CO3	Develop IoT-based systems using ESP32/Raspberry Pi with cloud integration. *(Create)*
	CO4	Analyze IoT security challenges and propose suitable solutions. *(Analyze)*
	CO5	Design and test an end-to-end IoT project for a real-world application. *(Evaluate, Create)*

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Module 1: Introduction to IoT and Industry 4.0**	1,2,5	4
	1.1	Concepts of IoT: Architecture, protocols, and standards..		
	1.2	IoT Communication Technologies (Wi-Fi, Bluetooth, Zigbee, LoRa, NB-IoT)		
	1.3	MQTT, CoAP, HTTP		
2		**Module 2: Sensors, Actuators, and Microcontrollers (6 Hours)**	1,2	6
	2.1	Types of Sensors (Temperature, Humidity, Pressure, Motion, etc.)		
	2.2	Actuators: DC Motors, Relays, Servo Motors		
	2.3	Microcontrollers: ESP32, Raspberry Pi, Arduino		
	2.4	Data Acquisition and Processing		
3		**Module 3 IoT Protocols and Communication**	1,2,5	6
	3.1	Introduction to MQTT, CoAP, HTTP, and WebSockets		
	3.2	Message Queue Telemetry Transport (MQTT) and Publish-Subscribe Model		
	3.3	Data Transmission using HTTP and REST APIs		
		Module 4: IoT Cloud Platforms ,Data Analytics Security ,Privacy in IoT	1,3,5	4
4	4.1	IoT Cloud Platforms: Thingspeak, Firebase, AWS IoT		
		Data Analytics: Role of big data and machine learning in IoT. Visualization Tools: Grafana, Tableau, and Power BI.		

	4.2	IoT Data Lifecycle: Acquisition, transmission, storage, and visualization		
	4.3	IoT Databases: Time-series databases and NoSQL		
	4.4	IoT Security Challenges and Threats, Encryption Techniques: AES, RSA, TLS, Secure Authentication & Data Protection in IoT		
		Module5:,IoT Applications, Future Trends and Emerging Technologies	4,5	6
5	**5.1**	Smart Manufacturing: Automation, predictive maintenance, and robotics.		
	5.2	IoT in Logistics and Supply Chain: RFID, smart tracking, and inventory management.		
	5.3	IoT in Renewable Energy: Smart grids, monitoring, and optimization		
	5.4	AI in IoT: Role of machine learning and deep learning. 5G and IoT: Opportunities and challenges. Edge AI: Combining IoT devices with AI at the edge. Sustainability in IoT: Energy-efficient frameworks and green IoT.		
	5.5	Smart Manufacturing: Automation, predictive maintenance, and robotics.		
			Total	**26**

Module No.	**Sr.no**	**Suggested List of Tutorials**	**Ref.**	**Hrs.**
1	**1**	**Sending ESP32 Sensor Data to Thingspeak Visualisation(Use Tinkercad Simulation Platform)** • Upload temperature & humidity data to Thingspeak • View real-time plots on Thingspeak dashboard		2
2	**2**	**Setup and Configuration of an IoT Development Board** Objective: Install and configure ESP32 or Raspberry Pi for IoT projects. Tools: Arduino IDE, Python.		2
3	**3**	**Implement MQTT for Sensor Data Communication** Objective: Transmit real-time sensor data to a cloud platform using MQTT. Tools: MQTT.fx, HiveMQ.		2
4	**4**	**Compare IoT Protocols (CoAP vs. MQTT)** Objective: Analyze energy consumption and latency differences between protocols. Tools: Python, Wireshark.		2
5	**5**	**LoRa Communication Setup** Objective: Establish communication between two LoRa nodes and measure range. Tools: LoRa modules, Arduino IDE.		2
6	**6**	**Interfacing Sensors and Actuators**		2

		Objective: Interface temperature, humidity, and motion sensors with ESP32 to trigger an actuator. Tools: Arduino IDE, Blynk App.		
7	**7**	**Build a Smart Home Automation System** Objective: Control appliances using voice commands via Google Assistant. Tools: ESP32, Node-RED, Google API**.**		4
8	**8**	**IoT-Based Energy Monitoring** Objective: Monitor and analyze household energy consumption in real-time. Tools: ESP32, Current Sensor, ThingSpeak.		4
9	**9**	**Integrating ESP32 with Google Firebase:**Send & retrieve sensor data from Firebase Realtime Database **Logging IoT Data to Google Sheets using ESP32 & IFTTT** Automate data logging to Google Sheets via IFTTT **IoT Data Visualization Using Grafana** Objective: Collect sensor data and visualize it in Grafana dashboards. Tools: InfluxDB, Grafana.		4
10	**10**	**Real-Time IoT Data Analytics** Objective: Perform basic analytics on IoT data (e.g., finding temperature trends). Tools: Python, Pandas, Matplotlib.		2
			Total	**26**

Course Assessment:

Theory:

ISE-1:
Activity: Quiz and assignments 10 Marks
Case Study Presentation
ISE-2: Two hours 10 Marks
Activity: Article Discussion, Quiz and Assignments
Outcome: Reflective Journal

MSE: 90 minutes30 Marks written examination based on 50% syllabus
ESE: 90 minutes 30Marks (remaining 50% syllabus) written examination based on entire syllabus

Lab:

ISE:
1. ISE-1 will be conducted for four or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2
a. Remaining Four experiments or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 30 marks.
b. Simulation using modern tools to solve the given problem statement for 10 marks/Mini project

Recommended Books:

1. **Arshdeep Bahga, Vijay Madisetti "Internet of Things: A Hands-On Approach"** Publisher: Orient Blackswan Private Limited - New Delhi
2. Peter Waher, "Mastering Internet of Things: Design and Create Your Own IoT Applications", Packt Publishing (March 28, 2018); eBook (Free Edition)
3. Perry Lea," "IoT and Edge Computing for Architects: Implementing Edge and IoT Systems from Sensors to Clouds with Azure IoT and AWS IoT Core", Publisher(s): Packt Publishing ISBN: 9781839214806
4. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Publisher New York, NY : Apress
5. David Hanes, Gonzalo Salgueiro, Rob Barton," IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things" Released June 2017Publisher(s): Cisco Press ISBN: 978013430709

Online Resources:

6. https://onlinelibrary.wiley.com/doi/book/10.1002/9781119740780?msockid=0d711fd0b87062382ca90a8bb9c26374(Print ISBN:9781119740759 |Online ISBN:9781119740780 |DOI:10.1002/9781119740780)

Further Reading:

1. Adrian McEwen, Hakim Cassimally, "Designing the Internet of Things"
2. Klaus Schwab, "The Fourth Industrial Revolution"

DOUBLE MINOR (DM) (OPTIONAL MINOR IN EMERGING AREAS)

Automation and Robotics (offered to Comp, CSE and ECS)

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		2	2	--	2	2	--	4
25DM31	Introduction to CAD/CAM	Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes	Basics of Mathematics.	
Course Outcomes	CO1	Use of computer graphics in design.
	CO2	Understand Fundamental Concepts geometric transformation.
	CO3	Apply parametric equations for curve and surface generation.
	CO4	Understand the fundamental principles, components, and working of CNC machines.
	CO5	Apply the appropriate code for performing particular tasks in a CNC.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction to CAD:** Need and Utility of CAD systems in industry, Fundamentals of computer graphics, Types of Geometric Modelling, **Raster Graphics:** line and circle algorithm.	1-8	6
2	2.1	**Geometric Transformation:** Homogenous Transformation (2D Translation, scaling, Reflection, Rotation)	1-8	6
	2.2	Window Viewport and Clipping.		
3	3.1	**Curves And Surfaces:** Cubic spines Bezier curves & B- spines (No Numerical).	1-8	4
	3.2	CAD Application software's, Product data exchanges formats (STEP, IGES)		
4	4.1	**CNC Machines:** Fundamental elements of CNC, Benefits of CNC, Computer control concepts, Data processing units. **Basics of control systems:** Motion controller, Interpolation-Linear & Circular, Positioning & contouring control loops, Incremental & Absolute system, DNC & CNC systems and Adaptive control system. **CNC Hardware Basics:** CNC drives, Spindle design, Actuation and Feedback devices.	1-8	4

5	**5.1**	**CNC Programming and simulation:** G & M code, Tool length, nose radius & Diameter compensation, Canned cycles, Turning & Machining centre programming. CAM simulation software.	1-8	6
			Total	**26**

Tutorial:

Sr. No.	Tutorial Details	Hours
1	Line DDA algorithm numerical.	**01**
2	Bresenham's Line Algorithm.	**01**
3	Circle Algorithm.	**01**
4	2 D transformation using translation and Rotation matrix.	**01**
5	Compound 2 D transformation.	**01**
6	Bezier Curve.	**01**
7	Turning Centre (Sinumerik)Programming.	**01**
8	Machining Centre (Fanuc) Programming.	**01**
	Total Hours	**08**

Course Assessment:

Theory:

ISE-1:
Activity: Quizzes/Assignment on first two modules (20 Marks)

ISE-2:
Activity: Quizzes/Assignment on last three modules (20 Marks)

MSE: 90 minutes 30 Marks written examination based on 50% syllabus

ESE: 90 minutes 30 Marks written examination based on remaining syllabus after MSE

Tutorial:

1. **ISE-1**
   First Four tutorials (20 marks)
   Continuous pre-defined rubrics-based evaluation for 20 marks.
2. **ISE-2**

i. Next four tutorials (30 marks)
Continuous pre-defined rubrics-based evaluation for 30 marks

Recommended Books:

1. *CAD/CAM* by Groover and Zimmers
2. *CAD Principles and Applications* by Barr, Krimger and Lazaer
3. William M Neumann and Robert F.Sproul "*Principles of Computer Graphics*", Mc Graw Hill Book Co. Singapore, 1989.
4. Donald Hearn and M. Pauline Baker "*Computer Graphics*", Prentice Hall, Inc., 1992.
5. Foley, Wan Dam, Feiner and Hughes – *Computer graphics principles & practices, Pearson Education – 2003.*
6. CAD / CAM by P.N. Rao (Tata-Mcgraw- Hill) 2
7.*Computer Graphics* by Hearn and Baker (PHI)
8. *Mastering CAD – CAM* by Ibarahim Zeid (Tata-Mcgraw-Hill) 4

Links for online NPTEL/SWAYAM courses:

1. https://nptel.ac.in/courses/112/102/112102101/
2. https://nptel.ac.in/courses/106/102/106102065/
3. https://nptel.ac.in/courses/106/102/106102065/
4. https://nptel.ac.in/courses/112/102/112102103/
5. https://nptel.ac.in/courses/112/105/112105211/
6. https://nptel.ac.in/courses/112/104/112104265/
7. https://www.youtube.com/watch?v=2cCMty9v3Tg
8. https://www.youtube.com/watch?v=2zPh26Q1BT8

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25DM32	3D Printing	L	T	P	L	T	P	Total
		2	2	--	2	2	--	4
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes	Basic Engineering Drawing & Design.	
Course Outcomes	CO1	Illustrate understanding of various cost-effective alternatives for manufacturing products and select the feasible 3D Printing for specific technical application
	CO2	Understand and apply the principles of liquid-based rapid prototyping and tooling processes to build and generate data for 3D printing of various objects.
	CO3	Understand and apply the principles of solid-based rapid prototyping systems for efficient 3D printing and product development.
	CO4	Understand and apply the principles of powder-based additive manufacturing systems for efficient prototyping and production of complex geometries.
	CO5	Understand and apply reverse engineering techniques in 3D printing to reconstruct, modify, and optimize existing designs for manufacturing and prototyping.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	Introduction to 3D printing, its historical development, advantages. Classification of 3D printing process, Advantages & Disadvantages, Applications to various fields, Rapid Tooling, Design Consideration.	1-8	6
2	2.1	**Liquid-Based Systems:** Stereolithography (SLA): Photopolymerization process, Working Principle, Advantages and limitation, Application	1-8	6
	2.2	Solid ground curing: Working Principle, Advantages and limitation, Application.		
3	3.1	**Solid Based Rapid Prototyping Systems:** LOM (Laminated Object Manufacturing) System: Working Principle, Advantages and limitation, Application.	1-8	4
	3.2	FDM (Fused Deposition Modelling) System: Working Principle, Advantages and limitation, Application.		
	4.1	**Powder Based Systems:**		

4		SLS (Selective Laser Sintering):Working Principle, Advantages and limitation, Application.	1-8	6
	4.2	(3DP) Three-Dimensional Printing: Working Principle, Advantages and limitation, Application.		
	4.3	(EBM) Electron Beam Melting: Working Principle, Advantages and limitation, Application.		
5	**5.1**	**Reverse Engineering:** Data Extraction, Data Processing**.** **Applications and Case Studies:** Engineering Applications, Medical Applications.	1-8	4
			Total	**26**

Tutorial:

Sr. No.	Tutorial Details	Hours
1	Preprocessing of 3d Print Component.	**01**
2	3D Printing of Component.	**01**
3	Case study on SLA.	**01**
4	Case study on LOM.	**01**
5	Case study on FDM.	**01**
6	Case study on SLS.	**01**
7	Case study on 3DP.	**01**
8	Case study on EBM.	**01**
	Total Hours	**08**

Course Assessment:

Theory:

ISE-1:

Activity: Quizzes/Assignment on first two modules (20 Marks)

ISE-2:

Activity: Quizzes/Assignment on last three modules (20 Marks)

MSE: 90 minutes 30 Marks written examination based on 50% syllabus

ESE: 90 minutes 30 Marks written examination based on remaining syllabus after MSE

Tutorial:

ISE-1

First Four tutorials (20 marks)

Continuous pre-defined rubrics-based evaluation for 20 marks.

ISE-2

Next four tutorials (30 marks)

Continuous pre-defined rubrics-based evaluation for 30 marks

Recommended Books:

1. Chua C.K., Leong K.F., and Lim C.S., "Rapid Prototyping Principles and Applications",
2. World Publishing Co. Pte. Ltd.
3. Gibson, D.W. Rosen, and B. Stucker, "Additive Manufacturing Technologies Rapid
4. Prototyping to Direct Digital Manufacturing", 2010, Springer Inc.
5. Ali Kamrani, EmadAbouel Nasr, "Rapid Prototyping Theory and Practice", 2006, Springer

6. RafiqNoorani, Rapid Prototyping: Principles and Applications, John Wiley & Sons, Inc., 2006, ISBN 0-471-73001-7
7. James O. Hamblen, and Michael D. Furman, "Rapid Prototyping of Digital Systems", Kluwer Academic Publishers.
8. Kenneth G. Cooper, "Rapid Prototyping Technology Selection and Application", 2001, Marcel Dekker Inc, New York.

Links for online NPTEL/SWAYAM courses:

1. https://onlinecourses.nptel.ac.in/noc24_me138/preview
2. https://onlinecourses.nptel.ac.in/noc22_me74/preview
3. https://onlinecourses.nptel.ac.in/noc22_me130/preview
4. https://onlinecourses.nptel.ac.in/noc25_mm02/preview

DOUBLE MINOR (DM) (OPTIONAL MINOR IN EMERGING AREAS)

Sustainability (offered to all)

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25DM41	Design Thinking for Sustainability	L	T	P	L	T	P	Total
		2	2	--	2	2	--	4
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Tut	20	--	30	--	50	

This course explores how Design Thinking methodologies can drive sustainable innovation across various sectors. By integrating human-centered design, systems thinking, and circular economy principles, students will learn to develop solutions that address environmental, social, and economic challenges while fostering long-term sustainability.

Pre-requisite Course Codes		--
Course Outcomes	CO1	Explain the principles of Design Thinking and their application to sustainable innovation
	CO2	Apply problem-solving techniques to address sustainability challenges
	CO3	Apply systems thinking and circular economy principles to sustainable product and service design
	CO4	Develop prototypes and iterative solutions to sustainability challenges.
	CO5	Use collaborative, interdisciplinary approaches to problem-solving

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Ancient Indian Sustainable Practices in Engineering and Management** Overview of insights into sustainable solutions in construction, energy, materials, water management, transportation, and financial management	1	2
	1.2	**Introduction to Design Thinking for Sustainability** Overview of Design Thinking principles (Empathize, Define, Ideate, Prototype, Test). Fundamentals of sustainability in design. Importance of sustainability in innovation and problem-solving. Case studies of successful sustainable design projects. UN SDGs and their role in design.	2-3	3
2	2.1	**Human-Centered & Systems Thinking for Sustainability** Understanding user needs and behavior for sustainable solutions. Empathy in sustainable design – Ethical considerations and inclusivity. Systems thinking approach – How different systems interact in sustainable development. Tools for mapping stakeholder impact and environmental consequences.	2-3	3
	2.2	**Problem Framing & Identifying Sustainability Challenges** Defining real-world sustainability challenges. Conducting sustainability-focused design research.	2-3	5

		Life Cycle Thinking (LCT) – Cradle-to-cradle design and environmental impact analysis. Problem framing techniques – How to ask the right sustainability questions. Integrating biodiversity into design – Living walls, urban forests, pollinator-friendly spaces Passive design strategies– Natural ventilation, daylighting, thermal mass. Green buildings and materials– LEED, BREEAM, IGBC certification. Net-zero and energy-efficient buildings – Smart homes, solar panels, green roofs. Sustainable urban planning– Smart cities, transit-oriented development, walkable communities.		
3	**3.1**	**Ideation for Sustainable Innovation** Brainstorming for green solutions– Ideation techniques for sustainability. Biomimicry in sustainable design– Learning from nature's solutions. Regenerative and resilient design principles. Case studies – Sharkskin-inspired materials, termite-inspired ventilation, lotus-effect coatings.	4	4
	3.2	**Prototyping & Testing for Sustainability** Creating low-impact prototypes using sustainable materials. Digital prototyping and simulation tools for eco-friendly design. Evaluating sustainability impact and feasibility in prototypes. Rapid testing and iteration for scalable, sustainable solutions.	2-4	3
4	**4.1**	**Circular Economy & Sustainable Business Models** Principles of the circular economy and zero-waste design. Business models for sustainability– Social enterprises, green start-ups, and impact investing. Sustainable product-service systems (PSS)	5	2
	4.2	**Sustainable Innovation in Different Sectors** Sustainable architecture & urban planning – Green buildings, smart cities. Eco-friendly product design – Sustainable packaging, furniture, and technology. Sustainable fashion and textiles – Ethical sourcing, upcycling, slow fashion. Green transportation and mobility solutions – EVs, bike-sharing, public transport innovations.	2-5	2
	4.3	**Digital Technologies & Sustainability** Sustainable UX/UI design – Reducing digital carbon footprint. AI and IoT in smart sustainability solutions. Blockchain for supply chain transparency and sustainability tracking. 3D printing and additive manufacturing for zero-waste production.		2

Total	**26**

Recommended Books:

1. B Mahadevan, Vinayak Rajat Bhat, Nagendra Pavana R. N., "*Introduction to Indian Knowledge System: Concepts and Applications*" PHI, 2022
2. Idris Mootee *Design Thinking for Strategic Innovation*
3. William McDonough & Michael Braungart *Cradle to Cradle: Remaking the Way We Make Things*
4. Janine Benyus *Biomimicry: Innovation Inspired by Nature*
5. Peter Lacy, Jessica Long, Wesley Spindler *The Circular Economy Handbook*
6. IDEO's *Design Thinking Toolkit for Sustainability*

Theory Assessment:

ISE-1: Case studies of sustainable innovations in different industries **20 Marks**
MSE: 90 minutes **30 Marks** written examination based on 50% syllabus
ISE-2: Case studies of companies using circular economy models: **20 Marks**
ESE: 90 minutes **30 Marks** written examination based on remaining syllabus after MSE

Tutorial Assessment:

Activity-1: Complex Problem Solving using Design Thinking principles **(20 Marks)**
Activity-2: Create a campaign to promote sustainability **30 Marks**

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25DM42	Green Computing	L	T	P	L	T	P	Total
		2	2	--	2	2	--	4
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Tut	20	--	30	--	50	

Green computing focuses on environmentally sustainable computing practices. This course covers energy-efficient hardware, software, and system designs, as well as strategies for reducing IT's environmental footprint.

Pre-requisite Course Codes		--
Course Outcomes	CO1	Explain the fundamentals of green computing and sustainability
	CO2	Explain energy-efficient computing technologies
	CO3	Explore designs and energy management techniques for green data center and sustainable materials in Electronics
	CO4	Explain strategies for development of green hardware and software
	CO5	Explain policies, standards and regulations for sustainability
	CO6	Identify future trends in green computing

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction to Green Computing** Definition and scope of green computing Environmental impact of computing and IT systems The need for sustainable computing practices Life cycle assessment of computing devices	1,2	3
	1.2	**Energy-Efficient Computing** Energy consumption in computing devices Power management techniques in hardware and software Energy-efficient processors and architectures Low-power computing techniques (e.g., Dynamic Voltage and Frequency Scaling - DVFS) Virtualization and cloud computing for energy optimization	1,2	3
2	2.1	**Green Data Centers and Cloud Computing** Energy-efficient data center architectures Energy-efficient cooling and thermal management Renewable energy integration in data centers Sustainable cloud computing practices	1,2	3
	2.2	**Sustainable Materials in Electronics** Environmental impact of traditional materials in electronics Biodegradable and recyclable materials for hardware components Alternative materials to reduce toxic waste (e.g., lead-free soldering, bio-plastics) Sustainable circuit board manufacturing (e.g., bio-resin PCBs)	1,2	4

		E-waste management and recycling Reducing E-Waste Through Material Innovation		
3	**3.1**	**Sustainable Hardware** Design and manufacturing of eco-friendly hardware Upgradeability and modular design Energy-efficient storage and networking devices Recycling and refurbishing computing devices Green supply chain and procurement strategies	1,2	4
	3.2	**Green Software Development** Energy-efficient programming techniques Optimized algorithms for power-aware computing Power-aware computing in mobile and embedded systems	1,2	3
4	**4.1**	**Policies, Regulations, and Industry Standards** Global sustainability standards (e.g., Energy Star, EPEAT, ISO 14001) WEEE (Waste Electrical and Electronic Equipment) directive Government regulations on IT sustainability Corporate sustainability initiatives Green IT frameworks and assessment tools	1,2	3
	4.2	**Future Trends and Research in Green Computing** AI and machine learning for energy-efficient computing Blockchain and green IT solutions IoT and smart grids for sustainable computing Future of green technology	3,4,5	3
			Total	**26**

Recommended Books:

1. Bud E. Smith Green *Computing: Tools and Techniques for Saving Energy, Money, and Resources*, 1st Edition, CRC Press
2. Toby J. Velte, Anthony T. Velte, Robert Elsenpeter *Green IT: Reduce Your Information System's Environmental Impact While Adding to the Bottom Line*, 1st Edition, McGraw Hill Osborne Media
3. Wu-chun Feng *Green Computing Book*, 1st Edition, CRC Press
4. Sourav Banerjee, Chinmay Chakraborty, Kousik Dasgupta *Green Computing and Predictive Analytics for Healthcare*, 1st Edition, Chapman & Hall
5. Stephen Peake *Renewable Energy: Power for a Sustainable Future*, Oxford University Press, 3rd Edition
6. Research papers and case studies from IEEE, ACM, and sustainability journals

Theory Assessment:

ISE-1: Article Reflection: **20 Marks**
MSE: 90 minutes **30 Marks** written examination based on 50% syllabus
ISE-2: Quiz: **20 Marks**
ESE: 90 minutes **30 Marks** written examination based on remaining syllabus after MSE

Tutorial Assessment:

Activity-1: Case Study (20 Marks) on one of following topic (not limited to)-

1. Sustainable data centers
2. Sustainable software solutions
3. Best practices from major IT manufacturers
4. Companies adopting sustainable materials (e.g., Dell, HP)
5. Energy-efficient hardware initiatives from companies (e.g., Apple, Google, Microsoft)
6. Innovations in reducing toxic waste in electronics
7. Success stories in reducing hardware-related carbon footprints

Activity-2: Green Digital Certificate:**30 Marks**

Complete Online Certificate Course (and submit certificate) from INCO Academy: This Self- paced online Free Course equips learners with the knowledge and skills to build sustainable digital solutions.
(https://greendigitalcertificate.inco-group.co/course)

DOUBLE MINOR (DM) (OPTIONAL MINOR IN EMERGING AREAS)

Data Science (offered to ECS, Mech)

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25DM51	Statistics for Data Science	L	T	P	L	T	P	Total
		2	2	0	2	2	--	4
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes		BSC11ME01, BSC11ME03, VSE11ME02
Course Outcomes	CO1	Apply basic statistical techniques to any given structured data base and summarize it
	CO2	Use discrete and continuous probability distribution to solve mathematical problems based on it
	CO3	**Use appropriate sampling method for any real world case study**
	CO4	Apply hypothesis testing techniques to real world scenarios and draw meaningful conclusions.
	CO5	Conduct analysis of variance by constructing ANOVA table for one way and two way ANOVA

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction**	1,3	5
	1.1	Data and Statistics: Elements, Variables, and Observations, Scales of Measurement, Categorical and Quantitative Data, Cross-Sectional and Time Series Data, Descriptive Statistics, Tabular and Graphical Summarizing of Categorical Data, Summarizing of Quantitative Data, Cross Tabulations and Scatter Diagram.		
	1.2	Numerical Measures: Measures of Location, Measures of Variability, Measures of Distribution Shape, Relative Location, and Detecting Outliers, Box Plot, Measures of Association Between Two Variables, Scatter plot, QQ plot		
2		**Probability**	1,3	5
	2.1	Probability: Experiments, Counting Rules, and Assigning Probabilities, Events and Their Probabilities, Complement of an Event, Addition Law Independent Events, Multiplication Law, Baye's theorem		
	2.2	Discrete Probability Distributions: Random Variables, Discrete Probability Distributions, Expected Value and Variance, Binomial Probability Distribution, Poisson Probability Distribution		
	2.3	Continuous Probability Distributions: Uniform Probability Distribution, Normal Curve, Standard Normal Probability		

		Distribution, Computing Probabilities for Any Normal Probability Distribution		
3		**Sampling**	1,3	4
	3.1	Sampling from a Finite Population, Sampling from an Infinite Population, Other Sampling Methods, Stratified Random Sampling, Cluster Sampling, Systematic Sampling, Convenience Sampling, Judgment Sampling, parameter and statistic, standard error of statistic, sampling and non-sampling errors, Central Limit theorem		
	3.2	Interval Estimation: Point estimation, Confidence Intervals, Student's t-Distribution,		
4		**Hypothesis Tests**	1,3	7
	4.1	Developing Null and Alternative Hypotheses, Type I and Type II Errors, Population Mean: Known, Population Mean: Unknown, Inference About Means and Proportions with Two Populations, Inferences About Population Variances		
	4.2	Chi-Square Distribution, Tests of Goodness of Fit, Multinomial Population, Test of Independence		
5		**The Analysis of Variance (ANOVA)**	1,3	5
	5.1	F distribution, Variance analysis in One way classification, Variance analysis in Two way classification		
			Total	**26**

Course Assessment:

Theory:

ISE-1: 20 Marks
Activity: Any two activities like quiz/ Assignments/crossword/ oral/case study on initial 50% syllabus
ISE-2: 20 Marks
Activity: Any two activities like quiz/ Assignments/crossword/ oral/case study on remaining 50% syllabus

MSE : 30 Marks written examination based on 50% syllabus
ESE : 30 Marks written examination based on remaining syllabus

Tutorial:

ISE-1: 20 Marks
Evaluation based on first four tutorials
ISE-2: 30 Marks
Evaluation based on next six tutorials

Topics for Tutorial
Tutorial 1: Calculate statistical measures for any real world available data using python
Tutorial 2: Show different graphs (scatter plot, box plot and QQ plot) for the given data using python
Tutorial 3: Problem solving for binomial/Poisson distribution
Tutorial 4: Problem solving for Normal Probability Distribution
Tutorial 5: Case study on sampling
Tutorial 6: Central limit theorem quiz
Tutorial 7: Hypothesis testing (one population problem solving)
Tutorial 8: Hypothesis testing(two population problem solving)
Tutorial 9: Quiz/tutorial on chi square testing
Tutorial 10: programming of ANOVA using any software

Recommended Books:

1. David R. Anderson, Dennis J. Sweeney, Thomas A. Williams "Statistics For Business And Economics"11th Edition, South-Western, Cengage Learning
2. John A. Rice , "Mathematical Statistics and Data Analysis", University of California, Berkeley,Thomson Higher Education
3. S.C. Gupta, V.K. Kappor, "Fundamentals Of Mathematical Statistics (A Modern Approach)" Tenth Revised Edition, Sultan Chand & Sons Educational Publishers New Delhi
4. Jay L. Devore, "Probability and Statistics for Engineering and the Sciences", Cengage Publication.
5. O'Reilly Media, Wes McKinney, "Python for Data Analysis", 2nd Edition, O'Reilly Media, Wes McKinney.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25DM52	Data Analytics and Visualization	L	T	P	L	T	P	Total
		2	2	0	2	2	--	4
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes		BSC11ME01, BSC11ME03, DM51
Course Outcomes	CO1	Comprehend basics of data analytics and visualization
	CO2	Perform various analysis and visualization technique using python or any other software
	CO3	Apply various regression models on given data set and perform prediction.
	CO4	Demonstrate advance understanding of Time series concepts and analysis of data using various time series models.
	CO5	Analyze Text data and gain insights.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction**	1,2	4
	1.1	Data Analytics Lifecycle overview: Key Roles for a Successful Analytics, Background and Overview of Data Analytics Lifecycle Project		
	1.2	Need of exploratory data analysis, cleaning and preparing data, Feature engineering, Missing values, understand dataset through various plots and graphs (histogram, scatter plot, bar chart, pie chart, stem and leaf plot, density plot), draw conclusions, the Kinds of Data Analytics – Descriptive, Diagnostic, Predictive and Data Mining		
2		**Data analytics and Visualization with Python**	2	4
	2.1	Essential Data Libraries for data analytics: Pandas, NumPy, SciPy. Plotting and visualization with python: Introduction to Matplotlib, Basic Plotting with Matplotlib, Create Histogram, BarChart, Pie chart, Box Plot, violin plot using Matplotlib. Introduction to seaborn Library, MultiplePlots,		
3		**Regression**	2,5	6
	3.1	Simple Linear Regression: Simple Linear Regression Model, Regression Equation, Least Squares Method, Coefficient of Determination, Correlation Coefficient, Regression coefficient, Model Assumptions, testing for Significance, Residual Analysis: Outliers and Influential Observations, explained and unexplained variation		

	3.2	Multiple Regression: Multiple Regression Model, Least Squares Method, Multiple Coefficient of Determination, Model Assumptions, Testing for Significance, Categorical Independent Variables, Residual Analysis		
4		**Time Series Analysis and Prediction**	1,3	6
	4.1	Overview of Time Series Analysis, Components of time series, decomposition of time series, methods of finding trend, methods of finding seasonal variation, Box-Jenkins Methodology		
	4.2	ARIMA Model, Autocorrelation Function (ACF, PACF), Autoregressive Models, Moving Average Models ,ARMA and ARIMA Models , Building and Evaluating an ARIMA Model		
5		**Text Analytics**	1,4	6
	5.1	History of text mining, Roots of text mining overview of seven practices of text analytic, Application and use cases for Text mining: extracting meaning from unstructured text, Summarizing Text.		
	5.2	Text Analysis Steps, A Text Analysis Example, Collecting Raw Text , Representing Text ,Term Frequency—Inverse Document Frequency (TFIDF),Categorizing Documents by Topics, Determining Sentiments , Gaining Insights .		
			Total	**26**

Course Assessment:

Theory:

ISE-1: 20 Marks
Activity: Any two activities like quiz/ Assignments/crossword/ oral/case study on initial 50% syllabus
ISE-2: 20 Marks
Activity: Any two activities like quiz/ Assignments/crossword/ oral/case study on remaining 50% syllabus

MSE : 30 Marks written examination based on 50% syllabus
ESE : 30 Marks written examination based on remaining syllabus

Tutorial:

ISE-1: 20 Marks
Evaluation based on first four tutorials
ISE-2: 30 Marks
Evaluation based on next six tutorials

Topics for Tutorial
Tutorial 1: Case study on exploratory data analysis
Tutorial 2: Perform exploratory analysis on any real world data using python
Tutorial 3: Perform visualization task in python for the given data
Tutorial 4: Perform visualization task in Excel for the given data
Tutorial 5: Problem solving on Regression
Tutorial 6: Create a Linear Regression model for a dataset and display the error measures, Chose a dataset with categorical data and apply linear regression model (using python)
Tutorial 7: Quiz on Time series forecasting
Tutorial 8: Implement ARIMA model in python
Tutorial 9: Implement TFIDF algorithm in Python
Tutorial 10: Build interactive dashboard using Tableu

Recommended Books:

1. Wes McKinney, "Python for Data Analysis", 3rd Edition, Publisher(s): O'Reilly Media, Inc.
2. Bharati Motwani , "Data Analytics using Python", 2nd Edition, Wiley Publications
3. George Athanasopoulos , Rob J Hyndman, "Forecasting: Principles and Practice", 3rd Edition, Otext Publication
4. Dipanjan Sarkar, "Text Analytics with Python: A Practitioner's Guide to Natural Language Processing", 2ND EDITION, Apress publisher
5. David R. Anderson, Dennis J. Sweeney, Thomas A. Williams "Statistics For Business And Economics"11th Edition, South-Western, Cengage Learning

DOUBLE MINOR (DM) (OPTIONAL MINOR IN EMERGING AREAS)

Artificial Intelligence and Machine Learning (offered to Mech)

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25DM61	Statistics for Data Science	L	T	P	L	T	P	Total
		2	2	0	2	2	--	4
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes		BSC11ME01, BSC11ME03, VSE11ME02
Course Outcomes	CO1	Apply basic statistical techniques to any given structured data base and summarize it
	CO2	Use discrete and continuous probability distribution to solve mathematical problems based on it
	CO3	**Use appropriate sampling method for any real world case study**
	CO4	Apply hypothesis testing techniques to real world scenarios and draw meaningful conclusions.
	CO5	Conduct analysis of variance by constructing ANOVA table for one way and two way ANOVA

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction**	1,3	5
	1.1	Data and Statistics: Elements, Variables, and Observations, Scales of Measurement, Categorical and Quantitative Data, Cross-Sectional and Time Series Data, Descriptive Statistics, Tabular and Graphical Summarizing of Categorical Data, Summarizing of Quantitative Data, Cross Tabulations and Scatter Diagram.		
	1.2	Numerical Measures: Measures of Location, Measures of Variability, Measures of Distribution Shape, Relative Location, and Detecting Outliers, Box Plot, Measures of Association Between Two Variables, Scatter plot, QQ plot		
2		**Probability**	1,3	5
	2.1	Probability: Experiments, Counting Rules, and Assigning Probabilities, Events and Their Probabilities, Complement of an Event, Addition Law Independent Events, Multiplication Law, Baye's theorem		
	2.2	Discrete Probability Distributions: Random Variables, Discrete Probability Distributions, Expected Value and Variance, Binomial Probability Distribution, Poisson Probability Distribution		

	2.3	Continuous Probability Distributions: Uniform Probability Distribution, Normal Curve, Standard Normal Probability Distribution, Computing Probabilities for Any Normal Probability Distribution		
3		**Sampling**	1,3	4
	3.1	Sampling from a Finite Population, Sampling from an Infinite Population, Other Sampling Methods, Stratified Random Sampling, Cluster Sampling, Systematic Sampling, Convenience Sampling, Judgment Sampling, parameter and statistic, standard error of statistic, sampling and non-sampling errors, Central Limit theorem		
	3.2	Interval Estimation: Point estimation, Confidence Intervals, Student's t-Distribution,		
4		**Hypothesis Tests**	1,3	7
	4.1	Developing Null and Alternative Hypotheses, Type I and Type II Errors, Population Mean: Known, Population Mean: Unknown, Inference About Means and Proportions with Two Populations, Inferences About Population Variances		
	4.2	Chi-Square Distribution, Tests of Goodness of Fit, Multinomial Population, Test of Independence		
5		**The Analysis of Variance (ANOVA)**	1,3	5
	5.1	F distribution, Variance analysis in One way classification, Variance analysis in Two way classification		
			Total	**26**

Course Assessment:

Theory:

ISE-1: 20 Marks
Activity: Any two activities like quiz/ Assignments/crossword/ oral/case study on initial 50% syllabus
ISE-2: 20 Marks
Activity: Any two activities like quiz/ Assignments/crossword/ oral/case study on remaining 50% syllabus

MSE : 30 Marks written examination based on 50% syllabus
ESE : 30 Marks written examination based on remaining syllabus

Tutorial:

ISE-1: 20 Marks
Evaluation based on first four tutorials
ISE-2: 30 Marks
Evaluation based on next six tutorials

Topics for Tutorial
Tutorial 1: Calculate statistical measures for any real world available data using python
Tutorial 2: Show different graphs (scatter plot, box plot and QQ plot) for the given data using python
Tutorial 3: Problem solving for binomial/Poisson distribution
Tutorial 4: Problem solving for Normal Probability Distribution
Tutorial 5: Case study on sampling
Tutorial 6: Central limit theorem quiz
Tutorial 7: Hypothesis testing (one population problem solving)
Tutorial 8: Hypothesis testing(two population problem solving)
Tutorial 9: Quiz/tutorial on chi square testing
Tutorial 10: programming of ANOVA using any software

Recommended Books:

1. David R. Anderson, Dennis J. Sweeney, Thomas A. Williams "Statistics For Business And Economics"11th Edition, South-Western, Cengage Learning
2. John A. Rice , "Mathematical Statistics and Data Analysis", University of California, Berkeley,Thomson Higher Education
3. S.C. Gupta, V.K. Kappor, "Fundamentals Of Mathematical Statistics (A Modern Approach)" Tenth Revised Edition, Sultan Chand & Sons Educational Publishers New Delhi
4. Jay L. Devore, "Probability and Statistics for Engineering and the Sciences", Cengage Publication.
5. O'Reilly Media, Wes McKinney, "Python for Data Analysis", 2nd Edition, O'Reilly Media, Wes McKinney.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25DM62	Fundamentals of AI & ML	L	T	P	L	T	P	Total
		2	2	--	2	2	--	4
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		TUT	20	--	30	--	50	

Pre-requisite Course Codes	Mathematics & Statistics, python Programming Skills	
Course Outcomes	CO1	To develop a basic understanding of AI building blocks presented in intelligent agents.
	CO2	To choose an appropriate problem-solving method and knowledge representation technique.
	CO3	To acquire fundamental knowledge of machine learning models.
	CO4	**To Apply** classification techniques to categorize given datasets into distinct classes using machine learning models.
	CO5	**To Apply** different regression techniques to predict continuous values from given datasets.
	CO6	**To Analyze** model performance using evaluation metrics like Confusion Matrix, Precision, Recall, and F1-score.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Title: Introduction to Artificial Intelligence**		
	1.1	**Introduction:** History of Artificial Intelligence, Intelligent Systems: Categorization of Intelligent System, Components of AI Program, Foundations of AI, Sub-areas of AI, Applications of AI, Current trends in AI, Ethics, Challenges, and Future Trends in AI	1,2	3
	1.2	**Intelligent Agents**: Agents and Environments, The concept of rationality, The nature of environment, The structure of Agents, Types of Agents, Learning Agent.	1,2,3	1
2		**Title: AI Techniques & Problem Solving**		
	2.1	**Uninformed Search Methods:** Breadth First Search (BFS), Depth First Search (DFS), Depth Limited Search	1,2,4	2
	2.2	**Informed Search Methods:** Greedy best first Search, A* Search, Memory bounded heuristic Search.	1,2,4	2
	2.3	**Knowledge Representation & Reasoning**: Logical Reasoning (Propositional & Predicate Logic), Expert Systems and Decision Trees	1,2,4	2
3		Title: **Introduction to Machine Learning**		
	3.1	Definition & Importance of ML, Differences Between AI, ML & Data Science, paradigms of machine learning- Supervised learning,	1,2,3	2

		unsupervised learning, semi-supervised learning, semi supervised learning , Transfer learning and domain adaptation		
	3.2	Training Error, Generalization error, Overfitting, Underfitting, Bias Variance trade-off.	1,2	2
4		**Title: Learning with Regression and Trees**		
	4.1	**Learning with Regression**: Definition of Regression in Machine Learning , Real-World Applications of Regression (Stock Price Prediction, House Price Estimation, Sales Forecasting) Linear Regression, Multivariate Linear Regression, Logistic Regression.	1,2,6	2
	4.2	**Learning with Trees**: Decision Trees, Constructing Decision Trees using Gini Index (Regression)	1,2,3,7	2
5		**Title: Learning with Classification**		
5	**5.1**	Definition & Importance of Classification, Difference between Classification and Regression, Real-World Applications of Classification (Spam Detection, Fraud Detection, Medical Diagnosis) , Types of Classification Algorithms.	1,2,4	2
	5.2	Support Vector Machine: Concept of Hyperplanes & Support Vectors, SVM for linear and nonlinear classification, Basics of Kernel trick.	1,2,3	2
	5.3	Support Vector Regression, Multiclass Classification	1,3	1
6		**Title: Learning with Clustering**		
	6.1	Definition & Importance of Clustering, major clustering approaches, Applications of Clustering (Customer Segmentation, Anomaly Detection, Image Segmentation)	4,5	1
	6.2	Clustering Techniques & Algorithms: K-Means Clustering, Hierarchical Clustering, Density-Based Clustering (DBSCAN)	4,5	2
			Total	**26**

Module No.	**Sr.no**	**Suggested List of Tutorial**	**Ref.**	**Hrs.**
1	**1.1**	**Breadth-First Search (BFS):** • For a given a scenario where multiple paths exist between locations, how would BFS ensure finding the shortest path? • Apply BFS to a transportation network, a social network, or a maze-solving problem and describe the order of exploration. **Depth-First Search (DFS):** • In a game tree or file system, how would DFS be used to traverse the structure efficiently? • Given a complex decision-making problem, apply DFS to find all possible solutions before making a decision.	1,2,3	4
	1.2	**Greedy Best-First Search:** In a **delivery routing system**, how can **Greedy BFS** be applied to find a quick, though not necessarily optimal, delivery path?	1,2,3	4

		• Apply **Greedy BFS** to a **word puzzle game**, where you move toward the most promising next step based on estimated success. ***A* Search*** • You are designing a **navigation system for a self-driving car**, how would you use **A*** to ensure an optimal route? • Apply **A*** to **project scheduling**, where tasks must be completed in an optimal sequence based on priority and dependencies.		
	1.3	Case study on State space formulation and PEAS representation for various AI applications	1,2	2
2	**2.1**	**Linear Regression & Classification** • For any given dataset, apply Linear Regression to predict a continuous outcome. • **For any given dataset**, apply **Logistic Regression** for binary classification. • For any given dataset, apply a Decision Tree to classify or predict outcomes. • **For any given dataset**, determine whether a **Linear or Non-Linear** classification approach is suitable.	**6,7,8**	4
	2.2	Consider a classification problem where the target variable has three or more categories (e.g., classifying emails as Spam, Promotions, or Primary). • How would you use algorithms like Softmax Regression, Decision Trees, or Random Forest to build a model? • How do you evaluate the model using Precision, Recall, and Confusion Matrix? • If new class probabilities are given, how do you decide which class a new instance belongs to?	6,7	4
3	**3.1**	For any given dataset, apply K-Means Clustering to segment data into groups.	8,9	2
	3.2	For any given dataset, apply Hierarchical Clustering to create a hierarchical grouping. • Consider a dataset where you want to **cluster products based** on their sales performance. • What are the differences between Agglomerative and Divisive Clustering? • How do you decide which two clusters to merge first using Single-Linkage vs. Complete-Linkage? • How can you visualize the hierarchical structure using a dendrogram?	8,9	2
	3.3	**For any given dataset, apply DBSCAN to detect clusters and outliers.**	8,9	2
4	**4.1**	Mini project/presentation/Group activity/ Simulation using modern tools on regression, classification and clustering	13,14,15	2
			Total	**26**

Course Assessment:

Theory:

ISE-1:
Activity: Quiz , Mind map and assignments 20 Marks
ISE-2: Two hours 20 Marks
Activity: Article Discussion, Quiz and Assignments
Outcome: Reflective Journal

MSE: 90 min 30 Marks written examination based on 50% syllabus
ESE: 90 min 30 Marks written examination based on remaining 50% syllabus

TUT:

ISE:
1. ISE-1 will be conducted for 50% of numerical problems given in the syllabus. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2
a. Remaining 50% of numerical problems given in the syllabus. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Simulation using modern tools to solve the given problem statement for 10 marks/Mini project

Recommended Books:

1. 1. Stuart J. Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach", Fourth Edition" Pearson Education, 2020
2. Saroj Kaushik, "Artificial Intelligence", Cengage Learning, First edition, 2011
3. Nils J. Nilsson, Principles of Artificial Intelligence, Narosa Publication
4. Deepak Khemani, A First Course in Artificial Intelligence, McGraw Hill Publication
5. Peter Harrington, "Machine Learning in Action", Dream Tech Press.
6. Ethem Alpaydın, "Introduction to Machine Learning", MIT Press.
7. Stephen Marsland, "Machine Learning an Algorithmic Perspective", CRC Press.
8. Han Kamber, "Data Mining Concepts and Techniques", Morgan Kaufmann Publishers.
9. Margaret. H. Dunham, ―Data Mining Introductory and Advanced Topics, Pearson Education.
10. Kevin P. Murphy, Machine Learning "A Probabilistic Perspective".
11. Samir Roy and Chakraborty, "Introduction to soft computing", Pearson Edition.
12. Richard Duda, Peter Hart, David G. Stork, "Pattern Classification", Second Edition, Wiley Publications.

Online Resources:

13. https://onlinecourses.nptel.ac.in/noc21_cs24/preview
14. https://onlinecourses.nptel.ac.in/noc25_cs50/preview?utm_source=chatgpt.com
15. https://onlinecourses.nptel.ac.in/noc21_cs85/preview

Further Reading:

1. https://onlinecourses.nptel.ac.in/noc21_cs85/preview?utm_source=chatgpt.com
2. https://www.youtube.com/playlist?list=PLZoTAELRMXVPBTrWtJkn3wWQxZkmTXGwe

DOUBLE MINOR (DM) (OPTIONAL MINOR IN EMERGING AREAS)

Blockchain Technology (offered to ECS)

Course Code	Course Name		Teaching Scheme (Hrs/week)				Credits Assigned			
			L	T	P		L	T	P	Total
25DM71	Blockchain Basics		2	2	--		2	2	--	4
			Examination Scheme							
			ISE1	MSE	ISE2		ESE		Total	
		TH	20	30	20		30		100	
		TU	20	--	30		--		50	

Pre-requisite Course Codes	PCC13CE11	
Course Outcomes	CO1	Explain Blockchain concepts in the context of distributed ledger.
	CO2	Associate concepts of cryptocurrencies, consensus algorithms and mining with security of blockchain.
	CO3	Explain basic working principles of Ethereum.
	CO4	Apply the concepts of smart contact using Solidity programming for a given application.
	CO5	Explore Hyperledger Fabric and its working as a private blockchain.
	CO6	Demonstrate the components of blockchain and the processes used in blockchain for a given problem as well as in real world applications.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction to Blockchain Technology:** What is a blockchain, Origin of blockchain, Foundation of blockchain: Genesis block, Merkle trees, limitations and applications of blockchain	1,3	3
	1.2	Components of blockchain, Block in blockchain, Types of blockchain: Public, Private, and Consortium, Consensus protocols: Proof-of-Work (PoW), Proof-of-Burn (PoB), Proof-of-Stake (PoS), and Proof-of-Elapsed Time (PoET), mining in blockchain, Mining pool and its methods	1,3	4
2	2.1	Ethereum and its Components, Mining in Ethereum, Ethereum Virtual Machine (EVM), Transaction, Accounts, Architecture and Workflow, Mist Wallet, Ethereum frameworks	1,3	03
	2.2	Exploring etherscan.io and the block structure Ethereum test networks Decentralized file system: IPFS	1,2	03

3	**3.1**	**Programming for Blockchain:** Introduction to Smart Contracts, Types of Smart Contracts, Limitations of Smart Contracts	**1**	**1**
	3.2	Introduction to Programming: Solidity Programming – Basics, functions, Visibility and Activity Qualifiers, Address and Address Payable, Bytes and Enums, Arrays-Fixed and Dynamic Arrays, Special Arrays-Bytes and strings, Struct, Mapping, Inheritance, Error handling, events, If-Then-Else, For loop	**Useful Link 5**	**4**
4		Need of Private Blockchain, Consensus Algorithms for Private Blockchain - PAXOS, Byzantine Faults: Byzantine Fault Tolerant (BFT) and Practical BFT	**1, Ref.3**	**4**
5		Introduction to Hyperledger, Tools and Frameworks Hyperledger Fabric: Hyperledger Fabric Architecture, Components of Hyperledger Fabric, Transaction Flow, application for supply chain management	**1, Ref.3**	**4**
			Total	**26**

Suggested list of tutorials: (Minimum 10)

Sr. no.	Suggested Tutorials	Hrs.
1	Explore various blockchain platforms other than Bitcoin and Ethereum	2
2	Case study: blockchain security threats with real life incidents of the attacks	2
3	Case study of application of blockchain in Fintech	2
4	Case study of supply chain management using blockchain	2
5	Case study: Blockchain integrated with AI/Cloud computing/IoT	2
6	Block mining and reward transfer to the account	2
7	Solidity program: voting application	2
8	Solidity program: crowd funding	2
9	Solidity program: Transactions using Remix IDE and MetaMask	2
10	Storing and retrieving file from IPFS	2
11	Smart contract execution using Ganache	2

Recommended Books:

1. Blockchain Technology, Chandramouli Subramanian, Asha A. George, Abhillash K. A and Meena Karthikeyen, Universities Press.
2. Mastering Ethereum, Building Smart Contract and Dapps, Andreas M. Antonopoulos Dr. Gavin Wood, O'reilly.
3. Imran Bashir, Mastering Blockchain: A deep dive into distributed ledgers, consensus protocols, smart contracts, DApps, cryptocurrencies, Ethereum, and more, 3rd Edition, Packt Publishing.
4. Blockchain for Beginners, Yathish R and Tejaswini N, SPD
5. Blockchain Basics, A non-Technical Introduction in 25 Steps, Daniel Drescher, Apress
6. Blockchain with Hyperledger Fabric, Luc Desrosiers, Nitin Gaur, Salman A. Baset, Venkatraman Ramakrishna, Packt Publishing

Useful Links:
1. https://www.blockchain.com/explorer/assets/btc
2. https://etherscan.io/
3. https://bitcoin.org/bitcoin.pdf
4. https://ethereum.org/en/whitepaper/
5. https://docs.soliditylang.org/
6. Research paper on integration of blockchain and Cloud computing: https://ieeexplore.ieee.org/document/9252909 DOI: *10.1109/ACCESS.2020.3036812*
7. https://www.researchgate.net/publication/333639731_Blockchain_Technologies_for_IoT
8. Research paper on integration of blockchain and AI: https://ieeexplore.ieee.org/iel7/6287639/10380310/10379100.pdf DOI: *10.1109/ACCESS.2023.3349019*
9. https://www.infosys.com/industries/financial-services/white-papers/documents/blockchain-adoption-financial-services.pdf

Course Assessment:

Theory:

ISE-1:
Activity: Quiz/Assignments 20 Marks
ISE-2: Two hours 20 Marks
Activity: Article Discussion/Quiz/Assignments/Seminar

MSE: 90 minutes 30 Marks written examination based on 50% syllabus
ESE: 90 minutes 30 Marks written examination based on remaining syllabus after MSE

Practical: (10 Nos.)

ISE1: 20 marks based on first five tutorials as per the predefined rubrics
ISE2: 30 marks based on the remaining five tutorials as per the predefined rubrics

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
25DM72	Bitcoin and Crypto currency	2	2	--		2	2	--	4

	Examination Scheme				
	ISE1	MSE	ISE2	ESE	TOTAL
Theory	20	30	20	30	100
TUT	20	-	30	-	50

Pre-requisite Course Codes	**Introduction to Cryptography:** Hash functions, Public key cryptography, Digital Signature (ECDSA)	
Course Outcomes	CO1	Describe the basic concept of Block chain.
	CO2	Associate knowledge of consensus and mining in Block chain
	CO3	Summarize the bit coin crypto currency at an abstract level
	CO4	Apply the concepts of keys, wallets and transactions to the Bit coin network
	CO5	Interpret the knowledge of Bit coin network, nodes and their roles
	CO6	Illustrate the applications of Block chain and analyze case studies

Sr. No.	Module	Topics	Ref	Hours
0	**Prerequisite**	**Introduction to Cryptography:** Symmetric Key Cryptography, Public key cryptography, Hash functions, Digital Signature (ECDSA)		**3**
1	**Introduction to Block chain**	Structure of a Block, Block Header, Block Identifiers: Block Header Hash and Block Height, The Genesis Block, Linking Blocks in the Block chain.	**1, 4**	**2**
2	**Consensus and Mining**	Decentralized Consensus, Byzantine General's Problem, Independent Verification of Transactions, Mining Nodes, Aggregating Transactions into Blocks, Constructing the Block header, Mining the Block, Successfully Mining the Block, Validating a New Block, Assembling and Selecting Chains of Blocks, Block chain Forks **Self-learning Topics:** Study different consensus algorithms	**1,3**	**6**
3	**Introduction to Bit coin**	What is Bit coin and the history of Bit coin, Bit coin Transactions, Altcoins, Tokens (Utility and Security), UTXO and double spending. **Self-learning Topics:** Study the website coinmarketcap.com/	**1,3**	**4**

4	**Concepts of Bit coin**	**Keys and addresses, Wallets and Transactions:** Public Key Cryptography and Crypto currency, Private and Public Keys, Bit coin Addresses, Base58 and Base58Check Encoding, Nondeterministic (Random) Wallets, Deterministic (Seeded) Wallets, HD Wallets (BIP-32/BIP-44), Transaction Outputs and Inputs, Transaction Fees, Transaction Scripts and Script Language, Turing Incompleteness, Stateless Verification, Script Construction (Lock + Unlock), Pay-to-Public-Key-Hash (P2PKH). **Self-learning Topics:** Visit and use https://bitcoin.org/en/	**1,3**	**6**
5	**Bit coin Networks**	Peer-to-Peer Network Architecture, Node Types and Roles, Incentive based Engineering The Extended Bitcoin Network, Bitcoin Relay Networks, Network Discovery, Full Nodes, Exchanging "Inventory", Simplified Payment Verification (SPV) Nodes, Bloom Filters, SPV Nodes and Privacy, Encrypted and Authenticated Connections, Transaction Pools **Self-learning Topics:** Study technical papers based on bitcoin security	**1,3**	**3**
6	**Cryptocurrency Applications & Case Studies**	Domain-Specific Applications: FinTech, Records & Identities, cross-border payments, Gaming and NFTs **Self-learning Topics:** Read Technical papers on bitcoin applications	**2,4,6**	**2**

Suggested list of tutorials: (Minimum 10)

Module No	Sr. no.	Suggested List of Tutorials	Ref	Hrs.
1	1	Introduction to Blockchain **Objective:** Understand the basic structure of blockchain and how blocks are linked. Topics: Block structure, Block header and identifiers, The Genesis Block, Linking Blocks in Blockchain **Activity:** Visualize the blockchain structure using a block explorer.	1,4	2
2	2	Consensus and Mining Basics **Objective:** Learn about decentralized consensus and the mining process. Activity: Research and compare different consensus algorithms of Polygon. RCorda, Litecoin	1,3	2
4	3	Bitcoin Transactions and Fees	1,3	2

		Objective: Learn how Bitcoin transactions work and how fees are determined. **Topics :** Transaction inputs and outputs, Pay-to-Public-Key-Hash (P2PKH), Transaction scripts and Bitcoin script language, Transaction fees and balance calculations **Hands-on Activity:** Use a Bitcoin block explorer to analyze a real transaction.		
4	4	Blockchain Forks and Network Disruptions **Objective:** Understand blockchain forks and their impact. **Topics :** Soft forks vs hard forks, Chain reorganizations, Famous forks (e.g., Bitcoin Cash) **Activity:** Research a famous Bitcoin fork and discuss its impact.	1,3	2
3	5	Creating and Sharing Tokens **Topics:** Token standards (ERC-20, ERC-721), Smart contracts for tokens, **Hands-on Activity:** Use an online platform (Ethereum Remix) to create a simple token.	1,3	2
5	6	Bitcoin Security and Privacy **Objective:** Understand security risks and privacy concerns in Bitcoin **Topics:** Private key security, Bitcoin transaction anonymity, Common attack vectors (51% attack, Sybil attack) **Activity:** Read a technical paper on Bitcoin security and summarize key findings.	1,3	2
6	7	DeFi and Future of Cryptocurrency **Objective:** Understand Decentralized Finance (DeFi) and upcoming blockchain trends. **Topics:** DeFi platforms, Staking and yield farming, The future of Bitcoin and Layer 2 solutions **Activity:** Research and present an upcoming DeFi project.	2,4, 6	2
6	8	Cross-Chain Transactions and Atomic Swaps **Objective:** Learn how Bitcoin interacts with other blockchains. **Topics :** Introduction to atomic swaps, Hashed Time-Locked Contracts (HTLC) ,Cross-chain trading using Lightning Network , Role of decentralized exchanges (DEXs) **Hands-on Activity:** Use a testnet **atomic swap** simulator to swap Bitcoin with another cryptocurrency.	2,4, 6	2
6	9	**Regulatory Challenges and Legal Considerations in Bitcoin** **Objective:** Understand the legal aspects and global regulations of Bitcoin. **Topics :** Bitcoin's legal status in different countries, Taxation and reporting for Bitcoin transactions, Anti-Money Laundering (AML) and Know Your Customer (KYC) laws, Impact	2,4, 6	2

		of Central Bank Digital Currencies (CBDCs) on Bitcoin **Activity:** Research Bitcoin regulations in our country and prepare a summary. Analyze a case study of Bitcoin-related legal action (e.g., Silk Road, Mt. Gox).		
6	10	**Stablecoins - Bridging Crypto and Traditional Finance** **Objective:** Understand the role of stablecoins in the cryptocurrency ecosystem. **Topics :** Definition and types of stablecoins (Fiat-backed, Crypto-backed, Algorithmic) , Use cases and advantages of stablecoins, Risks and regulatory challenges, Popular stablecoins (USDT, USDC, DAI) **Activity:** Research and compare different stablecoins based on their stability mechanism and adoption.	2,4, 6	2

Recommended Books:

1. "Mastering Bitcoin, PROGRAMMING THE OPEN BLOCKCHAIN", 2nd Edition by Andreas M. Antonopoulos, June 2017, O'Reilly Media, Inc. ISBN: 9781491954386.
2. "Blockchain Applications: A Hands-On Approach", by Arshdeep Bahga, Vijay Madisetti, Paperback – 31 January 2017.
3. "Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction", July 19, 2016, by Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, Steven Goldfeder, Princeton University Press.
4. Mastering Blockchain", by Imran Bashir, Third Edition,Packt Publishing
5. **"**Mastering Ethereum: Building Smart Contracts and Dapps Paperback" byAndreas Antonopoulos, Gavin Wood, Publisher(s): O'Reilly Media
6. "Blockchain revolution: how the technology behind bitcoin is changing money, business and the world $ don tapscott and alex tapscot, portfolio penguin, 856157449

Online References:

Sr. No.	Website Name
1	https://andersbrownworth.com/blockchain/
2	https://andersbrownworth.com/blockchain/public-private-keys/
3	https://www.coursera.org/learn/cryptocurrency
4	https://coinmarketcap.com/

Course Assessment:

Theory:

ISE-1:
Activity: Quiz / Assignments 20 Marks
ISE-2: Two hours 20 Marks
Activity:
Quiz/Assignments/Group
discussion
MSE: 90 min 30 Marks written examination based on 50% syllabus
ESE: 90 min 30 Marks written examination based on remaining 50% syllabus after MSE

TUT:

ISE:

1. ISE-1 will be conducted for four or 50% of tutorials. Continuous pre-defined rubrics-based evaluation for 20 marks.

2. ISE-2

a. Remaining Four experiments or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

b. Simulation using modern tools to solve the given problem statement/ Debate/ research paper analysis/ case studies for 10 marks/Mini project

DOUBLE MINOR (DM) (OPTIONAL MINOR IN EMERGING AREAS)

Cyber Security (offered to ECS)

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25DM81	Cyber Security Essentials	L	T	P	L	T	P	Total
		2	2	--	2	--	2	4
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes		
Course Outcomes	CO1	**Identify** cybersecurity threats, vulnerabilities, and risks in digital systems.
	CO2	**Analyze** the theoretical principles behind common attack vectors and defense mechanisms
	CO3	**Evaluate** security policies, risk management strategies, and regulatory frameworks.
	CO4	**Discuss** the theoretical foundations of cryptography and data protection.
	CO5	**Critique** theoretical models of secure network architectures and propose enhancements.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	**Cybersecurity Threats and Vulnerabilities**			
	1.1	**Overview & Importance of Cybersecurity** • Role and significance of cybersecurity in the digital age • Overview of key cybersecurity domains • Historical milestones and evolution of cyber threats • Impact of past incidents on current cybersecurity paradigms	1, 2, 4	2
	1.2	**Fundamental Terminologies & Concepts** • Definitions of threat, vulnerability, risk, and mitigation • Overview of cybersecurity frameworks and theoretical models • Classification of cyber threats and threat actors • Threat intelligence	1, 2, 4	2
	1.3	**Malware: Viruses, Worms, Trojans, and Ransomware** • Characteristics and behaviors of various malware types • Theoretical discussion of propagation methods and impact	1, 2, 4	1
	1.4	**Vulnerability Fundamentals** • Examination of vulnerabilities in software, hardware, and human factors • Common security weaknesses (e.g., unpatched systems)	1, 2, 4	2
2	**Cyber Attack Vectors and Defense Mechanisms**			

	2.1	**Introduction to Attack Vectors** • Definition and significance of attack vectors • Overview of classification	1, 2, 4	1
	2.2	**Network-Based Attacks** • DoS/DDoS, Man-in-the-Middle attacks • Network vulnerabilities	1, 2, 4	1
	2.3	**Application-Based Attacks** • SQL Injection, XSS, CSRF • Underlying exploitation principles	1, 2, 4	1
	2.4	**Social Engineering & Insider Threats** • Phishing, spear phishing, pretexting • Theoretical analysis of insider risks	1, 2, 4	1
	2.5	**Advanced Persistent Threats (APTs)** • Multi-vector, long-term infiltration strategies • Theoretical models of APTs	1, 2, 4	1
	2.6	**Defense Mechanisms** • Conceptual frameworks for mitigating attacks • Comparative analysis of defense strategies	1, 2, 4	1
3	**Security Policies and Risk Management Strategies**			
	3.1	**Introduction to Risk Management** • Theoretical concepts of risk, impact, and likelihood • Overview of risk management processes • Risk Assessment Models: NIST SP 800-30, OCTAVE, DREAD, ISO/IEC 27005	1, 2, 4	2
	3.2	**Security Policies/Standards, Regulatory & Legal Frameworks** • Analysis of key standards (ISO, NIST, CIS) • Components and rationale behind effective policies • Overview of major regulations (e.g., GDPR, HIPAA) • Impact on cybersecurity practices.	1, 2, 4	2
	3.3	**Incident Response & Disaster Recovery** • Conceptual models of incident response planning • Best practices from a theoretical standpoint	1, 2, 4	1
	3.4	**Evaluating and Updating Security Policies** • Critical assessment techniques for policy effectiveness • Theoretical case studies on policy evolution	1, 2, 4	1
4	**Foundations of Cryptography and Data Protection**			
	4.1	**Introduction to Cryptography** • Basic principles and history of cryptography • Theoretical importance of confidentiality, integrity, and authenticity • Symmetric and asymmetric encryption • Discussion of use cases and underlying mathematical concepts	1, 2, 4	2
	4.2	**Hashing Algorithms, Digital Signatures & Certificates**	1, 2, 4	1

		• Overview of hashing techniques and their theoretical applications • Analysis of digital signatures and certificate frameworks		
	4.3	**Key Management and Cryptographic Protocols** • Theoretical approaches to secure key generation, distribution, and storage • Discussion on cryptographic protocols and their underlying principles	1, 2, 4	1
	4.4	**Data Protection Techniques** Encryption Methods: Advanced Encryption Standard (AES) for data at rest, TLS/SSL for securing data in transit. Data Masking Techniques, Tokenization Approaches, Full disk and file-level encryption strategies, Data Loss Prevention (DLP) conceptual models	1, 2, 4	2
5	**Secure Network Architectures**			
	5.1	**Network Security & Frameworks** Secure network architecture theories, defense-in-depth strategies, Firewall models and their theoretical foundations, Intrusion Detection & Prevention, Virtual Private Networks (VPNs) & Remote Access Security, VPN technologies and secure tunneling, challenges in ensuring secure remote access.	1, 3, 4	4
	5.2	**Wireless Network Security** WEP, WPA, WPA2, WPA3, comparative analysis of Secure Network Architectures Authentication Methods: 802.1X Framework, EAP Methods: Attack Vectors: Evil Twin Attacks, Deauthentication Attacks, Man-in-the-Middle (MitM)	1, 3, 4	2
			Total	**26**

Suggested Tutorials	
Sr. No.	**Tutorial**
1	**Threat Identification Workshop (CO1):** An in-class activity where students work in small groups on simulated scenarios to identify potential cybersecurity threats, vulnerabilities, and risks. They document their findings on a shared digital whiteboard or paper. A group report (2–3 pages) summarizing identified threats with justifications, submitted at the end of the session.
2	**Historical Cyber Incident Analysis (CO1):** A case study in which groups review documented historical cybersecurity incidents to examine the sequence of events, exploited vulnerabilities, and overall impact. A 10-minute group presentation accompanied by a one-page summary report detailing lessons learned.
3	**Attack Vector Simulation Discussion (CO2):** A group discussion/simulation where students map out theoretical attack vectors (network-based, application-based, etc.) on paper and discuss possible defense mechanisms.

	A flowchart and a one-page commentary explaining the simulated attack vectors and defenses.
4	**Network Attack Case Study (CO2):** A case study focusing on a specific network attack (e.g., DDoS or Man-in-the-Middle). Students dissect the case to understand how the attack was executed and evaluate theoretical defense strategies. A detailed case study report (3–4 pages) along with a brief 5-minute summary presentation.
5	**Policy Evaluation Assignment (CO3):** A written assignment where students are provided with sample security policies to evaluate their strengths and weaknesses using theoretical frameworks, then propose improvements. An analytical essay (4–5 pages) with an annotated copy of the policy document.
6	**Risk Management Comparative Analysis (CO3):** A written assignment in which students compare various risk assessment models (NIST SP 800-30, OCTAVE, DREAD, ISO/IEC 27005) through research and theoretical analysis. A comparative analysis report (4–5 pages) supported by tables and diagrams as needed.
7	**Cryptography Theory Seminar (CO4):** A seminar/presentation where students research and present on the theoretical foundations of cryptography—including symmetric vs. asymmetric encryption, hashing, and digital signatures—with emphasis on underlying mathematics and conceptual frameworks. A 15-minute presentation with supporting slides and a brief summary handout (1–2 pages).
8	**Data Protection Techniques Debate (CO4):** A debate/discussion activity that divides the class into teams to debate the merits and drawbacks of various data protection techniques (e.g., AES vs. TLS/SSL, tokenization, data masking) using theoretical evidence. Each team submits a position paper (2–3 pages) outlining their arguments and supporting evidence.
9	**Network Architecture Critique Workshop (CO5):** A workshop where groups review several secure network architecture models, analyzing defense-in-depth strategies, firewall models, and VPN configurations, then critique their theoretical effectiveness. A critique report (around 3 pages) and a group discussion presentation of key findings.
10	**Secure Architecture Enhancement Project (CO5):** A group project where teams select an existing network architecture model and propose theoretical enhancements based on current literature and best practices. A comprehensive project report (5–6 pages) along with a 15-minute group presentation outlining proposed improvements.
11	**Integrated Threat Analysis Exercise (CO1 & CO2):** An in-class activity/simulation where students are given a comprehensive scenario that includes multiple threat elements; they identify threats (CO1) and then analyze associated attack vectors (CO2). A combined analysis report (2–3 pages) and a visual diagram or mind map illustrating the relationship between threats and attack vectors.
12	**Attack Response Simulation and Demonstration (CO2 & CO3):** A simulation exercise where students role-play an attack scenario in a simulated environment and develop a theoretical incident response plan incorporating risk management and policy-based mitigation strategies. Additionally, the instructor demonstrates a live or recorded attack (e.g., simulated phishing or network intrusion) to illustrate key concepts. A written incident response plan (3 pages) and a brief in-class demonstration analysis with active participation in a discussion.
13	**Security Policy and Cryptography Integration (CO3 & CO4):** An assignment/discussion where students evaluate how cryptographic techniques (e.g., encryption, key management, digital signatures) support and reinforce security policies and risk management strategies. An integrated analytical report (4 pages) and active participation in an in-class discussion.

14	**Cryptography and Network Architecture Synergy (CO4 & CO5):** A group project where students investigate the interplay between cryptographic protocols and secure network design by analyzing case studies and proposing a cohesive integrated model. A project report (5 pages) accompanied by a 15-minute group presentation detailing the proposed integrated model.
15	**Comprehensive Security Analysis and Strategic Recommendations (CO1, CO2, CO3, CO4, CO5):** In this capstone project, teams are provided with a detailed fictional scenario of a medium-sized organization facing diverse cybersecurity challenges. Students must perform a thorough analysis by identifying potential threats and vulnerabilities (CO1); examining and analyzing relevant attack vectors (CO2); evaluating risk management strategies and security policies (CO3); recommending appropriate cryptographic and data protection measures (CO4); and designing a secure network architecture to mitigate the identified risks (CO5). A comprehensive strategic report (8–10 pages) detailing the analysis, recommendations, and proposed security architecture, along with a final presentation (20 minutes) summarizing the findings and strategic recommendations.

Course Assessment:

Theory:

ISE-1: Activity: Quiz and assignments 20 Marks/ One hour Test 20 Marks
ISE-2: One hours 20 Marks
Activity: Case studies, Article Discussion, Quiz and Assignments

MSE: 90minutes- 30 Marks written examination based on 50% syllabus
ESE: 90minutes- 30 Marks written examination based on remaining 50% syllabus

Tutorial:

ISE-1: Activity/ Quizzes/ Assignments (20 Marks)
ISE-2: Activity: Case studies, Article Discussion/ Quiz/ Assignments (20 Marks), Seminar on Recent Research paper/ real life Cyber security incident analysis(10Marks)

Recommended Books:

1. William Stallings and Lawrie Brown authored "Computer Security: Principles and Practice" (5th edition), published by Pearson Education in 2023.
2. Charles P. Pfleeger, Shari Lawrence Pfleeger, and Lizzie Coles-Kemp authored "Security in Computing" (6th edition), published by Addison-Wesley Professional in 2023.
3. Bernard Menezes and Ravinder Kumar authored "Cryptography, Network Security, and Cyber Laws" (assumed 3rd edition), published by Cengage Learning in 2021.
4. Matt Bishop authored "Computer Security: Art and Science" (1st edition), published by Addison-Wesley Professional in 2003.

Online Resources:

1. ITACT 2000: https://www.meity.gov.in/content/information-technology-act-2000-0
2. https://eprocure.gov.in/cppp/rulesandprocs/kbadqkdlcswfjdelrquehwuxcfmijmuixngudufgbuubgubfugbububjxcgfvsbdihbgfGhdfgFHytyhRtMTk4NzY=
3. NIST Cybersecurity Framework: https://www.nist.gov/cyberframework

4. MITRE ATT&CK Framework: https://attack.mitre.org/
5. OWASP Top Ten: https://owasp.org/www-project-top-ten/
6. US-CERT: https://www.us-cert.gov/
7. Center for Internet Security (CIS): https://www.cisecurity.org/
8. SANS Institute Whitepapers: https://www.sans.org/white-papers/
9. Cybrary – Free Cyber Security Training: https://www.cybrary.it/
10. Cybersecurity & Infrastructure Security Agency (CISA): https://www.cisa.gov/
11. Krebs on Security: https://krebsonsecurity.com/
12. Google Security Blog: https://security.googleblog.com/
13. Microsoft Security Blog: https://www.microsoft.com/security/blog/

NPTEL:

1. https://nptel.ac.in/courses/128106006
2. https://archive.nptel.ac.in/courses/106/106/106106129/

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25DM82	Web application penetration testing and Ethical hacking	L	T	P	L	T	P	Total
		2	2	--	2	2	--	4
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes	Basics of networking and web technologies.	
Course Outcomes	CO1	**Integrate** foundational cybersecurity concepts with ethical hacking methodologies into a cohesive theoretical framework.
	CO2	**Synthesize** advanced penetration testing methodologies and stages as applied to web applications.
	CO3	**Critique** prevalent web application vulnerabilities and the conceptual techniques for their exploitation.
	CO4	**Evaluate** legal, ethical, and regulatory dimensions that govern ethical hacking practices.
	CO5	**Formulate** comprehensive strategies for vulnerability assessment and incident response.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	**Cybersecurity and Ethical Hacking**			
	1.1	**Cybersecurity Foundations:** Importance of cybersecurity in today's digital landscape. The CIA Triad: Confidentiality, Integrity, Availability. Overview of common cyber threats (malware, phishing, ransomware, DDoS). Types of security controls: Preventive, Detective, Corrective	1, 2	2
	1.2	**Ethical Hacking Foundations:** Definition, scope, and objectives of ethical hacking. Classification of hackers: White Hat, Black Hat, Grey Hat. Phases of ethical hacking: Reconnaissance, Scanning, Exploitation, Maintaining Access, Covering Tracks	2, 4	2
	1.3	**Technical Underpinnings:** Basic networking concepts: TCP/IP, DNS, DHCP, OSI Model. Introduction to Linux fundamentals: File permissions, processes, and basic commands	3	2
2	**Web Application Security and Vulnerabilities**			
	2.1	**Web Technologies and Architecture:** Overview of web application architecture. Core web protocols: HTTP/HTTPS. Role of front-end technologies: HTML, CSS, JavaScript	5	2
	2.2	**Common Web Vulnerabilities:**	4, 5	3

		OWASP TOP10, SQL Injection, Cross-Site Scripting (XSS), Cross-Site Request Forgery (CSRF), File Inclusion Vulnerabilities (Local/Remote), Additional vulnerabilities (e.g., XML External Entity attacks)		
	2.3	**Vulnerability Assessment:** Methods for vulnerability identification. Principles of risk assessment and vulnerability prioritization	1	1
3	**Reconnaissance and Information Gathering**			
	3.1	**Reconnaissance Strategies:** Passive reconnaissance techniques (OSINT): WHOIS, DNS enumeration, social media profiling, Active reconnaissance techniques: Port scanning, banner grabbing, network mapping	2, 4	2
	3.2	**Tools and Methodologies:** Overview of OSINT tools (e.g., conceptual insights into Maltego, Recon-ng, Google Dorks). Review of active scanning tools (e.g., Nmap, Netcat)	4	2
	3.3	**Web Application Reconnaissance:** Directory enumeration and hidden URL identification. Theoretical exploration of web reconnaissance tools (e.g., Burp Suite, DirBuster)	5	2
4	**Penetration Testing Methodologies**			
	4.1	**Penetration Testing Process:** Penetration testing stages: Pre-Engagement, Reconnaissance, Scanning, Exploitation, Post-Engagement. Analysis of theoretical testing approaches.	4	2
	4.2	**Testing Methodologies and Approaches:** Understanding and Comparative study of Black Box, White Box, and Grey Box testing, Exploitation techniques. Red Teaming, Blue Teaming, Purple Teaming, Social Engineering Testing, Risk-Based Testing.	4, 5	3
	4.3	**Frameworks and Guidelines:** Overview frameworks: NIST Penetration Testing Guide, OWASP Testing Guide. Differentiation between vulnerability assessment and penetration testing approaches	1	1
5	**Legal, Ethical, and Defensive Perspectives**			
	5.1	**Legal and Regulatory Context:** Overview of cyber laws and regulations (e.g., IT Act, GDPR, HIPAA, CCPA), ethical considerations, compliance, and the importance of permissions	2	2
	5.2	**Incident Response and Defensive Mechanisms:** Incident Response Lifecycle: Preparation, Detection, Containment, Recovery. Defensive strategies: System hardening, firewalls, IDS/IPS, patch management.	1	2
	5.3	**Case Studies and Governance:** Analysis of significant cybersecurity breaches, Overview of governance frameworks and compliance standards (ISO 27001, PCI DSS, SOC 2) and strategic defense best practices	2	2
			Total	**26**

Suggested Tutorials	
Sr. No.	**Tutorial**
1	**Network Traffic Analysis with Wireshark** **Objective:** Use Wireshark to analyze packet captures and identify potential threats. **Activity:** 1. Open provided .pcap files in Wireshark. 2. Identify protocols, IP addresses, and suspicious traffic patterns. 3. Detect threats like DNS anomalies, SQL injection, or SYN floods. 4. Answer analysis questions, e.g., attacker IP or unauthorized access details. **Tools:** Wireshark and pre-captured .pcap files(sample captures).
2	**Exploiting and Mitigating Advanced Buffer Overflow Attacks** • **Objective:** Analyze and exploit a buffer overflow vulnerability, then implement mitigation techniques. **Activity:** • Use a vulnerable program to: o Craft a payload using Python and exploit the vulnerability. o Investigate the memory layout using tools like GDB and Radare2. o Apply modern mitigation techniques (ASLR, stack canaries) to secure the program.
3	**Deconstructing Cyber Attacks from Real-World Incidents** • **Objective:** Analyze the stages of a real-world cyber attack and propose a response strategy. **Activity:** • Provide learners with anonymized data from a famous cyber attack (e.g., SolarWinds breach). o Use log files, network traffic, and timelines to reconstruct the attacker's steps. o Propose immediate actions, long-term defensive strategies, and policy improvements.
4	**Designing a Cybersecurity Framework for a Smart City** • **Objective:** Create a scalable cybersecurity framework for interconnected IoT systems in a smart city. **Activity:** • Provide a scenario with IoT devices (traffic lights, surveillance cameras, etc.). o Identify potential vulnerabilities and map them to threats. o Propose a secure architecture using tools like Zero Trust and IDS/IPS for IoT.
5	**Simulating an Advanced Persistent Threat (APT)** • **Objective:** Simulate an APT attack on a controlled network and analyze the indicators of compromise (IOCs). **Activity:**

	• Learners simulate an APT using tools like Metasploit and Cobalt Strike alternatives (e.g., Covenant). o Perform reconnaissance, exploit vulnerabilities, and maintain persistence. o Analyze IOCs using Splunk or ELK stack for detection and reporting.
6	**Reconnaissance Competition: Defend vs. Attack** • **Objective:** Perform reconnaissance to identify vulnerabilities while defending your own system. **Activity:** • Split students into two teams: o Team A: Conduct passive and active reconnaissance on Team B's mock network. o Team B: Implement monitoring tools (e.g., Wireshark, Suricata) to detect Team A's activities. o Swap roles after analyzing each round's performance.
7	**Exploiting Multi-Stage Web Vulnerabilities** • **Objective:** Chain multiple vulnerabilities to compromise a web application entirely. **Activity:** • Set up a vulnerable application with: o Weak authentication (SQL injection). o Improper session management (Session ID theft). o File upload vulnerability (Remote code execution). o Learners must exploit all three in sequence to gain full system access.
8	**Redesigning a Penetration Testing Report** • **Objective:** Create a business-focused penetration testing report from technical findings. **Activity:** • Provide raw penetration test data, including vulnerabilities and exploited systems. o Convert technical findings into an executive summary for non-technical stakeholders. o Include risk prioritization, cost implications, and remediation recommendations.
9	**Analyzing Compliance Gaps in a Healthcare System** • **Objective:** Evaluate a healthcare network for compliance with HIPAA regulations. **Activity:** • Provide a virtualized healthcare setup. o Identify gaps in data encryption, access controls, and audit logs. o Propose solutions to meet compliance standards and create an audit report.
10	**Incident Response Drill with Live Attack Simulation** • **Objective:** Develop and execute an incident response plan for a simulated security incident. **Activity:** • Simulate an attack (e.g., ransomware outbreak) in a controlled lab environment. o Detect and contain the attack. o Perform forensic analysis to determine the root cause. o Report findings and execute a recovery plan.

Course Assessment:

Theory:

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ESE: 90minutes- 30 Marks written examination based on remaining 50% syllabus

Tutorial:

ISE-1: Activity, Quizzes, Assignments (20 Marks)
ISE-2: Activity: Case studies, Article Discussion, Quiz and Assignments (20 Marks), Attack simulations/ Penetration testing Project(10Marks)

Recommended Books:

1. William Stallings, *Computer Security Principles and Practice*, Seventh Edition, Pearson Education,
2. Charles P. Pfleeger, *Security in Computing*, Fifth Edition, Pearson Education,
3. Bernard Menezes, *Network Security and Cryptography*, Cengage Learning.
4. Ummed Meel, *Advanced Penetration Testing with Kali Linux: Unlocking Industry-Oriented VAPT Tactics*, BPB Publications,
5. Prakhar Prasad, *Mastering Modern Web Penetration Testing*, Packt Publishing

Online Resources:

1. https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-53r5.pdf
2. https://www.csoonline.com/article/571697/penetration-testing-explained-how-ethical-hackers-simulate-attacks.html
3. https://link.springer.com/article/10.1365/s43439-023-00100-2
4. https://owasp.org/www-project-web-security-testing-guide/
5. https://amigocyber.com/ethical-hacking-in-practice-real-world-case-studies/