CURRICULUM & SYLLABUS

OF

COURSEWORK

FOR

Doctor of Philosophy (Ph.D.)

IN

ELECTRICAL AND ELECTRONICS ENGINEERING

[w. e. f. 2025-26]

FACULTY OF ENGINEERING AND TECHNOLOGY

SRM UNIVERSITY DELHI-NCR, SONEPAT

Plot No.39, Rajiv Gandhi Education City, P.S. Rai, Sonepat

Haryana-131029

SRM UNIVERSITY
DELHI-NCR, SONEPAT

VISION

SRM University Delhi-NCR, Sonepat, Haryana aims to emerge as a leading world-class university that creates and disseminates knowledge upholding the highest standards of instruction in Medicine & Health Sciences, Engineering & Technology, Management, Law, Science & Humanities. Along with academic excellence and skills, our curriculum imparts integrity and social sensitivity to mould our graduates who may be best suited to serve the nation and the world.

MISSION

1. To create a diverse community campus that inspires freedom and innovation.
2. To promote excellence in educational & skill development processes.
3. To continue to build productive international alliances.
4. To explore optimal development opportunities available to students and faculty.
5. To cultivate an exciting and rigorous research environment.

Table 1.Credit Distribution for Ph.D. Coursework

Subject Code	Subject Name	L	T	P	C	Exam Hrs.	Max. Marks	
							Int.	Ext.
RES701	Research Methodology	4	0	0	4	3	30	70
x CPE-RPE101	Research and Publication Ethics	2	0	0	2	3	30	70
PCSE-0101	Seminar on Review of Literature	0	0	0	4	-	-	-
-	Elective - I	4	0	0	4	3	30	70
Total Credit					**14**			

X

Amended w.e.f. January 01, 2020, as per UGC D.O. No. F-1-1/2018 (Journal/CARE)

LIST OF OPEN AND DEPARTMENTAL ELECTIVES

Code	Course	L	T	P	C
25XXX	Advance Mathematics and Computations	4	0	0	4
25XXX	Nano Technology	4	0	0	4
25XXX	Engineering Economics and Management	4	0	0	4
25XXX	Industrial Management	4	0	0	4
25XXX	Reliability and quality Management	4	0	0	4
25XXX	Entrepreneurship Development	4	0	0	4
25XXX	Automotive engineering for electric vehicles	4	0	0	4
25XXX	Hybrid electric vehicles	4	0	0	4
25XXX	Computer Networks	4	0	0	4
25XXX	Internet of Things	4	0	0	4
25XXX	Electro-chemistry of fuel cells	4	0	0	4
25XXX	Electric drives and controls for electric vehicles	4	0	0	4
25XXX	Artificial intelligence & neural network	4	0	0	4
25XXX	Discrete Transform and Signal Processing	4	0	0	4
25XXX	Energy storage system and management system	4	0	0	4
25XXX	Network security & cryptography	4	0	0	4
25XXX	Embedded systems design	4	0	0	4
25XXX	Electric Vehicle Machines and Drives	4	0	0	4
25XXX	Power electronics for renewable energy systems	4	0	0	4
25XXX	Instrumentation System	4	0	0	4
25XXX	Solar Photovoltaic Systems	4	0	0	4
25XXX	Energy Storage Technology	4	0	0	4
25XXX	Control Systems for Electric Vehicle	4	0	0	4

	Research Methodology	L	T	P	C
Course Code:	RES 701	4	0	0	4
Course Type:	Prerequisite				
Pre-Requisite	Nil				

Course Objective

To equip students with the essential knowledge and skills for conducting academic research, including research design, data collection, analysis, ethical considerations, and effective presentation of findings.

Course Learning Outcomes (CLOs)

By the end of the course, students will be able to:

1. Demonstrate understanding of research fundamentals by explaining different methodologies and selecting appropriate approaches for given research problems.
2. Design research studies by formulating valid research questions, developing proposals, and applying ethical data collection and sampling techniques.
3. Analyze research data using appropriate statistical tools (descriptive statistics, regression, ANOVA) to test hypotheses and interpret results.
4. Communicate research findings effectively through properly structured reports, academic presentations, and by utilizing research tools while adhering to publication ethics.

Unit 1: Introduction to Research

Introduction, Philosophical Underpinnings, Meaning of Research, Objectives of Research, Motivations in Research, Types of Research, Research Approaches, Significance of Research, Scope of Research, Literature Review, Research Methods vs. Research Methodology, Research Process, Research and Scientific Methods, Criteria of Good Research, Research Questions, Research problem, Selecting the Problem, Necessity and Techniques of Research Problem, Qualitative & Quantitative Research, Research Proposal, Synopsis, Transdisciplinarity, Mult disciplinarity & Interdisciplinarity in Research.

Unit II: Data Collection & Sampling

Collection of Primary Data/Sources, Secondary Data/Sources, Observation Method, Interview, Libraries, Archives & Repositories, Questionnaire, Schedules, Case Study and other Innovative Methods, Research Procedure. Sampling, Steps and Criteria for selecting a Sample procedure, Characteristics of Good Sampling, Types of Sample Design, Selecting Random Samples, Complex Random Sampling Design.

Unit III: Data Analysis & Interpretation

Measures of Central Tendency, Dispersion, Correlation & Regression, Chi-Square Test: applications, Steps, Characteristics, Limitations, Analysis of Variance & Co-variance.

Hypothesis: Meaning, Basic Concepts, Flow Diagram, Testing, of Means, Testing of Hypothesis testing of Correlation coefficients, Limitations of Tests of Hypothesis

Theory & Empirical approaches, Ethnographic, Comparative and Interpretative Research.

Unit IV: Research Tools & Ethics in Research

Computer Fundamentals, Basics, Data Representation, Word Processing Package, Creating & Editing a Word document Ethical issues related to Publishing & Plagiarism, LaTex tool for Detection and Elimination of Plagiarism, Intellectual Property Rights, Copy Rights & Patent Laws.

Unit V: Research Report & Presentations

Structure & Components of Research Report, Types of Report, Layout of Research Report, Mechanism of Writing a Research Report.

Presentation: Tailoring the presentation to the target audience, Oral Presentation, Poster Presentation, Submission of Research Article, Thesis Writing, Visual & Delivery.

Reference

1. Adam Pzreworsky and Frank Solomon. On the Art of Writing Proposals, rev. edn, New York, 1995.
2. Blaxter Loraine, Hughes Christina and Tight Malcolm. How to Research, Open University Press, 2006.
3. Gerard Guthrie. Basic Research Methods, Sage, London, 2010.
4. Kothari, C. R. Research Methodology: Methods and Techniques, New Age Publishers, Delhi, 2018.
5. Rand R. Wilcox, Fundamentals of Modern Statistical Research, Springer, New York, 2010.
6. Ross, Timothy J. Fuzzy Logic with Engineering Applications, 2nd Edn. Wiley Publications, 2005.

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
Research Methodology	**CO1**	**x**	**x**	**x**	**x**

	Research and Publication Ethics	L	T	P	C
Course Code:	**CPE-RPE101**	**4**	**0**	**0**	**4**
Course Type:	**Prerequisite**				
Pre-Requisite	**Nil**				

Course Objective
To develop understanding of research ethics, publication integrity, and tools to detect misconduct and evaluate research quality.

Course Learning Outcomes (CLOs)
By the end of this course, students will be able to:

1. Demonstrate understanding of research ethics by explaining philosophical foundations and applying ethical standards (COPE guidelines) to prevent misconduct (plagiarism, falsification, fabrication).
2. Evaluate publication credibility by detecting predatory journals and effectively utilizing open-access tools and journal finders.
3. Apply research integrity tools, including plagiarism-checking software and citation analysis techniques (h-index, Impact Factor), to ensure academic quality.
4. Navigate scholarly databases (Scopus, Web of Science) to retrieve, assess, and document research using standard metrics and ethical practices.

1. **Pedagogy:** Classroom teaching, guest lectures, group discussions, and practical sessions.
2. **Evaluation:** Continuous assessment will be done through tutorials, assignments, quizzes, and group discussions. Weightage will be given for active participation. Final written examination will be conducted at the end of the course.
3. **Course structure:** The course comprises of six modules listed in table below. Each module has 4-5 units.

MODULES	UNIT TITLE	TEACHING HOURS
Theory		
RPE 01	Philosophy and Ethics	4
RPE 02	Scientific Conduct	4
RPE 03	Publication Ethics	7
Practice		
RPE 04	Open Access Publishing	4
RPE 05	Publication Misconduct	4
RPE 06	Databases and Research Metrics	7
	Total	**30**

SYLLABUS IN DETAIL

THEORY

RPE 01: PHILOSOPHY AND ETHICS (3 hrs.)

1. Introduction to philosophy: definition, nature and scope, concept, branches
2. Ethics: definition, moral philosophy, nature of moral judgments and reactions

RPE 02: SCIENTIFICCONDUCT (5 hrs.)

1. Ethics with respect to science and research
2. Intellectual honesty and research integrity
3. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP)
4. Redundant publications: duplicate and overlapping publications, salami slicing
5. Selective reporting and misrepresentation of data

RPE 03: PUBLICATION ETHICS (7 hrs.)

1. Publication ethics: definition, introduction and importance
2. Best practices / standards setting initiatives and guidelines: COPE, WAME, etc.
3. Conflicts of interest
4. Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types
5. Violation of publication ethics, authorship and contributorship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals

PRACTICE

RPE 04: OPEN ACCESS PUBLISHING (4 hrs.)

1. Open access publications and initiatives
2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies
3. Software tool to identify predatory publications developed by SPPU
4. Journal finder/journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggested, etc.

RPE 05: PUBLICATION MISCONDUCT

(4hrs.)

(A) Group Discussions (2 hrs.)

1. Subject specific ethical issues, FFP, authorship
2. Conflicts of interest
3. Complaints and appeals: examples and fraud from India and abroad

(B) Software tools (2 hrs.):Use of plagiarism software like Tumitin, Urkund and other open source software tools

RPE 06: DATABASES AND RESEARCH METRICS

(7hrs.)

(A) Databases (4 hrs.)

1. Indexing databases
2. Citation databases: Web of Science,

Scopus, etc. (B) Research Metrics (3 hrs.)

1. Impact Factor of journal as per Journal Citation Report, SNIP, SIR, IPP, Cite Score
2. Metrics: h-index, g index, i10 index, altmetrics

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
Research and Publication Ethics	**CO1**	**x**	**x**	**x**	**x**

	ADVANCE MATHEMATICS AND COMPUTATIONS	L	T	P	C
Course Code:	**24EVOE02**	**4**	**0**	**0**	**4**
Course Type:	**Prerequisite**				
Pre-Requisite	**Nil**				

COURSE OBJECTIVES (COs)

In this course, students will learn advanced mathematics involved in electronics. This course also focuses on modelling various systems and conducting statistical tests.

COURSE LEARNING OUTCOMES (CLOs)

By the end of this course, students will:

1. Acquire knowledge about advanced mathematics involved in electronics engineering.
2. Be able to model systems and analyze them.
3. Be able to apply various tests for statistical analysis.
4. Utilize mathematical and statistical methods to solve complex engineering problems in electronics.

UNIT	CONTENTS	HOURS
UNIT-I:	Linear, partial and special differential equation, Different coordinate systems and its conversion, Laplace, Fourier and z- transform, Empirical law of the curve fitting, distribution functions (binomial, Poision, normal, uniform, exponential, rectangular) and Tests (T,F,X2).	9
UNIT-II:	Method for numerical solution of algebraic and transcendental equations: Direct methods: Bisection method, Regula-Falsi method; iterative method: Newton-Raphson method, Rate of convergence, Interpolation, Newton forwarded and backward interpolation, Lagrange's and Newton's divided difference for unique interval.	9
UNIT-III:	Numerical differentiation and integration method, Simpsion's rules, Trapezoidal rule and Romberg's method, Numerical solution of ordinary differential equations: Euler method, modified Euler method and Runge-kutta methods	9
UNIT-IV:	Introduction, definition of modeling and simulation, different types of models, Application of mathematical modeling.	9
UNIT-V:	Continuity equation, energy equation, equation of motion, transport equation, equation of states, phase and chemical equilibrium.	9

TEXTBOOKS

1. Tsividis, Y., *Operation and Modeling of the MOS Transistor*, Oxford University Press, 2nd ed. (2008).
2. Sze, S.M., *Physics of Semiconductor Devices*, Wiley (2008).
3. Muller, R.S., Kamins, T.I., and Chan, M., *Device Electronics for Integrated Circuits*, John Wiley, 3rd ed. (2007).

REFERENCE BOOKS

1. Taur, Y., and Ning, T.H., *Fundamentals of Modern VLSI Devices*, Cambridge University Press (2009).
2. Massobrio, G., and Antognetti, P., *Semiconductor Device Modeling*, McGraw Hill (1998).

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
ADVANCE MATHEMATICS AND COMPUTATIONS	**CO1**	**X**	**X**	**X**	**X**

	NANO TECHNOLOGY	L	T	P	C
Course Code:	**24EVOE03**	**4**	**0**	**0**	**4**
Course Type:	**Prerequisite**				
Pre-Requisite	**Nil**				

COURSE OBJECTIVES (COs)

The objective of this course is to make students familiar with the important concepts applicable to small electronic devices, their fabrication, characterization, and application.

COURSE LEARNING OUTCOMES (CLOs)

The students will be exposed to various opportunities in the emerging field of nanoelectronics and nanotechnologies.

UNIT	CONTENTS	HOURS
UNIT-I:	**LIMITATIONS OF CMOS** ➢ Fundamentals of MOSFET devices ➢ Scaling of CMOS – Limitations ➢ Alternative concepts in materials ➢ Structures of MOS devices: SOI MOSFET, FINFETS, Dual ➢ Gate MOSFET, Ferroelectric FETs	9
UNIT-II:	**MICRO AND NANO FABRICATION** ➢ Optical Lithography ➢ Electron Beam Lithography ➢ Atomic Lithography ➢ Molecular Beam Epitaxy ➢ Nano Lithography	9
UNIT-III:	**CHARACTERIZATION EQUIPMENTS** ➢ Principles of Electron Microscopes ➢ Scanning Electron Microscope (SEM) ➢ Transmission Electron Microscope (TEM) ➢ Atomic Force Microscope (AFM) ➢ Scanning Tunneling Microscope (STM)	9
UNIT-IV:	**NANO DEVICES – I** ➢ Resonant Tunneling Diodes ➢ Single Electron Devices ➢ Josephson Junction ➢ Single Flux Quantum Logic ➢ Molecular Electronics	9
UNIT-V:	**NANO DEVICES – II** ➢ Quantum Computing: Principles, Qubits ➢ Carbon Nanotubes (CNT): Characteristics, CNTFET, Applications of CNT ➢ Spintronics: Principle, Spin Valves, Magnetic Tunnel ➢ Junctions, Spin FETs, MRAM	9

TEXT BOOK

1. Rainer Waser (Ed.), "Nanoelectronics and Information Technology", Wiley -VCH, Edition II, 2005.

REFERENCE BOOKS

1. Thomas Heinzel, "A Microscopic Electronics in Solid State Nanostructure", Wiley -VCH.
2. Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, and Burkhard Raguse, "Nanotechnology – (Basic Science and Emerging Technologies)", Overseas Press.
3. Mark Ratner and Daniel Ratner, "Nanotechnology: A Gentle Introduction to the Next Big Idea", Pearson Education, 2003.

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
NANO TECHNOLOGY	**CO1**	**X**	**X**	**X**	**X**

	ENGINEERING ECONOMICS AND MANAGEMENT	L	T	P	C
Course Code:	**24EVOE04**	**4**	**0**	**0**	**4**
Course Type:	**Prerequisite**				
Pre-Requisite	**Nil**				

1. COURSE OBJECTIVES (COs)

Understand microeconomics, time value of money, depreciation, project management techniques, and industrial safety issues.

2. COURSE LEARNING OUTCOMES (CLOs)

To provide engineering students with the management skills to enable them to assess, evaluate, and take key management decisions by applying management concepts.

UNIT	CONTENTS	HOURS
UNIT-I	Introduction to Economics for Engineers: Role and importance, Law of demand and supply, Break-even analysis, Pricing policies.	9
UNIT-II	Financial Management: Cost determination, Balance sheet, Cost-benefit analysis, Time value of money, Methods of depreciation, Long-term and short-term financing, financial institutions.	9
UNIT-III	Project Management: Nature and functions of management, Project phases and techniques, CPM, PERT, Human aspects of project management – issues and problems, Managing vs. leading a project.	9
UNIT-IV	Marketing and Industrial Management: Marketing concepts, Marketing mix, Product life cycle, Plant layout and location, Material handling, Productivity, Plant maintenance, Industrial safety.	9
UNIT-V	Emerging Trends in Management: Current trends in financing, Role and applications of Industrial Engineering, Process of project management and its future, Ethics and project management, E-marketing – Ethical and legal issues.	9

4. Textbooks

1. R. Pannerselvam, *Engineering Economics*, PHI, 2001.
2. O.P. Khanna, *Industrial Engineering and Management*, Dhanpat Rai and Sons, 1992.

5. Reference Books

1. Kotler, *Marketing Management*, Pearson Education, 12th Edition.
2. Prasanna Chandra, *Finance Sense for Non-Finance Executives*, TMH.

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
ENGINEERING ECONOMICS AND MANAGEMENT	**CO1**	**X**	**X**	**X**	**X**

	INDUSTRIAL MANAGEMENT	L	T	P	C
Course Code:	**24EVOE05**	**4**	**0**	**0**	**4**
Course Type:	**Prerequisite**				
Pre-Requisite	**Nil**				

COURSE OBJECTIVES (COs) Understand strategic planning, management, entrepreneurship, production, markets, pricing strategies, and a company's interaction with its environment.

COURSE LEARNING OUTCOMES (CLOs)

1. Choose, prepare, interpret, and use cost estimates as a basis for different situations in an industrial company.
2. Interpret financial statements and other financial reports of industrial companies, including the income statement, balance sheet, cash flow statement, and key financial measures.
3. Describe how management control of results, actions, people, and culture functions in an industrial company.

UNIT	CONTENTS	HOURS
UNIT-I:	**Introduction to Management** ➢ Entrepreneurship and Organization ➢ Nature and Importance of Management ➢ Functions of Management ➢ Taylor's Scientific Management Theory ➢ Fayol's Principles of Management ➢ Maslow's Theory of Human Needs ➢ Douglas McGregor's Theory X and Theory Y ➢ Herzberg's Two-Factor Theory of Motivation ➢ Systems Approach to Management ➢ Leadership Styles ➢ ◦ Social Responsibilities of Management	9
UNIT-II:	**Designing Organizational Structures** ◦ Departmentation and Decentralization ◦ Types of Organizational Structures: ➢ Line Organization ➢ Line and Staff Organization ➢ Functional Organization ➢ Committee Organization ➢ Matrix Organization ➢ Virtual Organization ➢ Cellular Organization ➢ Team Structure ➢ Boundary-less Organization ➢ Inverted Pyramid Structure ➢ Lean and Flat Organizational Structure ◦ Merits, Demerits, and Suitability of Different Structures	9
UNIT-III:	**Operations Management** ➢ Objectives ➢ Product Design Process ➢ Process Selection ➢ Types of Production Systems: ➢ Job Production ➢ Batch Production ➢ Mass Production ➢ Plant Location Factors: Urban vs. Rural Site Comparison ➢ Types of Plant Layouts ➢ Design of Product Layout ➢ Line Balancing (RPW Method) ➢ Value Analysis: ➢ Definition ➢ Types of Values ➢ Objectives ➢ Phases of Value Analysis o o FAST Diagram	9

UNIT-IV:	**Work Study & Statistical Quality Control** ➢ Work Study: ➢ Introduction, Definition, Objectives ➢ Steps in Work Study ➢ Method Study: Definition, Objectives, Steps ➢ Work Measurement: Purpose, Types of Study ➢ Stopwatch Methods: Steps, Key Rating, Allowances, Standard Time Calculations ➢ Work Sampling ➢ Statistical Quality Control: ➢ Variables and Attributes ➢ Shewhart Control Charts for Variables (X-chart, R-chart) ➢ Charts for Attributes (p-chart, c-chart) ➢ Acceptance Sampling (Single Sampling, Double Sampling Plans, ➢ OC Curves)	9
UNIT-V:	➢ **Job Evaluation & Project Management** ➢ Job Evaluation: ➢ Methods of Job Evaluation: Simple Routing Objective Systems, Classification Method, Factor Comparison Method, Point Method ➢ Benefits and Limitations of Job Evaluation ➢ Project Management (PERT/CPM): ➢ Network Analysis ➢ Programme Evaluation and Review Technique (PERT) ➢ Critical Path Method (CPM) ➢ Identifying Critical Path ➢ Probability of Completing the Project within Given Time ➢ Project Cost Analysis ➢ Project Crashing (Simple Problems)	9

TEXTBOOKS:

1. *Industrial Engineering and Management* – O.P. Khanna, Khanna Publishers
2. *Industrial Engineering and Management Science* – T.R. Banga & S.C. Sarma, Khanna Publishers

REFERENCE BOOKS:

1. *Motion and Time Study* – Ralph M. Barnes, John Wiley & Sons
2. *Work Study* – ILO
3. *Human Factors in Engineering & Design* – Ernest J. McCormick, TMH

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
INDUSTRIAL MANAGEMENT	**CO1**	**X**	**X**	**X**	**X**

	RELIABILITY AND QUALITY MANAGEMENT	L	T	P	C
Course Code:	**24EVOE06**	**4**	**0**	**0**	**4**
Course Type:	**Prerequisite**				
Pre-Requisite	**Nil**				

Course Objective:
To introduce the concepts of Statistical Quality Control (SQC), process control, acceptance sampling, and reliability in manufacturing.

Course Learning Outcomes (CLOs):
Upon successful completion of this course, students will be able to:

- Apply SQC techniques for effective process control and quality improvement.
- Implement acceptance sampling procedures for quality assurance.
- Analyze and enhance system reliability in manufacturing processes.
- Utilize statistical tools to monitor and improve production efficiency.

UNIT	CONTENTS	HOURS
UNIT-I:	**Introduction and Process Control for Variables** ➢ Introduction, definition of quality, basic concepts of quality. ➢ Definition of SQC, benefits and limitations of SQC. ➢ Quality assurance, quality control. ➢ Quality cost, variation in process, causes of variation. ➢ Theory of control charts, uses of control charts. ➢ Control charts for variables: X Chart, R Chart, and σ Chart. ➢ Process capability, process capability studies with simple problems. ➢ Six Sigma concepts.	9
UNIT-II:	**Process Control for Attributes** ➢ Control charts for attributes: ➢ Control chart for non-conforming: P Chart and NP Chart. ➢ Control chart for nonconformities: C Chart and U Chart. ➢ State of control and process out-of-control identification in charts. ➢ Pattern study	9
UNIT-III:	**Acceptance Sampling** ➢ Lot-by-lot sampling: Types and probability of acceptance in single, double, and multiple sampling techniques. ➢ Operating Characteristic (O.C.) curves. ➢ Producer's risk and consumer's risk. ➢ AQL, LTPD, AOQL concepts. ➢ Standard sampling plans for AQL and LTPD. ➢ Uses of standard sampling plans.	9
UNIT-IV:	**Life Testing & Reliability** ➢ Life testing: Objective and failure data analysis. ➢ Mean failure rate, mean time to failure (MTTF), mean time between failures (MTBF), hazard rate. ➢ Weibull model, system reliability, series, parallel, and mixed configurations (with simple problems). ➢ Maintainability and availability (with simple problems). ➢ Acceptance sampling based on reliability test. ➢ O.C. curves.	9
UNIT-V:	**Quality and Reliability** ➢ Reliability improvements: Techniques. ➢ Use of Pareto analysis. ➢ Design for reliability. ➢ Redundancy unit and standby redundancy.	9

	➢ Optimization in reliability. ➢ Product design, product analysis, product development, product life cycles.	

Textbooks

1. Douglas C. Montgomery, *Introduction to Statistical Quality Control*, 4th Edition, John Wiley, 2001.
2. Srinath L.S., *Reliability Engineering*, Affiliated East-West Press, 1991.

Reference Books

1. John S. Oakland, *Statistical Process Control*, 5th Edition, Elsevier, 2005.
2. Connor P.D.T.O., *Practical Reliability Engineering*, John Wiley, 1993.

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
RELIABILITY AND QUALITY MANAGEMENT	CO1	X	X	X	X

	ENTREPRENEURSHIP DEVELOPMENT	L	T	P	C
Course Code:	**24EVOE07**	**4**	**0**	**0**	**4**
Course Type:	**Prerequisite**				
Pre-Requisite	**Nil**				

Course Objective:

To develop entrepreneurial qualities, motivation, and essential skills for efficiently running a business.

Course Learning Outcomes (CLOs):

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

1. Apply entrepreneurial skills to start and manage a business effectively.
2. Develop business strategies for growth and sustainability.
3. Analyze market opportunities and financial risks in entrepreneurship.
4. Demonstrate problem-solving and decision-making abilities in business operations.

UNIT	CONTENTS	HOUR
UNIT-I:	**Entrepreneurship** ➢ Entrepreneur – Types of Entrepreneurs ➢ Difference Between Entrepreneur and Entrepreneurship ➢ Entrepreneurship in Economic Growth ➢ Factors Affecting Entrepreneurial Growth	9
UNIT-II:	**Motivation** ➢ Major Motives Influencing an Entrepreneur ➢ Achievement Motivation Training ➢ Self-Rating, Business Games, Thematic Apperception Test ➢ Stress Management ➢ Entrepreneurship Development Programs – Need,	9
UNIT-III:	**Business** ➢ Small Enterprises – Definition, Classification, Characteristics ➢ Ownership Structures ➢ Project Formulation – Steps in Setting Up a Business ➢ Identifying and Selecting a Good Business Opportunity ➢ Market Survey and Research ➢ Techno-Economic Feasibility Assessment ➢ Preparation of Preliminary Project Reports	9
UNIT-IV:	**Financing and Accounting** ➢ Need for Finance and Sources of Finance ➢ Term Loans, Capital Structure, Financial Institutions ➢ Management of Working Capital ➢ Costing and Break-Even Analysis ➢ Taxation – Income Tax, Excise Duty, Sales Tax	9
UNIT-V:	**Support to Entrepreneurs** ➢ Sickness in Small Business – Concept, Magnitude, Causes, and Consequences ➢ Corrective Measures ➢ Business Incubators ➢ Government Policy for Small-Scale Enterprises ➢ Growth Strategies in Small Industry – Expansion, Diversification, Joint Venture, Merger, and Sub-Contracting	9

Textbooks

1. Khanka S.S., *Entrepreneurial Development*, S. Chand & Co. Ltd., New Delhi, 2013.
2. Donald F. Kuratko, *Entrepreneurship – Theory, Process, and Practice*, 9th Edition, Cengage Learning, 2014.

Reference Books

1. Hisrich R.D., Peters M.P., *Entrepreneurship*, 8th Edition, Tata McGraw-Hill, 2013.
2. Mathew J. Manimala, *Entrepreneurship Theory at Cross Roads: Paradigms and Praxis* .

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
ENTREPRENEURSHIP DEVELOPMENT	CO1	X	X	X	X

	AUTOMOTIVE ENGINEERING FOR ELECTRIC VEHICLES	L	T	P	C
Course Code:	**24EVDE01**	**4**	**0**	**0**	**4**
Course Type:	**Prerequisite**				
Pre-Requisite	**Nil**				

Course Objectives (COs)

This course develops entrepreneurial qualities, motivation, and essential skills for effectively running a business.

Course Learning Outcomes (CLOs)

Upon completion of this course, students will be able to:

1. Classify electric vehicles based on the configuration level.
2. Analyze the suspension and transmission systems associated with EVs.
3. Analyze the braking and steering systems of EVs.
4. Evaluate the factors affecting the performance of batteries.

UNIT	CONTENTS	HOUR S
UNIT-I:	**ENTREPRENEURSHIP** ➢ Entrepreneur – Types of Entrepreneurs ➢ Difference between Entrepreneur and Intrapreneur ➢ Entrepreneurship in Economic Growth ➢ Factors Affecting Entrepreneurial Growth	9
UNIT-II:	**MOTIVATION** ➢ Major Motives Influencing an Entrepreneur ➢ Achievement Motivation Training ➢ Self-Rating, Business Games, Thematic Apperception Test ➢ Stress Management ➢ Entrepreneurship Development Programs – Need, Objectives	9
UNIT-III:	**BUSINESS** ➢ Small Enterprises – Definition, Classification, Characteristics ➢ Ownership Structures ➢ Project Formulation – Steps in Setting Up a Business ➢ Identifying and Selecting a Good Business Opportunity ➢ Market Survey and Research ➢ Techno-Economic Feasibility Assessment ➢ Preparation of Preliminary Project Reports ➢ Project Appraisal – Sources of Information ➢ Classification of Needs and Agencies	9
UNIT-IV:	**FINANCING AND ACCOUNTING** ➢ Need and Sources of Finance ➢ Term Loans, Capital Structure, Financial Institutions ➢ Management of Working Capital ➢ Costing and Break-Even Analysis ➢ Taxation – Income Tax, Excise Duty, Sales Tax	9
UNIT-V:	**SUPPORT TO ENTREPRENEURS** ➢ Sickness in Small Business – Concept, Magnitude, Causes, and ➢ Consequences ➢ Corrective Measures ➢ Business Incubators ➢ Government Policy for Small-Scale Enterprises ➢ Growth Strategies in Small Industry – Expansion, Diversification, Joint Venture, Merger, and Subcontracting	9

Textbooks

1. Khanka, S.S., *Entrepreneurial Development*, S. Chand & Co. Ltd., Ram Nagar, New Delhi, 2013.
2. Donald F. Kuratko, *Entrepreneurship – Theory, Process, and Practice*, 9th Edition, Cengage Learning, 2014.

Reference Books

1. Hisrich R. D., Peters M. P., *Entrepreneurship*, 8th Edition, Tata McGraw-Hill, 2013.
2. Mathew J. Manimala, *Entrepreneurship Theory at Crossroads: Paradigms and Praxis* .

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
AUTOMOTIVE ENGINEERING FOR ELECTRIC VEHICLES	CO1	x	x	x	x

	Hybrid Electric Vehicles	L	T	P	C
Course Code:	**24EVDE02**	**4**	**0**	**0**	**4**
Course Type:	**PE**				
Pre-Requisite	**None**				

COURSE OBJECTIVES (COs)

To provide fundamental knowledge of hybrid and electric vehicles, their operation, energy storage needs, and emerging technologies.

COURSE LEARNING OUTCOMES (CLOs) At the end of the course, the student will be able to:

1. Realize the importance of electric transportation systems.
2. Understand the basics of electric vehicle components and configuration.
3. Understand the various charging types, comfort, and safety methods.
4. Understand the application of electric vehicles in Smart Grid.

UNI	COURSE CONTENTS	HOURS
UNIT-I	**ELECTRIC VEHICLES** ➢ History of Modern Transportation ➢ Importance of Different Transportation Development Strategies to Future Oil Supply ➢ Introduction to Electric Vehicles ➢ History of Hybrid and Electric Vehicles ➢ Social, Environmental Importance, and Key Challenges of Hybrid and Electric Vehicles ➢ Specifications of PHEVs, BEVs, EVs ➢ Plug-in Hybrid Vehicle Characteristics ➢ The Future of Electric Vehicles	9
UNIT-II	**ENERGY STORAGE AND BATTERY TECHNOLOGY** ➢ Introduction to Energy Storage Systems ➢ Battery Requirements for HEVs, PHEVs, and EVs ➢ Types of Batteries and Their Properties ➢ Working Principle and Construction of Lead-Acid, Nickel Cadmium, Nickel Metal ➢ Hydride, Lithium-Ion Batteries ➢ Maintenance and Charging of Batteries ➢ Diagnosing Lead-Acid Battery Faults ➢ Advanced Battery Technology ➢ Developments in Electrical Storage	9
UNIT-III	**CHARGING AND STARTING SYSTEMS** ➢ Requirements of the Charging System ➢ Charging System Principles ➢ Alternators and Charging Circuits ➢ Diagnosing Charging System Faults ➢ Advanced Charging System Technology ➢ New Developments in Charging Systems ➢ Requirements of the Starting System ➢ Starter Motors and Circuits ➢ Types of Starter Motors ➢ Diagnosing Starting System Faults ➢ Advanced Starting System Technology ➢ New Developments in Starting Systems ➢ Case Studies	9
UNIT-IV	**HYBRID ELECTRIC VEHICLE DRIVE TRAIN AND SAFETY** ➢ Requirement of Drive Train ➢ Architecture of Hybrid Drive Train ➢ Sizing of Components ➢ Series Configuration ➢ Parallel Configuration ➢ Parallel and Series Configuration ➢ Security: Airbags and Belt Tensioners ➢ Diagnosing Comfort and Safety System Faults ➢ Advanced Comfort and Safety Systems Technology ➢ New Developments in Comfort and Safety Systems	9

UNIT-V	**EMERGING TECHNOLOGIES** ➢ Introduction to Emerging Technologies ➢ Electric Vehicle Supply Equipment (EVSE) ➢ Smart Vehicles in Smart Grid ➢ Vehicle-to-Grid (V2G) Technologies: Unidirectional and Bidirectional ➢ Need for Charging Station Selection (CSS) Server ➢ Smart Grid Technologies: Applications and Benefits ➢ Smart Meter ➢ Smart Charger: Purpose and Benefits	9

TEXT BOOKS

1. M. Ehsani, Y. Gao, and A. Emadi, *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design*, Second Edition, CRC Press, ISBN: 978-1-4200-5398-2, Aug. 2009.
2. Tom Denton, *Automobile Electrical and Electronic Systems*, Elsevier Butterworth-Heinemann, Third Edition, 2004.
3. Emadi, *Advanced Electric Drive Vehicles*, CRC Press, ISBN: 978-1-4665-9769-3, Oct. 2014.

REFERENCE BOOKS

1. Iqbal Hussain, *Electric & Hybrid Vehicles – Design Fundamentals*, Second Edition, CRC Press, 2011.
2. James Larminie, *Electric Vehicle Technology Explained*, John Wiley & Sons, 2003.
3. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, *Smart Grid: Technology and Applications*, John Wiley & Sons Inc, 2012.

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
Hybrid Electric Vehicles	**CO1**	**X**	**X**	**X**	**X**

	COMPUTER NETWORKS	L	T	P	C
Course Code:	**24EVDE03**	**4**	**0**	**0**	**4**
Course Type:	**Prerequisite**				
Pre-Requisite	**Nil**				

COURSE OBJECTIVES (COs)

To provide a comprehensive understanding of computer networking, including OSI and TCP/IP models, data link and network layers, routing protocols, and application-layer paradigms.

COURSE LEARNING OUTCOMES (CLOs) After completion of the course, students would be able to:

1. Describe the functions of each layer in the OSI and TCP/IP model.
2. Describe the functions of the data link layer and explain the protocols.
3. Classify the routing protocols and analyze how to assign the IP addresses for the given network.
4. Describe the session layer design issues and transport layer services.

UNIT	CONTENTS	HOURS
UNIT-I	**Introduction** ➢ Internet: A brief history; Internet standards and standards organization ➢ OSI Reference Model; TCP/IP Model ➢ Types of Networks: Local Area Networks (LAN), Metropolitan Area ➢ Networks (MAN), Wide Area Network (WAN) ➢ Network Topologies: Bus, Star, Ring, Hybrid, Tree, Complete, Irregular ➢ Topology ➢ Addressing ➢ Physical Layer: Analog and digital signal properties (Sinewave, Phase, Wavelength, Bit rate) ➢ Transmission Impairment, Performance Measures (Bandwidth, Throughput, Latency, Jitter) ➢ Guided and unguided transmission media ➢ Circuit Switching, Packet Switching	9
UNIT-II	**Data Link Layer** ➢ Design Issues: Framing, Error Detection & Correction (Byte and Bit stuffing, Checksum, CRC, Hamming Codes) ➢ Elementary Data Link Protocols: Sliding Window Protocols ➢ Media Access Control: ➢ Random Access: Aloha, CSMA, CSMA/CD ➢ Controlled Access: Token Passing, Polling, Reservation ➢ Channelization: TDMA, FDMA, CDMA ➢ Ethernet Standard	9
UNIT-III	**Network Layer Protocols** ➢ IPv4 Addressing: Classful and Classless, Network Address Translation ➢ (NAT) ➢ IPv4 Packet Format ➢ IPv6 Addressing, IPv6 Packet Format ➢ ARP, RARP, DHCP, ICMP, IGMP	9
UNIT-IV	**Network Routing & Traffic Management** ➢ LAN Interconnecting Devices: Hubs, Switches, Bridges, Routers, Gateways ➢ Routing & Forwarding, Routing Table, Intra- and Inter-Domain Routing ➢ Distance Vector Routing (DVR), DVR Instability Problem and Solutions, RIP ➢ Link State Routing, OSPF, Path Vector Routing, BGP ➢ Virtual Private Networks (VPN) ➢ Routing Protocols: Implementation and Performance Analysis using Packet ➢ Tracer ➢ TCP and UDP Congestion Control ➢ Effects of Congestion, Traffic Management, TCP Congestion Control, Congestion Avoidance Mechanisms ➢ Queuing Mechanisms, QoS Parameters	9

UNIT-V	**Transport & Application Layer** ▪ Transmission Control Protocol (TCP) ▪ User Datagram Protocol (UDP) ▪ Congestion Control Mechanisms ▪ Application Layer Protocols: ▪ Email: SMTP, POP, IMAP ▪ FTP, NNTP, HTTP, DNS, WWW ▪ Firewall	9

TEXTBOOKS

1. Andrew S. Tanenbaum, "Computer Networks", Pearson, Fourth Edition, 2005.

REFERENCE BOOKS

1. Behrouz A. Forouzan, "Data Communication and Networking", Tata McGraw-Hill, 2004.
2. James F. Kurose and Keith W. Ross, "Computer Networking: A Top-Down Approach Featuring the Internet", Pearson Education, Third Edition, 2003.
3. William Stallings, "Data and Computer Communication", Seventh Edition, Pearson Education, 2003.

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
COMPUTER NETWORKS	**CO1**	**x**	**x**	**x**	**x**

	INTERNET OF THINGS	L	T	P	C
Course Code:	**24EVDE04**	**4**	**0**	**0**	**4**
Course Type:	**Prerequisite**				
Pre-Requisite	**Nil**				

COURSE OBJECTIVES (CO)

To equip students with knowledge of IoT protocols, sensor technologies, real-time applications, business intelligence, and information security.

COURSE LEARNING OUTCOMES (CLO) The syllabus has been prepared in accordance with the National Education Policy (NEP). After completing the course, students will be able to:

1. Understand the vision of IoT and communication protocols from a global context.
2. Understand and apply IoT protocols.
3. Apply and analyze sensor networks and their components in the IoT domain.
4. Design portable IoT using appropriate boards.
5. Evaluate the applications of IoT in agriculture, healthcare, smart grid, and factory settings.
6. Build and create state-of-the-art architecture in IoT.

UNIT	CONTENTS	HOURS
UNIT-I	**Introduction to IoT:** Definition, Characteristics, Applications, Connectivity Layers, Addressing, Networking, Sensing: Sensors and Transducers, Sensor Classes, Sensor Types, Actuation: Actuator Basics, Actuator Types **Basics of IoT Networking:** IoT Components, Inter-dependencies, SoA, Wireless Networks, Protocol Classification, MQTT, Secure MQTT, CoAP, XMPP,AMQP (Advanced Message Queuing Protocol).	9
UNIT-II	**IoT Protocols:** Protocol Standardization for IoT-M2M and WSN Protocols. **Connectivity Technologies:** IEEE 802.15.4, ZigBee, 6LoWPAN, RFID, HART, NFC, Bluetooth, Zwave, ISA100.11a	9
UNIT-III	**Sensor Networks:** Basic Concepts, Wireless Sensor Networks, Sensor Nodes, Node Behaviour, Social Sensing, Application Examples, Target Tracking, Wireless Multimedia Sensor Networks, Coverage, Mobile Wireless Sensor Networks and their Applications, UAV (Unmanned Aerial Vehicle) Networks, Machine to Machine Communication, Interoperability in Internet of Things	9
UNIT-IV	**Introduction to Arduino**: Basic Concepts of Arduino Platform, Examples of Arduino Programming, Integration of Sensors and Actuators with Arduino, **Introduction to Raspberry Pi**, Implementation of IoT with Raspberry, Software Defined Networking, Software Defined IoT Networking	9
UNIT-V	**Cloud Computing:** Fundamentals, Service Models, Service Management and Security, Case Studies, Open Source Platform, Sensor Cloud, Fog Computing, **Application Domains of IoT:** Smart Cities: Need for Smart Cities, Challenges in Building Smart Cities, Some Technical Issues behind Enabling Smart Cities, Smart Homes: Home Area Networks (HANs), Connected Vehicles, Smart Grid, Industrial IoT, Data Handling and Analytics, Case Study: Agriculture, Healthcare, Activity	9
UNIT-VI	**PROJECT**	

TEXT BOOKS

1. Honbo Zhou, "The Internet of Things in the Cloud: A Middleware Perspective," CRC Press, 2012.
2. Arshdeep Bahga, Vijay Madisetti, "Internet of Things (A Hands-On-Approach)," VPT, 2014.
3. Dieter Uckelmann, Mark Harrison, "Architecting the Internet of Things," Springer, 2011.
4. Olivier Hersent, David Boswarthick, Omar Elloumi, "The Internet of Things – Key Applications and Protocols," Wiley, 2012.
5. "The Internet of Things: Enabling Technologies, Platforms, and Use Cases" by Pethuru Raj and Anupama C. Raman, CRC Press.

REFERENCE BOOKS

1. "Raspberry Pi Cookbook: Software and Hardware Problems and Solutions," Simon Monk, O'Reilly (SPD), 2016, ISBN: 9789352133895.
2. "Getting Started with Raspberry Pi," Matt Richardson & Shawn Wallace, O'Reilly (SPD), 2014, ISBN: 9789350239759.

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
INTERNET OF THINGS	**CO1**	**X**	**X**	**X**	**X**

	ELECTRO-CHEMISTRY OF FUEL CELLS	L	T	P	C
Course Code:	**24EVDE05**	**4**	**0**	**0**	**4**
Course Type:	**PE**				
Pre-Requisite	**None**				

COURSE OBJECTIVES (CO)

To provide knowledge on fuel cell types, thermodynamics, electrochemical concepts, performance characteristics, and hydrogen fueling.

COURSE LEARNING OUTCOMES (CLO) The syllabus has been prepared in alignment with the National Education Policy (NEP). After completion of the course, students will be able to:

1. Explain the various types of fuel cells.
2. Learn the thermodynamic background of fuel cells.
3. Gain an understanding of the fundamental concepts of electrochemical fuel cells.
4. Understand the performance behavior of fuel cells.
5. Know the various technologies of hydrogen fueling.

UNIT	CONTENTS	HOURS
UNIT-I	**Introduction to Fuel Cells** ➢ Introduction, working, and types of fuel cells ➢ Low, medium, and high-temperature fuel cells ➢ Liquid and methanol types ➢ Proton exchange fuel cell, solid oxide fuel cells, hydrogen fuel cells ➢ Thermodynamics and electrochemical kinetics of fuel cells	9
UNIT-II	**Thermodynamics** ➢ Enthalpy change of a reacting system ➢ Systematic Gibbs free energy ➢ Ideal efficiency of energy conversion ➢ Energy balance in fuel cells	9
UNIT-III	**Electrochemistry** ➢ Nernst equation ➢ Relation of fuel consumption to current output ➢ Stoichiometric coefficients and utilization percentages of fuel and oxygen ➢ Mass flow rate calculation for fuel and oxygen in a single cell and fuel cell stack ➢ Total voltage and current for fuel cells in parallel and series connections ➢ Over-potential and polarizations ➢ DMFC operation scheme ➢ General issues: Water flooding and water management, polarization in PEMFC	9
UNIT-IV	**Fuel Cell Components and their impact on performance** ➢ Fuel cell performance characteristics: Current/voltage, voltage efficiency, and power density ➢ Ohmic resistance, kinetic performance, mass transfer effects ➢ Membrane electrode assembly components ➢ Fuel cell stacks, bi-polar plates, humidifiers, and cooling plates	9
UNIT-V	**Fueling and Hydrogen Storage Technology** ➢ Hydrogen storage technologies: Pressure cylinders, liquid hydrogen, metal hydrides ➢ Methods of hydrogen production ➢ Carbon fibers and reformer technology ➢ Steam reforming, partial oxidation, auto-thermal reforming ➢ CO removal ➢ Fuel cell technology based on renewable sources like biomass	9

TEXTBOOKS

1. Frano Babir, "PEM Fuel Cells: Theory and Practice," Elsevier Academic Press, USA, 2005.
2. Viswanathan B. and Scibioh Aulice M, "Fuel Cells: Principles and Applications," University Press, 2006.

REFERENCE BOOKS

1. Fuel Cells for Automotive Applications," Professional Engineering Publishing, UK, 2004.
2. Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, and Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design," CRC Press, 2003.
3. Young G. J., "Fuel Cells," Reinhold Publishing Corp., 1960.

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
ELECTRO-CHEMISTRY OF FUEL CELLS	CO1	x	x	x	x

	Electric Drives and Controls for Electric Vehicles	L	T	P	C
Course Code:	**24EVDE06**	**3**	**0**	**0**	**3**
Course Type:	**E**				
Pre-Requisite	**one**				

COURSE OBJECTIVES (CO)

To provide knowledge of motor characteristics, electric drive concepts, DC and AC drive mechanisms, and special electrical machine drives.

COURSE LEARNING OUTCOMES (CLO)

This syllabus aligns with the National Education Policy (NEP). Upon completing this course, students will be able to:

1. Describe motor and device characteristics and parameters.
2. Explain various electric drive concepts.
3. Understand the DC drive mechanism.
4. Understand the AC drive mechanism.

UNIT	CONTENTS	HOURS
UNIT-I	**MOTOR AND DEVICE CHARACTERISTICS** ➢ Review of motor principles ➢ Motor load dynamics ➢ Starting, braking, and speed control of DC and AC motors ➢ Power semiconductor devices: SCRs, IGBTs, and MOSFETs	9
UNIT-II	**ELECTRIC DRIVE CONCEPTS** ➢ Basic drive concepts ➢ Choice of electric drives and their advantages ➢ Nature and classification of drives ➢ Control and stability of electric drives ➢ Feedback control of drives ➢ Thermal effects in electrical machines ➢ Selection of motor and rating	9
UNIT-III	**DC DRIVES** ➢ Transient analysis of separately excited DC motors ➢ Converters: Single-phase uncontrolled, half-controlled, and fully controlled rectifiers ➢ Chopper control ➢ Closed-loop control of solid-state DC drives	9
UNIT-IV	**AC DRIVES** ➢ Operation of induction and synchronous motors ➢ Direct torque and flux control of induction motor drives ➢ Starting methods and speed control of single-phase induction motors ➢ Self-controlled synchronous motor drives ➢ Selection of motor and rating ➢ Vector control of synchronous motors	9
UNIT-V	**DRIVES FOR SPECIAL ELECTRICAL MACHINES** ➢ Drives for variable reluctance motors ➢ Microprocessor/microcontroller-based gate trigger signal generation ➢ Applications in special electrical machines ➢ Switched reluctance motor drives ➢ Brushless DC motor drives ➢ Permanent magnet drives .	9

TEXTBOOKS

1. Gopal K. D., *Fundamentals of Electric Drives*, Narosa Publishing House Pvt. Ltd.
2. Pillai S. K., *A First Course on Electrical Drives*, Wiley Eastern Ltd., Bombay, 2011.

REFERENCES

1. Ali Elamadi, *Handbook of Automotive Power Electronics and Drives*, CRC.
2. Bimal K. Bose, *Modern Power Electronics and Drives*, Elsevier Publishers, Butterworth.
3. Krishnan R., *Permanent Magnet Synchronous and Brushless DC Motor Drives*, CRC Publishers.
4. Krishnan R., *Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, and Design*.

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
ELECTRIC DRIVES AND CONTROLS FOR ELECTRIC VEHICLES	**CO1**	**X**	**X**	**X**	**X**

	ARTIFICIAL INTELLIGENCE & NEURAL NETWORK	L	T	P	C
Course Code:	**24EVDE07**	**4**	**0**	**0**	**4**
Course Type:	**Prerequisite**				
Pre-Requisite	**Nil**				

COURSE OBJECTIVES (COs)

To develop an understanding of AI principles, engineering challenges, and proficiency in AI programming.

COURSE LEARNING OUTCOMES (CLOs)

Upon completion of this course, students will be able to:

1. Understand different types of AI agents.
2. Apply various AI search algorithms, including uninformed, informed, heuristic, constraint satisfaction, and genetic algorithms.

UNIT	CONTENTS	HOURS
UNIT-I	**Introduction & Search Techniques** ➢ AI problems, foundation and history of AI. ➢ Intelligent agents: Agents and environments, the concept of rationality, nature of environments, structure of agents, problem-solving agents, problem formulation. ➢ Searching: Uniformed search strategies – Breadth-first search, depth-first search. ➢ Search with partial information: Heuristic search – Greedy best-first search, A* search. ➢ Game playing: Adversarial search, minimax algorithm, optimal decisions in multiplayer games, Alpha-Beta pruning, evaluation functions, and search cutting techniques.	9
UNIT-II	**Knowledge Representation & Reasoning** ➢ Logical agents, knowledge-based agents, the Wumpus world. ➢ Propositional logic: Resolution patterns, forward & backward chaining. ➢ First-order logic: Inference in first-order logic, propositional vs. first-order inference, unification & lifts, forward chaining, backward chaining, resolution.	9
UNIT-III	**Fundamentals of Neural Networks** ➢ Characteristics and historical development of neural networks. ➢ Principles of artificial neural networks: Terminology, models of neurons, topology, basic learning laws. ➢ Pattern recognition problems, basic functional units, pattern recognition tasks by functional units.	9
UNIT-IV	**Neural Network Analysis** ➢ Pattern association networks, pattern classification networks, pattern storage networks, pattern mapping networks. ➢ Feedback neural networks: Linear auto-associative feedforward networks, pattern storage networks.	9
UNIT-V	**Advanced Topics & Applications** ➢ Future aspects of nanoelectronics and molecular electronics. ➢ Competitive learning neural networks & complex pattern recognition. ➢ Pattern clustering networks, feature mapping networks, associative memory.	9

TEXT BOOKS

1. Stuart Russell, Peter Norvig, "Artificial Intelligence – A Modern Approach," 2nd Edition, PHI/Pearson Education.
2. Simon Haykin, "Neural Networks," PHI.
3. B. Yagna Narayana, "Artificial Neural Networks," PHI.

REFERENCE BOOKS

1. E. Rich, K. Knight, "Artificial Intelligence," 2nd Edition, TMH.
2. Patterson, "Artificial Intelligence and Expert Systems," PHI.
3. Giarrantana, Riley, "Expert Systems: Principles and Programming," 4th Edition, Thomson.

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
ARTIFICIAL INTELLIGENCE & NEURAL NETWORK	CO1	x	x	x	x

	Discrete Transforms and Signal Processing	L	T	P	C
Course Code:	**24EVDE08**	**3**	**0**	**0**	**3**
Course Type:	**C**				
Pre-Requisite	**one**				

COURSE OBJECTIVES (CO)

To equip students with knowledge of discrete-time signal analysis, Fourier transform properties, and filter design techniques.

COURSE LEARNING OUTCOMES (CLO)

At the end of the course, the student will be able to:

1. Classify signals and systems and their mathematical representation.
2. Learn the discrete Fourier transform and its properties.
3. Design IIR filters using analog-to-digital transformation.
4. Design FIR filters using window techniques and understand digital signal processors and their programming.

UNIT	COURSE CONTENTS	HOURS
UNIT-I	**Discrete Time Signals and Systems:** Classification of systems: Continuous, discrete, linear, causal, stability, dynamic, recursive, time variance; classification of signals: continuous and discrete, energy and power; mathematical representation of signals; spectral density; sampling techniques, quantization, quantization error, Nyquist rate, aliasing effect.	9
UNIT-II	**Overview of Discrete Signals:** Sampling theorem, DFT - Properties of DFT: time shifting, frequency shifting, interpolation, etc.; twiddle factor, linear convolution, circular convolution - graphical method, matrix method, and applications.	9
UNIT-III	**Discrete Fourier Transform & Computation:** Discrete Fourier Transform - properties, magnitude, and phase representation; Computation of DFT using FFT algorithm – DIT & DIF using radix-2 FFT – Butterfly structure; Realization of structures for discrete-time systems – Direct form-I & II, Cascade, Parallel forms, Ladder structure, and Lattice structure.	9
UNIT-IV	**Design of FIR Digital Filters:** FIR & IIR filter realization – Parallel & cascade forms; FIR design: Windowing Techniques – Need and choice of windows – Linear phase characteristics; Fixed point arithmetic – effect of quantization of the input data due to finite word length; Product round-off – need for scaling; Zero input limit cycle oscillations - Limit cycle oscillations due to overflow of adders.	9
UNIT-V	**Design of IIR Digital Filters:** Analog filter design – Butterworth and Chebyshev approximations; IIR Filters, digital design using impulse invariant and bilinear transformation; Warping, pre-warping.	9

TEXTBOOKS

1. John G. Proakis, Dimitris G. Manolakis, "Digital Signal Processing: Principles, Algorithms & Applications," Prentice Hall of India, New Delhi, 2014.
2. Oppenheim, A.V. and Schaffer, R.W., "Discrete Time Signal Processing," Prentice Hall of India, New Delhi, 2007.

REFERENCE BOOKS

1. Emmanuel C. Ifeachor, Barrie W. Jervis, "Digital Signal Processing: A Practical Approach," Pearson Education India Series, New Delhi, 2004.
2. Sanjit K. Mitra, "Digital Signal Processing: A Computer-Based Approach," Tata McGraw-Hill Publishing Company Limited, New Delhi, 2010.
3. Lonnie C. Ludeman, "Fundamentals of Digital Signal Processing," John Wiley & Sons, New Jersey, 2003.
4. Venkataramani B., Bhaskar M., "Digital Signal Processors: Architecture, Programming and Applications," Tata McGraw-Hill, New Delhi, 2003.
5. Johny R. Johnson, "Introduction to Digital Signal Processing," PHI, 2006.
6. Robert X. Gao and Ruqiang Yan, "Wavelets: Theory and Applications for Manufacturing," Springer, 2010.

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
Discrete Transforms and Signal Processing	**CO1**	**X**	**X**	**X**	**X**

	ENERGY STORAGE SYSTEM AND MANAGEMENT SYSTEM	L	T	P	C
Course Code:	**24EVDE09**	**4**	**0**	**0**	**4**
Course Type:	**E**				
Pre-Requisite	**NONE**				

Course Objectives (CO)

Upon completing this course, students will be able to:

To provide knowledge of energy storage systems, battery modeling, management, design, testing, and recycling.

Course Learning Outcomes (CLO)

This syllabus aligns with the National Education Policy (NEP). After completing this course, students will be able to:

1. Describe the working principles of electric vehicles.
2. Explain the construction and working principles of various motors used in electric vehicles.
3. Understand the working principles of electronics and sensor-less control in electric vehicles.
4. Describe different types of hybrid vehicles and their working principles.

UNIT	COURSE CONTENTS	HOURS
1	**UNIT – I MOTOR AND DEVICE CHARACTERISTICS** Review of motor principles, motor load dynamics, starting, braking & speed control of dc and ac motors- power semiconductor SCRs, IGBTs and MOSFETs	9
2	**UNIT – II ELECTRIC DRIVE CONCEPTS** Basic drive, choice of electric drives, advantages, nature and classification of drives, control and stability of electric drives, feedback control of drives, thermal effects in electrical machines, selection of motor and rating.	9
3	**UNIT – III DC DRIVES** Transient analysis of separately excited dc motors, converter - single phase uncontrolled, hal and fully controlled rectifiers, chopper control, closed loop control of solid-stat	
4	**UNIT – IV AC DRIVES** Operation of induction and induction motor, direct torque and flux control of induction motor drives, starting methods and speed control of single-phase induction motors, self-controlled synchronous motor drive, selection of motor and rating vector control of synchronous motor.	9
5	**UNIT – V DRIVES FOR SPECIAL ELECTRICAL MACHINES** Drives for variable reluctance motors, microprocessor/ microcontroller –gate trigger signal generation applications to special 8 electrical machines, switched reluctance motor drives, brushless DC motor drives, permanent magnet drives.	9

Textbooks

1. Ibrahim Dinçer, Halil S. Hamut, and Nader Javani, *Thermal Management of Electric Vehicle Battery Systems*, John Wiley & Sons Ltd., 2016.
2. Chris Mi, Abul Masrur, & David Wenzhong Gao, *Hybrid Electric Vehicle - Principles & Applications with Practical Properties*, Wiley, 2011.
3. Mehrdad Ehsani, Yimin Gao, Ali Emadi, *Modern Electric Hybrid Electric and Fuel Cell Vehicles*, Taylor & Francis Group, 2010.
4. James Larminie, John Lowry, *Electric Vehicle Technology Explained*, John Wiley & Sons Ltd, 2003.

References

1. G. Pistoia, J.P. Wiaux, S.P. Wolsky, *Used Battery Collection and Recycling*, Elsevier, 2001. (ISBN: 0-444-50562)
2. Guangjin Zhao, *Reuse and Recycling of Lithium-Ion Power Batteries*, John Wiley & Sons, 2017. (ISBN: 978-1-1193-2185-9)
3. T.R. Crompton, *Battery Reference Book (3rd Edition)*, Newnes-Reed Educational and Professional Publishing Ltd., 2000.
4. Arno Kwade, Jan Diekmann, *Recycling of Lithium-Ion Batteries: The LithoRec Way*, Springer.

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
ENERGY STORAGE SYSTEM AND MANAGEMENT SYSTEM	CO1	X	X	X	X

	NETWORK SECURITY & CRYPTOGRAPHY	L	T	P	C
Course Code:	**24EVDE10**	**4**	**0**	**0**	**4**
Course Type:	**E**				
Pre-Requisite	**NONE**				

COURSE OBJECTIVES (CO) To equip students with knowledge of security exploitation, secure programming, cryptographic principles, standard algorithms, and public key infrastructure.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with the National Education Policy (NEP). After completing the course, students will be able to:

1. Present the exploitation techniques in security.
2. Discuss various types of attacks and their characteristics.
3. Illustrate the basic concepts of encryption and decryption for secure data transmission.
4. Analyze various cryptography techniques and their applications.

UNIT NUMBER	COURSE CONTENTS
UNIT-I	**Photovoltaic (PV) Cell** ➢ Historical development of PV – Global and Indian energy scenario ➢ Photovoltaic effect – Direct solar energy conversion into electricity ➢ Solar cell fundamentals – p-n Junction, semiconductor properties, energy levels ➢ Basic equations and equivalent circuit of a solar cell ➢ Types of solar cells – Crystalline, multi-crystalline, thin-film silicon ➢ Emerging PV technologies and characteristics of single solar cell
UNIT-II	**PV Module Performance Analysis** Solar PV Module – Specifications and parameters Series and parallel connections of PV modules. I-V characteristics and maximum power point tracking (MPPT) algorithms Cell efficiency, fill factor, and performance variation due to irradiation and temperature.
UNIT-III	**Design of PV System** ➢ Classification of PV systems – Central Power Station, Distributed PV ➢ Standalone PV system vs. Grid-Interactive PV system ➢ Components: Charge controllers, batteries, inverters ➢ Design of standalone PV systems – Water pumping applications
UNIT-IV	**Grid-Tied Photovoltaic Systems** ➢ Key components and working of grid-connected PV systems ➢ Cost, investment, and economic aspects ➢ Classification of grid-tie inverters – Central, string, and micro inverters ➢ Inverter sizing, efficiency, and metering concepts in grid-tied systems
UNIT-V	**PV Applications** ➢ Building-integrated photovoltaic (BIPV) systems ➢ Grid-interacting central power stations ➢ Standalone PV applications for rural and remote areas ➢ PV applications in aircraft, power satellites

TEXT BOOKS

1. Jon Erickson, *Hacking: The Art of Exploitation*, 2nd Edition, Starch Press, 2008.
2. William Stallings, *Cryptography and Network Security: Principles and Practices*, 6th Edition, Pearson Education, 2014.

REFERENCE BOOKS

1. Chris Anley et al., *The Shellcoder's Handbook: Discovering and Exploiting Security Holes*, 2nd Edition.
2. N. Ferguson, B. Schneier, and T. Kohno, *Cryptography Engineering: Design Principles and Practical Applications*, Wiley, 2010.
3. Neil Daswani, Christoph Kern, and Anita Kesavan, *Foundations of Security: What Every Programmer Needs to Know*, 1st Edition, Apress, 2007.
4. *SNMP: A Guide to Network Management*, McGraw Hill.
5. H.H. Wang, *Telecom Network Management*, McGraw Hill.
6. U. Dlack, *Network Management*, McGraw Hill.

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
NETWORK SECURITY & CRYPTOGRAPHY	CO1	X	X	X	X

	EMBEDDED SYSTEMS DESIGN	L	T	P	C
Course Code:	**24EVDE11**	**4**	**0**	**0**	**4**
Course Type:	**PE**				
Pre-Requisite	**None**				

COURSE OBJECTIVES (CO)

To provide a comprehensive understanding of microcontrollers, programming techniques, interfacing methods, and project development.

COURSE LEARNING OUTCOMES (CLO)

At the end of the course, the student will be able to:

1. Understand the principles of embedded systems.
2. Gain knowledge of Microcontrollers and their interfacing with peripherals.

UNIT	COURSE CONTENTS	HOURS
UNIT I	**Introduction** ➢ Core of the embedded system ➢ Memory, Sensors (resistive, optical, position, thermal) ➢ Actuators (solenoid valves, relay/switch, opto-couplers) ➢ Communication Interface ➢ Embedded firmware (RTOS, Drivers, Application programs) ➢ Power-supply (Battery technology, Solar) ➢ PCB and Passive components ➢ Safety, reliability, and environmental issues ➢ Ethical practices	**9**
UNIT II	Embedded Hardware and Design: Introduction to ARM-v7-M (Cortex-M3),ARM- v7-R (CortexR4) and comparison in between them.	**9**
UNIT III	**Embedded Software, Firmware Concepts, and Design** ➢ Embedded C programming concepts (from an embedded system perspective) ➢ Optimization for Speed/Memory needs	**9**
UNIT IV	**Real-Time Operating Systems (RTOS)** ➢ POSIX Compliance ➢ Need for RTOS in Embedded Systems ➢ Foreground/Background systems ➢ Multitasking and context switching ➢ Interprocess Communication (IPC) ➢ Scheduler policies and kernel architecture ➢ Task scheduler, ISR, Semaphores, mailbox, message queues, pipes, events, timers ➢ Memory management	**9**
UNIT V	**Case Studies** 1. Medical Monitoring Systems 2. Process Control Systems (Temperature, Pressure) 3. Soft Real-Time Systems: Automated Vending Machines 4. Communication: Wireless Sensor Networks	**9**

TEXTBOOKS

1. *Introduction to Embedded Systems* – Shibu K. V. (TMH)
2. *Embedded System Design – A Unified Hardware and Software Introduction* – F. Vahid (John Wiley)
3. *Embedded Systems* – Rajkamal (TMH)
4. *Embedded Systems* – L. B. Das (Pearson)
5. *Embedded System Design* – S. Heath (Elsevier)

REFERENCE BOOKS AND MATERIALS

1. *Embedded Microcontroller and Processor Design* – G. Osborn (Pearson)
2. *Embedded Systems* – Frank Vahid, Wiley India, 2002
3. *Embedded Microcomputer Systems – Real-Time Interfacing* – Jonathan W. Valvano (Cengage Learning, Third or Later Edition)

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
EMBEDDED SYSTEMS DESIGN	**CO1**	**X**	**X**	**X**	**X**

	Electric Vehicle Machines and Drives	L	T	P	C
Course Code:	**24EVDE12**	**3**	**0**	**0**	**3**
Course Type:	**PE**				
Pre-Requisite	**None**				

Course Objectives (CO)

To provide knowledge of motor drive technologies, including DC motor control, induction motor drives, and SR motor drives for electric vehicles.

Course Learning Outcomes (CLO)

After completing the course, students will be able to:

1. Understand Motor Drive Technology and Energy Source Technology.
2. Apply design criteria for DC Motor Drives in EVs.
3. Implement design criteria for PM Brushless Motor Drives in EVs.
4. Develop design criteria for SR Motor Drives in EVs.

UNIT	COURSE CONTENTS	HOURS
UNIT-I	**Overview of EV Technologies:** Motor Drive Technology, Energy Source Technology, Battery Charging Technology, Vehicle-to-Grid Technology, Pure Electric Vehicle, Hybrid Electric Vehicle, Gridable Hybrid Electric Vehicle, Fuel-Cell Electric Vehicle.	**9**
UNIT-II	DC Motor Drives: System Configurations, DC Machines, DC–DC Converters, Soft-Switching DC–DC Converter Topologies, DC Motor Control, Regenerative Braking, Design Criteria of DC Motor Drives for EVs, Design Example for EVs.	**9**
UNIT-III	Induction Motor Drives: System Configurations, Induction Machines, Inverters for Induction Motors, Induction Motor Control, Design Criteria of Induction Motor Drives for EVs, Application Examples of Induction Motor Drives in EVs.	**9**
UNIT-IV	Permanent Magnet Brushless Motor Drives: System Configurations, PM Brushless Machines, PM Brushless Motor Control, Design Criteria of PM Brushless Motor Drives for EVs, Design Examples of PM Brushless Motor Drives for EVs, Planetary-Geared PM Synchronous Motor Drive, Outer-Rotor PM Brushless DC Motor Drive, Application Examples of PM Brushless Motor Drives in EVs.	**9**
UNIT-V	Switched Reluctance Motor Drives: SRM Machines, SR Converters, Comparison of SR Converters for EVs, SR Motor Control, Design Criteria of SR Motor Drives for EVs, Machine Initialization, Planetary-Geared SR Motor Drive, Outer-Rotor In-Wheel SR Motor Drive, Application Examples of SR Motor Drives in EVs, Stator-Permanent Magnet Motor Drives, Integrated-Starter-Generator Systems, Planetary-Geared Electric Variable Transmission Systems.	**9**

Textbook

1. K.T. Chau, *Electric Vehicle Machines and Drives - Design, Analysis, and Application*, 1st Edition, John Wiley & Sons, 2015.

Reference Books

2. Iqbal Hussein, *Electric and Hybrid Vehicles - Design Fundamentals*, 2nd Edition, CRC Press, 2010.
3. Gianfranco Pistoia, *Electric and Hybrid Vehicles - Power Sources, Models, Sustainability, Infrastructure, and the Market*, 1st Edition, Elsevier, 2010.

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
Electric Vehicle Machines and Drives	**CO1**	**X**	**X**	**X**	**X**

	Power Electronics for Renewable Energy Systems	L	T	P	C
Course Code:	**4EVDE13**	**4**	**0**	**0**	**4**
Course Type:	**PE**				
Pre-Requisite	**None**				

COURSE OBJECTIVES

To equip students with knowledge of power electronics applications in renewable energy, power converter topologies, control strategies, and grid-connected systems.

COURSE LEARNING OUTCOMES (CLO)

At the end of the course, the student will be able to:

1. Identify the impact of power electronics in renewable energy systems.
2. Demonstrate the application of power electronics in solar PV.
3. Analyze the performance of power converters in wind technology.
4. Devise the complete operation of small/medium-sized renewable energy systems and estimate the parameters of power converters for renewable energy systems.

UNIT	COURSE CONTENTS	HOURS
UNIT-I	**IMPACT OF POWER ELECTRONICS** ➢ Energy conservation ➢ Renewable energy systems	9
UNIT-II	**POWER CONVERTERS FOR RENEWABLE ENERGY** ➢ AC-link universal power converters ➢ AC-DC-AC converters for distributed power generation systems	9
UNIT-III	**POWER ELECTRONICS FOR SOLAR PV** ➢ Grid-connected PV system configurations: Centralized, String, Multi-string, AC-module	9
UNIT-IV	**POWER ELECTRONICS FOR WIND TECHNOLOGY** ➢ Power converters for wind turbines ➢ Power semiconductors for wind power converters ➢ Controls and grid requirements for modern wind turbines: Active power control	9
UNIT-V	**UNIVERSAL OPERATION OF SMALL/MEDIUM-SIZED RENEWABLE ENERGY SYSTEMS** ➢ Distributed power generation systems: Single-stage photovoltaic systems, Small/medium-sized wind turbine systems, Control structure ➢ Control of power converters for grid-interactive distributed power generation systems: Droop control, Power control in microgrids, Control design parameters, Harmonic compensation	9

TEXT BOOKS

1. Abu-Rub H., M. Malinowski, K. Al-Haddad, *Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications*, John Wiley & Sons Limited, UK, 2014.
2. Chakraborty S., M. G. Simões, W. E. Kramer, *Power Electronics for Renewable and Distributed Energy Systems: A Sourcebook of Topologies, Control and Integration*, Springer-Verlag, London, 2013.

REFERENCE BOOKS

1. Luo F. L., Y. Hong, *Renewable Energy Systems: Advanced Conversion Technologies and Applications*, CRC Press, New York, 2013.
2. Zhong Q., T. Hornik, *Control of Power Inverters in Renewable Energy and Smart Grid Integration*, John Wiley & Sons, Ltd, United Kingdom, 2013.
3. Fuchs E. F., M. A. S. Masoum, *Power Conversion of Renewable Energy Systems*, Springer Science & Business Media, LLC, London, 2011.

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
POWER ELECTRONICS FOR RENEWABL ENERGY SYSTEMS	**CO1**	**X**	**X**	**X**	**X**

	Instrumentation System	L	T	P	C
Course Code:	**24EVDE14**	**4**	**0**	**0**	**4**
Course Type:	**PE**				
Pre-Requisite	**None**				

COURSE OBJECTIVES

To acquire knowledge on working of sensors, transducers, and various display devices.

To provide knowledge of transducers, signal conditioning, telemetry systems, and display devices for data acquisition.

COURSE LEARNING OUTCOMES (CLO)

At the end of the course, the student will be able to:

1. Learn about various transducers and their working principles.
2. Learn different Op-amp based filters used for signal conditioning before data acquisition.
3. Learn the working principle of telemetry system used for transmission of acquired data.
4. Learn about various display devices.

UNIT	CONTENTS	HOURS
UNIT-I	**Introduction:** Generalized Measurement systems, Transduction principles, Classification of transducers, General transducers characteristics, Criteria for transducer selection. **Transducers:** Resistive, Inductive, Capacitive, Elastic and other types - Principles of operation, construction, theory, advantages, disadvantages, and applications.	9
UNIT-II	**Signal Conditioning:** Concept of signal conditioning, Applications of AC/DC bridges in instrumentation, Op-amp circuits used in instrumentation, Instrumentation amplifiers, Signal filtering, averaging, correlation, interference, grounding, and shielding.	9
UNIT-III	**Data Transmission Systems:** Definition, generalized block diagram of Telemetry system, classification of Telemetry system, working principle, block diagram, construction, salient features, and applications of the following Telemetry systems: ➢ DC voltage, current, and position telemetry system (Landline Telemetry system) ➢ Radio frequency amplitude modulated and frequency modulated telemetry system – theory related to amplitude and frequency modulation techniques ➢ Pulse telemetry systems ➢ Modem-based telemetry system	9
UNIT-IV	**Display Systems:** Construction, principle of operation, and salient features of various kinds of display devices such as LED, LCD, single and multi-digit LED 7-segmental display system (study of BCD to 7-segment code converter/decoder), design of LED Dot Matrix (3 x 5) numeric display system, and LCD 7-segmental numeric display system.	9
UNIT-V	**Recorders:** The working principle, construction, operation, and salient features of X-t strip chart recorder, X-Y strip chart recorder.	9

TEXT BOOKS

1. Sawhney A.K., "A Course in Electrical & Electronic Measurement and Instrumentation", Dhanpat Rai and Co (P) Ltd., reprint 2013.

REFERENCE BOOKS

1. Neubert H K P, "Instrument Transducers - An Introduction to Their Performance and Design", Clarendon Press, Oxford (1975).
2. Patranabis D., "Sensors and Transducers", PHI, 2003.
3. Murty D V S, "Transducers & Instrumentation", PHI, New Delhi.
4. Bell David A., "Electronic Instrumentation and Measurement", PHI, New Delhi.
5. Kalsi H S, "Electronic Instrumentation", Tata McGraw Hill.
6. Patranabis D., "Sensors and Transducers", PHI, New Delhi.

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
Instrumentation System	**CO1**	**X**	**X**	**X**	**X**

	Solar Photovoltaic Systems	L	T	P	C
Course Code:	**24EVDE15**	**4**	**0**	**0**	**4**
Course Type:	**PE**				
Pre-Requisite	**None**				

COURSE OBJECTIVES

To provide knowledge of photovoltaic systems, their applications, power conditioning, performance characteristics, and design for various applications.

COURSE LEARNING OUTCOMES (CLO)

At the end of the course, the student will be able to:

1. Understand the principle of direct solar energy conversion to power using PV technology.
2. Comprehend the performance and operating characteristics of PV systems and their components.
3. Understand the design of photovoltaic systems for a variety of applications.
4. Explain the basics of solar photovoltaic systems and identify the feasibility of PV systems as an alternative to fossil fuels.

UNIT	CONTENTS	HOURS
UNIT-I	**Photovoltaic(PV) cell** Historical development of PV –PV in world –Indian energy scenario Photovoltaic effect - Principle of direct solar energy conversion into electricity in a solar cell system, Solar cell - p-n Junction-Semiconductor properties-energy levels, basic equations and equivalent circuit, Solar cell- basic structure -crystalline, multi-crystalline, thin film silicon solar cells, Emerging new technologies and Characteristics-Single, Solar Cell Parameters.	9
UNIT-II	**PV MODULE PERFORMANCE ANALYSIS** Solar PV Module, Specifications of Solar PV Module, PV Module Parameters, Parallel and series connections, I-V characteristics of a PV module, maximum power point-MPPT basic Algorithms, Cell efficiency, fill factor, effect of irradiation and temperature	9
UNIT-III	**DESIGN OF PV SYSTEM** Classification -Central Power Station System, Distributed PV System-Stand alone PV System-Grid Interactive PV System, Charge controllers -Batteries –Inverters, Design of a standalone PV system-water pumping system	9
UNIT-IV	**GRIDTIEDPHOTOVOLTAIC SYSTEMS** Principle components in Grid –PV system, Cost and Investment, Classification of Grid Tie Inverters and Working Central inverter, String Inverter, Micro Inverter, Sizing the inverter and efficiency, Metering Concepts in Grid Tie systems, Introduction to hybrid PV system.	9
UNIT-V	**PV APPLICATIONS** Building-integrated photovoltaic units, grid-interacting central power stations, stand-alone devices for distributed power supply in remote and rural areas, PV applications in aircraft, power satellites. Home lighting - solar water pumping systems, Socio-economic and environmental merits of photovoltaic systems.	9

TEXTBOOKS

1. Chetan Singh Solanki, “Solar Photovoltaic: Fundamentals, Technologies and Application”, PHI Learning Pvt. Ltd., 2nd Edition, 2011.
2. R. Messenger, J. Ventre, “Photovoltaic Systems Engineering”, CRC Press.

REFERENCE BOOKS

3. Jha A.R., “Solar Cell Technology and Applications”, CRC Press, 2010.
4. S.P. Sukhatme, J.K. Nayak, “Solar Energy”, Tata McGraw Hill Education Private Limited, New Delhi, 2010.
5. Antonio Luque, Steven Hegedus, “Handbook of Photovoltaic Science and Engineering”, Wiley, 2nd Edition, 2010.
6. John R. Balfour, Michael L. Shaw, Sharlave Jarosek, “Introduction to Photovoltaics”, Jones & Bartlett Publishers, Burlington, 2011.
7. Michael Boxwell, “Solar Electricity Handbook: A Simple, Practical Guide to Solar Energy – Designing and Installing Solar PV Systems”, 2015.

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
Solar Photovoltaic Systems	**CO1**	**X**	**X**	**X**	**X**

	Energy Storage Technology	L	T	P	C
Course Code:	**24EVDE16**	**4**	**0**	**0**	**4**
Course Type:	**PE**				
Pre-Requisite	**None**				

COURSE OBJECTIVES

To provide an understanding of energy storage systems, their operation, selection, utilization, and key parameters.

COURSE LEARNING OUTCOMES (CLO)

At the end of the course, the student will be able to:

1. Apply suitable energy storage techniques for different energy sources.
2. Differentiate energy storage options based on operating conditions.
3. Understand the need and types of energy storage systems.
4. Economically analyze storage options.

UNIT	COURSE CONTENTS	HOURS
UNIT-I	**Introduction to Energy Storage** ➢ Requirement for energy storage. ➢ Current status. ➢ Electricity storage services and benefits. ➢ Cost performance and maturity of storage technology. ➢ Methods and tools for evaluation of storage. ➢ Future prospects of storage.	9
UNIT-II	**Electrochemical Energy Storage** ➢ Lead acid battery, Li-ion battery, Ni-metal hydride battery, Flow battery, Capacitor, etc. ➢ Comparison, Ragone plot, and state-of-the-art applications. ➢ Technical characteristics, battery states, and their estimation methods. ➢ Battery-based hybrid storage system, battery aging. ➢ Performance characteristics, testing, safety, standards, and system sizing.	9
UNIT-III	**Thermal Energy Storage (TES)** ➢ TES methods: Sensible, Latent, and Thermochemical TES. ➢ Selection depending on the application. ➢ Types of storage systems, design, and operation. ➢ Performance characteristics, testing, safety, standards, and system sizing. ➢ **Case study/project**.	9
UNIT-IV	**Hydrogen Energy Storage** ➢ Hydrogen economy. ➢ Hydrogen-based energy storage. ➢ Safety considerations.	9
UNIT-V	**Mechanical Energy Storage Systems** ➢ Flywheel energy storage (FES), pumped hydropower storage (PHS), and compressed-air energy storage (CAES). ➢ Comparison and application state-of-the-art including principles, function, and deployments. ➢ Performance characteristics, testing, safety, standards, and system sizing. ➢ Case study/project based on mechanical energy storage. ➢ Introduction to Hybrid Energy Storage Systems.	9

TEXTBOOKS

1. Patrick T. Moseley, Jurgen Garche, *Electrochemical Energy Storage for Renewable Sources and Grid Balancing*, Elsevier, USA, 2014.
2. Ter-Gazarian, A., *Energy Storage for Power Systems*, Peter Peregrinus Limited, London, 2011.
3. Ahmed Faheem Zobaa, *Energy Storage - Technologies and Applications*, InTech.
4. J. Jensen and B. Sorenson, *Fundamentals of Energy Storage*, Wiley-Interscience, New York.
5. C. Daniel, J. O. Besenhard, *Handbook of Battery Materials*, Wiley VCH Verlag GmbH & Co. KgaA.

REFERENCE BOOKS

1. Marc A. Rosen, *Energy Storage*, Nova Science Publishers, 2012.
2. Jonathan M. Bowen, *Energy Storage: Issues and Applications*, Nova Science Publishers, 2011.
3. Robert A. Huggins, *Energy Storage*, Springer, Germany, 2015.
4. Md. Rafiqul Islam Sheikh (Ed.), *Energy Storage*, Sciyo. ISBN 978-953-307-119-0.
5. Ahmed Faheem Zobaa (Ed.), *Energy Storage – Technologies and Applications*, InTech Publishers. ISBN 978-953-51-0951-8.

6. Marc A. Rosen (Ed.), *Energy Storage*, Nova Science Publishers Inc. ISBN 1613247087, 9781613247082.
7. Marcelo Gustavo Molina (Ed.), *Emerging Advanced Energy Storage Systems: Dynamic Modeling, Control and Simulation*, Nova Science Publishers Inc. ISBN 1613243928, 9781613243923.
8. Kevin Roebuck (Ed.), *Energy Storage: High-Impact Strategies - What You Need to Know*, Tebbo. ISBN 1743333404, 9781743333402.
9. Frank S. Barnes, Jonah G. Levine (Eds.), *Large Energy Storage Systems Handbook*, CRC Press Taylor & Francis Group. ISBN 978-1-4200-8601-0.

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
Energy Storage Technology	**CO1**	**X**	**X**	**X**	**X**

	CONTROL SYSTEMS FOR ELECTRIC VEHICLE	L	T	P	C
Course Code:	**24EVDE17**	**4**	**0**	**0**	**4**
Course Type:	**PE**				
Pre-Requisite	**None**				

COURSE OBJECTIVES: To introduce the principles, modeling, analysis, and design of feedback control systems for stability and performance optimization.

COURSE LEARNING OUTCOMES (CLO)

At the end of the course, the student will be able to:

1. Identify different physical systems and classify them as open-loop and closed-loop control systems.
2. Describe the mathematical relation between input and output for LTI systems.
3. Apply different time domain and frequency domain tools to analyze the absolute and relative stability of LTI systems.
4. Assess the performance of LTI systems to different inputs and design basic controllers to meet desired performance.

UNIT	CONTENTS	HOURS
UNIT-I	**Introduction to System Modelling (10 Hours)** ➢ Importance of control system in Electric Vehicles ➢ Study of control architecture in Electric Vehicles ➢ Systems models and their classifications ➢ Principles used in modelling of systems ➢ Fundamental studies of modelling of vehicle dynamics and control ➢ Longitudinal vehicle dynamics, vertical dynamics model, and lateral vehicle dynamics model ➢ Integrated vehicle dynamics	10
UNIT-II	**System Simulation and Validation (4 Hours)** ➢ System simulation: advantages and disadvantages ➢ Steps in simulation study ➢ Simulation of mechanical and electrical systems ➢ Introduction to modelling and simulation for Software-in-Loop (SIL) and ➢ Hardware-in-Loop (HIL) ➢ Study of control architecture	4
UNIT-III	**Model-Based Control Approach for Electric Vehicles (4 Hours)** ➢ Introduction to P, PI & PID Controllers ➢ Internal Model Control (IMC) Design ➢ Introduction to model-based control system design for Electric Vehicles	4
UNIT-IV	**State Space Representation (13 Hours)** ➢ Introduction to State Space ➢ State Space Representation: Companion Form (Controllable Canonical Form), Extended Controllable Canonical Form, Observable Canonical Form ➢ Concept of Diagonalization ➢ State transition matrix, Solution of state equation ➢ Steady-state error for state space system ➢ Controllability and Observability in state space ➢ Pole Placement by State Feedback and State Observer Design	13
UNIT-V	**Stability Aspects of Control Systems (11 Hours)** ➢ Stability concept and definition in the sense of Lyapunov ➢ Stability of continuous-time linear systems ➢ Lyapunov stability theorem ➢ Vehicle stability analysis ➢ **Applications:** Traction control, Vehicle control, Electric power steering control	11

TEXT BOOKS

1. Nise, N.S., *Control System Engineering*, Wiley, 6th Edition, 2010.
2. Golnaraghi, F. and Kuo, B.C., *Automatic Control Systems*, Prentice Hall, 9th Edition, 2008.

REFERENCE BOOKS

1. R. T. Stefani, B. Shahian, C. J. Savant Jr., and G. H. Hostetter, *Design of Feedback Control Systems*, Oxford University Press, 4th Edition, 2002.

2. Katsuhiko Ogata, *Modern Control Engineering*, PHI, 12th Edition, 2014.
3. Ashish Tewari, *Modern Control Design: With MATLAB and SIMULINK*, Wiley, 1st Edition, 2002.
4. L. Umanand, *Power Electronics: Essentials and Applications*, Wiley India, 2009.
5. Rajesh Rajamani, *Vehicle Dynamics and Control*, Springer, 2nd Edition, 2012.
6. Wuwei Chen, Hansong Xiao, Qidong Wang, Linfeng Zhao, and Maofei Zhu, *Integrated Vehicle Dynamics and Control*, Wiley, 1st Edition, 2016.
7. Hui Zhang, Dongpu Cao, and Haiping Du, *Modelling, Dynamics, and Control of Electrified Vehicles*, WP Publishing, Elsevier, 2018.

Mapping Matrix of Course

Course name	Course Objectives	CLO 1	CLO 2	CLO 3	CLO 4
CONTROL SYSTEMS FOR ELECTRIC VEHICLE	CO1	x	x	x	x