M.E. Degree

in

POWER ELECTRONICS AND DRIVES

CURRICULUM & SYLLABUS (CBCS)

Innovation and Product Development for Sustainability

(For students admitted from the Academic Year 2026-2027)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

St. XAVIER'S CATHOLIC COLLEGE OF ENGINEERING

CHUNKANKADAI, NAGERCOIL – 629 003.

KANYAKUMARI DISTRICT, TAMIL NADU, INDIA

VISION OF THE INSTITUTION

To be a centre of excellence in engineering education and research for a technically empowered humane society.

MISSION OF THE INSTITUTION

M1: Foster a vibrant academic environment for learning fundamental concepts, emerging technologies, and research-oriented practices.
M2: Cultivate personal maturity and professional skills through stimulating coaching and practical training.
M3: Provide inspiring high calibre faculty to mentor students from diverse backgrounds, especially the underprivileged.
M4: Create ample opportunities to transform rural youth into top class professionals and technocrats, capable of serving at the local and global levels with ethical integrity.

VISION OF THE PROGRAMME

Providing globally competent professionals, innovative researchers and successful entrepreneurs in the field of Electrical and Electronics Engineering for developing a technically empowered humane society.

MISSION OF THE PROGRAMME

- To impart high quality technical education in Electrical and Electronics Engineering with high calibre faculty members, excellent infrastructure and stimulating environment.
- To lead the students to learn and practice technologies that are prevalent in the related industries.
- To introduce the students to the latest concepts and innovations through technical gatherings and research collaborations.
- To inculcate ethical values, team spirit and leadership qualities to meet the social challenges and needs.

PROGRAMME EDUCATIONAL OBJECTIVES

PEO1: To design and test power electronic converters, drive systems and various controllers using advanced tools.
PEO2: To analyse and design power electronic systems and special electrical machines for efficient extraction and utilization of various renewable energy sources
PEO3: To develop smart products using cutting edge technologies to needs the societal needs and environmental aspects.
PEO4: To develop confidence and exhibit self-learning capability to demonstrate a pursuit in life-long learning through higher studies and research.

PROGRAMME OUTCOMES

PO1: An ability to independently carry out research/investigation and development work to solve practical problems.
PO2: An ability to write and present a substantial technical report/document.
PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO4: Apply the knowledge of basic science and engineering to control and test the power electronic systems and drives.
PO5: Analyse power electronics and drives related engineering problems and find innovative solutions to meet the requirement of social needs and environmental factors.
PO6: Design cost effective products using cutting edge technologies in power electronics and drives systems.

KNOWLEDGE AND ATTITUDE PROFILE (WK)

WK1: A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.
WK2: Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.
WK3: A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
WK4: Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.
WK5: Knowledge, including efficient resource use, environmental impacts, whole-life cost, re use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.
WK6: Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.
WK7: Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.
WK8: Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.
WK9: Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

PEO's – PO's MAPPING:

PEO	PROGRAMME OUTCOMES					
	1	2	3	4	5	6
I	2	2	2	3	1	2
II	2	2	2	3	2	2
III	3	1	2	2	3	3
IV	3	3	2	2	2	1

SUSTAINABLE DEVELOPMENT GOALS

GOAL 1: No Poverty
End poverty in all its forms everywhere
GOAL 2: Zero Hunger
End hunger, achieve food security and improved nutrition and promote sustainable agriculture
GOAL 3: Good Health and Well-being
Ensure healthy lives and promote well-being for all at all ages
GOAL 4: Quality Education
Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
GOAL 5: Gender Equality
Achieve gender equality and empower all women and girls
GOAL 6: Clean Water and Sanitation
Ensure availability and sustainable management of water and sanitation for all
GOAL 7: Affordable and Clean Energy
Ensure access to affordable, reliable, sustainable and modern energy for all
GOAL 8: Decent Work and Economic Growth
Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
GOAL 9: Industry, Innovation and Infrastructure
Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
GOAL 10: Reduced Inequality
Reduce inequality within and among countries
GOAL 11: Sustainable Cities and Communities
Make cities and human settlements inclusive, safe, resilient and sustainable
GOAL 12: Responsible Consumption and Production
Ensure sustainable consumption and production patterns
GOAL 13: Climate Action
Take urgent action to combat climate change and its impacts
GOAL 14: Life Below Water
Conserve and sustainably use the oceans, seas and marine resources for sustainable development
GOAL 15: Life on Land

Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

GOAL 16: Peace and Justice Strong Institutions

Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

GOAL 17: Partnerships to achieve the Goal

Strengthen the means of implementation and revitalize the global partnership for sustainable development.

SEMESTER: I

Number of Courses: 8
Total Credits: 23

Course Code	Course Title	Course Type	Classroom Instruction (CI) (in Hours per Semesters)		Lab Instruction (LI) (in Hours per Semesters)	Term Work (TW) and Self Learning (SL) (in Hours per Semesters)	Total Number of Hours (in Hours per Semesters)	Total Credits (C)=(Total Hours/30)	SDG Goal Mapped	Category
			L	T	P					
IP26 C07	Induction Programme*	IP	24	0	0	6	30	0	4,8,9, 16,17	IP
MA2 6102	Optimization and Transform Techniques for Power Electronics Engineering	TC	45	15	0	60	120	4	4,8,9, 12	BSC
PE26 101	Modelling and Design of SMPS	TC	45	0	0	45	90	3	4,7,9, 12	PCC
RM2 6C01	Research Methodology and Intellectual Property Rights	TC	45	15	0	60	120	4	1,2,3, 7	FC
PE26 102	Analysis of Power Converters	TC	45	15	0	60	120	4	7,11,1 3	PCC
PE26 103	System Design Using Microcontroller	TC	45	0	0	45	90	3	4,7,9, 12,13	PCC
RM2 6C02	Research Tool Laboratory	PC	0	0	60	0	60	2	4,9,16 ,17	FC
PE26 104	Power Electronics Converters Laboratory	PC	0	0	60	0	60	2	4,7,9, 12,13	PCC
PE26 105	Technical Seminar**	PC	0	0	30	0	30	1	4,7,9, 12,13	EEC
Total		-	249	45	150	276	720	23	-	-

* - Refer clause 21 in regulation 2026. The evaluation procedure is detailed in the syllabus.
** - Internally Evaluated Course. The evaluation procedure is detailed in the syllabus.

SEMESTER: II

Number of Courses: 7
Total Credits: 18

Course Code	Course Title	Course Type	Classroom Instruction (CI) (in Hours per Semesters)		Lab Instruction (LI) (in Hours per Semesters)	Term Work (TW) and Self Learning (SL) (in Hours per Semesters)	Total Number of Hours (in Hours per Semesters)	Total Credits (C)=(Total Hours/30)	SDG Goal Mapped	Category
			L	T	P					
PE26201	Electric Vehicles and Power management	TC	45	0	0	45	90	3	7,9,12,13	PCC
PE26202	Special Electrical Machines	TC	45	0	0	45	90	3	4,9	PCC
	Professional Elective I	TC	45	0	0	45	90	3	-	PEC
	Open Elective	TC	45	0	0	45	90	3	-	OEC
PE26203	Analysis of Electrical Drives	TCP	45	0	30	45	120	4	7,9,11,12,13	PCC
PE26204	Industry Collaborated Course I*	-	-	-	-	-	-	1	-	ICC
PE26205	Self-Learning Course*	-	-	-	-	-	-	1	-	SLC
Total		-	225	0	30	225	480	18	-	-

* - Evaluation and certification by course offering body.

PROFESSIONAL ELECTIVE I - SEMESTER II

Course Code	Course Title	Course Type	Classroom Instruction (CI) (in Hours per Semesters)		Lab Instruction (LI) (in Hours per Semesters)	Team Work (TW) and Self Learning (SL) (in Hours per Semesters)	Total Number of Hours (in Hours per Semesters)	Total Credits (C)=(Total Hours/30)	SDG Goal Mapped	Category
			L	T	P					
PE26001	Soft Computing Techniques	TC	45	0	0	45	90	3	3,4,7,9,11,13	PEC
PE26002	System Theory	TC	45	0	0	45	90	3	4,9	PEC
PE26003	Analysis of Electrical Machines and Drives	TC	45	0	0	45	90	3	4,7,9,11,12	PEC
PE26004	Battery Management system	TC	45	0	0	45	90	3	7,9,11,12,13	PEC

OPEN ELECTIVE I - SEMESTER II

Course Code	Course Title	Course Type	Classroom Instruction (CI) (in Hours per Semesters)		Lab Instruction (LI) (in Hours per Semesters)	Team Work (TW) and Self Learning (SL) (in Hours per Semesters)	Total Number of Hours (in Hours per Semesters)	Total Credits (C)=(Total Hours/30)	SDG Goal Mapped	Category
			L	T	P					
PE26901	Smart Grid	TC	45	0	0	45	90	3	7,9,11,12,13	PEC

SEMESTER: I

IP26C07	Induction Programme	L	T	P	TW/SL	Total	C	SDG
		24	0	0	6	30	0	4,8,9, 16,17

COURSE OBJECTIVES:

- To familiarize students with institutional policies, academic regulations, and programme structure.
- To introduce research methodology, ethical practices, and emerging engineering trends.
- To develop communication, technical writing, and presentation skills.
- o create awareness about career opportunities, higher education, and industry expectations.
- To inculcate professional ethics, teamwork, and leadership qualities.

COURSE CONTENT:

UNIT 1	INSTITUTIONAL ORIENTATION	4	0	0	1	5		4

Vision, Mission, and Quality Policy – Organizational structure – Campus facilities – Library, laboratory, and IT infrastructure – Student support systems – Interaction with faculty and peers.

Activities: Campus Resource Mapping and Group Presentation.

UNIT 2	ACADEMIC REGULATIONS & PROGRAMME STRUCTURE	4	0	0	1	5		4,9

Choice Based Credit System (CBCS) – Curriculum framework – Credit requirements – Evaluation and assessment procedures – Attendance norms – Examination system – Academic integrity guidelines.

Activities: Preparation of Individual Academic Plan.

UNIT 3	RESEARCH METHODOLOGY & EMERGING TECHNOLOGIES	8	0	0	2	10		4

Research process – Problem identification – Literature review – Research ethics and plagiarism – Overview of emerging technologies (AI, Data Science, IoT, etc.) – Interdisciplinary research opportunities.

Activities:. Mini Research Problem Identification and Presentation.

UNIT 4	**SKILL DEVELOPMENT & CAREER PLANNING**	**4**	**0**	**0**	**1**	**5**		**8**
Communication skills – Technical writing – Presentation skills – Resume preparation – Career opportunities – Higher studies – Competitive exams – Internship and placement readiness. **Activities:** Resume Preparation and Elevator Pitch Presentation.								
UNIT 5	**PROFESSIONAL DEVELOPMENT & WELL-BEING**	**4**	**0**	**0**	**1**	**5**		**16,17**
Engineering ethics – Professional values – Teamwork and leadership – Innovation and entrepreneurship – Startup ecosystem – Time management – Stress management – Counseling and mentoring support. **Activities:** Case Study Analysis on Ethics and Teamwork.								
COURSE OUTCOMES:								
At the end of the course, the students will be able to: **CO1:** Apply institutional policies and academic regulations to manage postgraduate studies effectively. **CO2:** Apply research methodologies and ethical principles to identify research problems. **CO3:** Demonstrate communication, technical writing, and presentation skills. **CO4:** Analyze career opportunities and industry expectations for informed decision-making. **CO5:**Apply professional ethics and teamwork skills in academic and organizational environments.								
Weightage: Continuous Assessment: 100%								
Assessment Methodology: Active Participation (40%), Assignments(30%), Quiz(30%)								
REFERENCES:								

1.	Johri, A., International Handbook of Engineering Education Research, Taylor & Francis, 2023.
2.	Murthy, D. N. P., & Page, N. W., Education and Research for the Future, Springer, 2023.
3.	Oliveira, T. A., & Hebebci, M. T. (Eds.), Current Academic Studies in Technology and Education 2024, ISRES Publishing, 2024.
4.	Kannan, R., Thirumalai, P., & Geetha, T. V. (Eds.), Proceedings of the International Conference on Technology for Education (T4E 2024), Springer, 2024.
5.	Rajesh, S., Raghu Prasad, B. K., & Praveen, K. V. (Eds.), Recent Advances in

	Sustainable Construction Technology, Geotechnics and Structural Engineering, Springer, 2026.
E-RESOURCES/E-MATERIALS:	
1.	https://alison.com/course/essentials-of-research-methodology
2.	https://www.coursera.org/learn/research-methodologies

Mapping of Course Outcomes to Programme Outcomes

COs \ POs	**PO1 (Research Capability)**	**PO2 (Technical Communication)**	**PO3 (Domain Mastery)**
CO1	2	1	2
CO2	3	2	2
CO3	1	3	1
CO4	2	2	2
CO5	1	2	1
CO	1.8	2.0	1.6

MA26102	**OPTIMIZATION AND TRANSFORM TECHNIQUES FOR POWER ELECTRONICS ENGINEERING**	**L**	**T**	**P**	**TW/SL**	**TOTAL**	**C**	**SDG**
		45	**15**	**0**	**60**	**120**	**4**	**4,8,9,12**

COURSE OBJECTIVES:

- To familiarize the students with the formulation and construction of mathematical models for a linear programming problem in real-life situations.
- To develop student's ability to formulate and solve real-world optimization problems using transportation and assignment models.
- To understand advanced matrix concepts such as norms, inner products, and various matrix decompositions to solve Engineering and optimization problems.
- To apply Fourier transforms to analyze harmonic spectra, evaluate electrical system dynamics, and solve partial differential equations for wave propagation.
- To introduce Z-transform techniques and solve discrete-time dynamics in power electronic converter systems.

<table>
<tr><td colspan="9">COURSE CONTENT:</td></tr>
<tr><td>UNIT 1</td><td>LINEAR PROGRAMMING</td><td>9</td><td>3</td><td>0</td><td>12</td><td>24</td><td></td><td>4,8,9,12</td></tr>
<tr><td colspan="9">Formulation of liner programming problems – Graphical solution method – Canonical and standard form of liner programming problem – Simplex method – Artificial variables: Big-M method.
Activity: Apply Big-M method for optimal allocation of limited power components in a converter system.</td></tr>
<tr><td>UNIT 2</td><td>TRANSPORTATION AND ASSIGNMENT MODELS</td><td>9</td><td>3</td><td>0</td><td>12</td><td>24</td><td></td><td>4,8,9,12</td></tr>
<tr><td colspan="9">Definition of the transportation model – Mathematical formulation of transportation models – Basic feasible solution: Vogel's approximation method – Optimality solution by modified distribution (MODI) method – Definition of the assignment model – Mathematical formulation of assignment models – Hungarian method for solving assignment problems.
Activity: Develop a transportation model to minimize power distribution losses in a microgrid network.</td></tr>
<tr><td>UNIT 3</td><td>MATRIX THEORY</td><td>9</td><td>3</td><td>0</td><td>12</td><td>24</td><td></td><td>4,9,12</td></tr>
<tr><td colspan="9">Definitions: Norms and inner products – Definitions: Band matrices and Toplitz matrices – Matrix decomposition: Cholesky decomposition – QR factorization – Least square approximations using QR factorization.
Activity: Apply QR factorization to solve systems in power-electronic controller design.</td></tr>
<tr><td>UNIT 4</td><td>FOURIER TRANSFORMS</td><td>9</td><td>3</td><td>0</td><td>12</td><td>24</td><td></td><td>4,9,12</td></tr>
<tr><td colspan="9">Statement of Fourier integral theorem – Fourier transform – Fourier transform pair – Properties: Linear, Change of scale, Shifting and Modulation – Transforms of polynomial functions – Parseval's identity (excluding proof) – Solutions to partial differential equations: The one dimensional wave equation in $(-\infty, \infty)$.
Activity: Apply Fourier transforms to analyze switching harmonics in Pulse Width Modulation inverters.</td></tr>
<tr><td>UNIT 5</td><td>Z-TRANSFORMS</td><td>9</td><td>3</td><td>0</td><td>12</td><td>24</td><td></td><td>4,9,12</td></tr>
<tr><td colspan="9">One sided Z-transform of sequence f(n) – Elementary properties: Linear and First shifting – Problems based on properties – Z-transform of functions n and n^2 using differentiation in the Z-domain – Initial and final value theorems (proof excluded) – Inverse Z-transforms using the convolution theorem.
Activity: Determine system response of digitally controlled DC– DC converters using initial/final value theorems.</td></tr>
</table>

COURSE OUTCOMES:	
At the end of the course, the students will be able to: **CO1:** Apply graphical, simplex and Big-M methods to solve linear programming problems and obtain optimal solutions. **CO2:** Solve transportation problems using modified distribution method and assignment problems using Hungarian method to obtain optimal allocation results. **CO3:** Apply matrix factorization techniques such as Cholesky and QR decompositions to decompose matrices in Engineering applications. **CO4:** Compute Fourier transforms and inverse transforms of polynomial functions and solve one-dimensional wave equations defined on$(-\infty, \infty)$. **CO5:** Utilize one-sided Z-transform techniques to effectively analyze and solve discrete-time sequences and systems.	
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%	
Assessment Methodology: Activity (30%) and Internal Assessment test (70%)	
REFERENCES:	
1.	Taha. H.A., "Operation Research: An Introduction", Eleventh edition, Pearson Education, New Delhi, Reprint 2023.
2.	Kanti Swarup, P. K. Gupta, Man Mohan , "Operation Research", Twentieth Edition, Sultan Chand & Sons, 2022.
3.	Richard Bronson & Gabriel B. Costa., "Schaum's Outline of Differential Equations", Fifth edition, McGraw Hill, 2022.
4.	Grewal. B.S., "Higher Engineering Mathematics", Khanna Publishers, Forty fifth edition, 2024.
5.	O'Neil. P.V., "Advanced Engineering Mathematics", Cengage Learning, Ninth edition, 2023.
E-RESOURCES/E-MATERIALS:	
1.	https://allen.in/jee/maths/graphical-method-linear-programming
2.	https://www.acsce.edu.in/acsce/wp-content/uploads/2020/03/1585041316993_Module-4.pdf
3.	https://ocw.mit.edu/courses/6-241j-dynamic-systems-and-control-spring-2011/04fddfbcb1eb933ecca85dab8bfbb171_MIT6_241JS11_chap04.pdf
4	https://www.geeksforgeeks.org/maths/fourier-transform/
5.	https://www.keysight.com/used/us/en/knowledge/formulas/z-transform-formula

Mapping of Course Outcomes to Programme Outcomes

Course Outcomes	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	-	1	3	1	-
CO2	2	-	1	3	1	-
CO3	2	-	1	3	1	-
CO4	2	-	1	3	1	-
CO5	2	-	1	3	1	-
Average	2	-	1	3	1	-

<table>
<tr><td rowspan="2">PE26101</td><td rowspan="2">MODELLING AND DESIGN OF SMPS</td><td>L</td><td>T</td><td>P</td><td>TW/SL</td><td>Total</td><td>C</td><td>SDG</td></tr>
<tr><td>45</td><td>0</td><td>0</td><td>45</td><td>90</td><td>3</td><td>4,7,9,12</td></tr>
<tr><td colspan="9">COURSE OBJECTIVES:</td></tr>
<tr><td colspan="9">

To inculcate knowledge on steady state analysis of Non-Isolated DC-DC converter
To perform steady state analysis of Isolated DC-DC converter
To educate on different converter dynamics
To impart knowledge on the design of controllers for DC-DC converters
To familiarize the design magnetics for SMPS applications

</td></tr>
<tr><td colspan="9">COURSE CONTENT:</td></tr>
<tr><td>UNIT 1</td><td>ANALYSIS OF NON-ISOLATED DC-DC CONVERTERS</td><td>9</td><td>0</td><td>0</td><td>9</td><td colspan="2">18</td><td>7,9</td></tr>
<tr><td colspan="9">Buck, Boost, Buck- Boost and Cuk converters: Principles of operation – Continuous conduction mode– Concepts of volt-sec balance and charge balance – Analysis and design based on steady state relationships – Introduction to discontinuous conduction.
Activity: Problem solving.</td></tr>
<tr><td>UNIT 2</td><td>ANALYSIS OF ISOLATED DC-DC CONVERTERS</td><td>9</td><td>0</td><td>0</td><td>9</td><td colspan="2">18</td><td>7,12</td></tr>
<tr><td colspan="9">Introduction – classification- forward- flyback- pushpull – half bridge – full bridge topologies design of SMPS – Applications
Activity: Design a 12V SMPS, Problem solving.</td></tr>
</table>

UNIT 3	**CONVERTER DYNAMICS**	**9**	**0**	**0**	**9**	**18**	**9,12**
AC equivalent circuit analysis – State space averaging – Circuit averaging – Averaged switch modeling – Transfer function model for buck, boost, buck-boost and cuk converters. **Activity:** Derive the small-signal transfer function of a Boost converter using state-space averaging model.							
UNIT 4	**CONTROLLER DESIGN**	**9**	**0**	**0**	**9**	**18**	**9,4**
Review of P, PI, and PID control concepts – gain margin and phase margin – Bode plot based analysis – Design of controller for buck, boost, buck-boost and cuk converters **Activity:** Design a PI controller for a DC-DC converter and analyze gain margin and phase margin using Bode plot.							
UNIT 5	**DESIGN OF MAGNETICS**	**9**	**0**	**0**	**9**	**18**	**9,12**
Basic magnetic theory revision – Inductor design – Design of mutual inductance – Design of transformer for isolated topologies. **Activity:** Comparative study on different types of magnetic core used in inductor.							

COURSE OUTCOMES:

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

CO1: Analyze Non-Isolated DC-DC converter
CO2: Analyze Isolated DC-DC converter
CO3: Derive the transfer function of DC-DC converters
CO4: Apply controller design techniques for DC-DC converters using PI/PID controllers and Bode plot analysis.
CO5: Apply magnetic design concepts for inductors and transformers in SMPS applications.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Activity (40%) & Internal Examinations (60%)

REFERENCES:

1.	John G. Kassakian, David J. Perreault, George C. Verghese, Martin F. Schlecht, “Principles of Power Electronics”, Cambridge University Press, Second Edition, 2023.
2.	Robert W. Erickson & Dragon Maksimovic, “Fundamentals of Power Electronics”, Springer, Third Edition, 2020
3.	Simon Ang and Alejandra Oliva, “Power-Switching Converters”, CRC press, Third eEdition, 2011.
4.	Philip T Krein, “Elements of Power Electronics”, Oxford University Press, Second Edition, 2017.

5.	Ned Mohan, "Power Electronics: A first course", Wiley, Third Edition, 2022.
6	IssaBatarseh, Ahmad Harb, "Power Electronics- Circuit Analysis and Design", Springer Nature, Second Edition, 2018.
7	V.Ramanarayanan, "Course material on Switched mode power conversion", First Edition, 2007
8	Alex Van den Bossche and VencislavCekovValchev, "Inductors and Transformers for Power Electronics", CRC Press, First Edition, 2005.
9	W. G. Hurley and W. H.Wolfle, "Transformers and Inductors for Power Electronics Theory, Design and Applications", Wiley, First Edition, 2013.
E-RESOURCES/E-MATERIALS:	
1.	https://ee.iisc.ac.in/wp-content/uploads/2023/01/SMPC_VRamnarayanan.pdf
2.	http://kcl.digimat.in/nptel/courses/video/108108036/lec18.pdf
3.	https://ocw.mit.edu/courses/6-334-power-electronics-spring-2007/pages/lecture-notes/

Mapping of Course Outcomes to Programme Outcomes

Course Outcomes	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	2	2	1
CO2	3	1	3	2	2	1
CO3	3	2	3	3	2	1
CO4	2	2	3	3	2	2
CO5	2	1	3	2	2	3
Average	**2.6**	**1.4**	**3.0**	**2.4**	**2.0**	**1.6**

RM26C01	RESEARCH METHODOLOGY AND INTELLECTUAL PROPERTY RIGHTS	L	T	P	TW/SL	Total	C	SDG
		45	15	0	60	120	4	1,2,3,7

COURSE OBJECTIVES:

- To understand modern research processes, ethics, and data-driven decision making.
- To familiarize students with research design, data collection, and analysis methods.
- To develop skills in technical writing, publication, and presentation.
- To create awareness on Intellectual Property Rights and patent systems.
- To introduce contemporary research tools and innovation protection mechanisms.

<table>
<tr><td colspan="9">COURSE CONTENT:</td></tr>
<tr><td>UNIT 1</td><td>RESEARCH DESIGN AND MODERN RESEARCH APPROACHES</td><td>9</td><td>3</td><td>0</td><td>12</td><td>24</td><td></td><td>1</td></tr>
<tr><td colspan="9">Research ecosystem and lifecycle, types of research, problem identification, literature gap analysis, research questions and hypotheses, AI-assisted literature review tools, research design frameworks, qualitative and quantitative research, experimental and survey methods, research ethics and plagiarism awareness.
Activities: Literature gap identification, ethics discussion.</td></tr>
<tr><td>UNIT 2</td><td>DATA COLLECTION, SOURCES AND PREPARATION</td><td>9</td><td>3</td><td>0</td><td>12</td><td>24</td><td></td><td>3</td></tr>
<tr><td colspan="9">Primary and secondary data sources, digital and open datasets, measurement scales, questionnaire design, sampling techniques, sample size estimation, data preprocessing, cleaning, transformation, and basic data visualization.
Activities: Questionnaire design, data visualization exercise.</td></tr>
<tr><td>UNIT 3</td><td>DATA ANALYSIS, INTERPRETATION AND SCIENTIFIC COMMUNICATION</td><td>9</td><td>3</td><td>0</td><td>12</td><td>24</td><td></td><td>2</td></tr>
<tr><td colspan="9">Descriptive and inferential statistics, hypothesis testing, correlation and regression basics, introduction to multivariate analysis, use of analytical tools (Excel/SPSS/Python – overview), interpretation of results, technical report writing, journal and conference paper formats (IEEE/IET), presentation techniques.
Activities: Data analysis demo, paper formatting.</td></tr>
<tr><td>UNIT 4</td><td>INTELLECTUAL PROPERTY RIGHTS AND INNOVATION ECOSYSTEM</td><td>9</td><td>3</td><td>0</td><td>12</td><td>24</td><td></td><td>7</td></tr>
<tr><td colspan="9">Concept, meaning, and significance of Intellectual Property Rights (IPR); types of IPR including patents, copyrights, trademarks, industrial designs, and geographical indications; role of IPR in innovation, research, and economic development; overview of national IPR framework with reference to Indian Patent Office and international agreements under World Intellectual Property Organization; importance of IPR in academia, industry, and technology-driven entrepreneurship. Activities: IPR case study.</td></tr>
<tr><td>UNIT 5</td><td>PATENTS AND TECHNOLOGY PROTECTION</td><td>9</td><td>3</td><td>0</td><td>12</td><td>24</td><td></td><td>2,7</td></tr>
<tr><td colspan="9">Patent concepts and objectives, patentability criteria, novelty and inventive step, patent specifications, prior art search, types of patent applications, patent filing process, examination</td></tr>
</table>

and grant, licensing and technology valuation, career opportunities in patent and innovation management.
Activities: Patent search exercise.

COURSE OUTCOMES:

At the end of the course, the students will be able to:
CO1: Apply suitable research methodologies to formulate research problems.
CO2: Design data collection instruments and choose appropriate sampling methods.
CO3: Analyze and interpret research data using basic analytical tools.
CO4: Apply appropriate IP strategies for safeguarding innovations and research outputs..
CO5: Apply principles of IPR, patents, and ethical research practices in research and innovation activities.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Internal Assessment Test (70%), Activities (30%)

TEXT BOOKS:

1.	John W. Creswell, J. David Creswell, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, Fifth Edition, Sage Publications, 2023
2.	Deborah E. Bouchoux, Intellectual Property: Patents, Trademarks, Copyrights and Trade Secrets, Fifth Edition, Cengage Learning, 2021

REFERENCES:

1.	Pamela S. Schindler, Business Research Methods, Fourteenth Edition, McGraw Hill, 2025.
2.	Deborah E. Bouchoux, Intellectual Property: Patents, Trademarks, Copyrights and Trade Secrets, Fifth Edition, Cengage Learning, 2021.
3.	David Hitchcock , Patent Searching Made Easy, Second Edition, Routledge, 2020.
4.	Wayne C. Booth, Gregory G. Colomb, Joseph M. Williams, Joseph Bizup, William T. FitzGerald , The Craft of Research, Fifth Edition, University of Chicago Press, 2024.
5.	V.K. Ahuja, Intellectual Property Rights: Law and Practice, Third Edition, LexisNexis, 2022.

E-RESOURCES/E-MATERIALS:

1.	WIPO IP Portal – Online learning modules on Intellectual Property Rights and patents.(https://www.wipo.int/academy)
2.	Google Scholar – Scholarly literature search and citation tracking platform.(https://scholar.google.com)
3.	Indian Patent Office (IPO) Website – Patent search, filing procedures, and legal guidelines. (https://ipindia.gov.in)

Mapping of Course Outcomes to Programme Outcomes

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	1	1
CO2	3	3	3	2	2	1
CO3	3	3	2	3	3	1
CO4	2	2	3	2	2	3
CO5	2	2	2	2	1	3

		L	T	P	TW/SL	Total	C	SDG
PE26102	**ANALYSIS OF POWER CONVERTERS**	**45**	**15**	**0**	**60**	**120**	**4**	**7,11**

COURSE OBJECTIVE:

- To analyze the operation of various semiconducting devices.
- To analyze the operation and performance of various types of converters used in power electronics applications.
- Design driver circuits for power semiconductor devices.

COURSE CONTENT:

UNIT 1	**POWER SEMI-CONDUCTOR DEVICES**	**9**	**3**	**0**	**12**	**24**	**-**	**7,11**

Characteristics of SiC planar power MOSFETs, Forward conduction and forward blocking, SiC IGBTs: Structure and Operation, Basics of GaN High Electron Mobility Transistors (HEMT), Planner and Lateral GaN power HFET, Latch up and Safe Operating Area (SOA).

Activities:
Performance comparison of various semi-conductor devices.

UNIT 2	**AC-DC CONVERTER**	**9**	**3**	**0**	**12**	**24**	**-**	**7,11**

Half controlled and fully controlled single phase and three phase converters – continuous and discontinuous modes of operation, Inverter operation and its limit – performance parameters.
Activities:
Problem solving

UNIT 3	INVERTERS	9	3	0	12	24	-	7,11
Principle of operation of half and full bridge inverters – Performance parameters – Voltage control of single-phase inverters– various harmonic elimination techniques. 180 degree and 120 degree conduction mode inverters with star and delta connected loads – voltage control of three phase inverters: single, multi pulse, sinusoidal, Space vector modulation techniques. **Activities:** Problem solving								
UNIT 4	**MULTILEVEL AND IMPEDANCE SOURCE INVERTERS**	**9**	**3**	**0**	**12**	**24**	**-**	**7,11**
Multilevel concept – diode clamped – flying capacitor – cascaded type multilevel inverters – Comparison of multilevel inverters – application of multilevel inverters – PWM techniques for MLI – Single phase &Three phase Impedance source inverters. **Activities:** Case study on different MLI.								
UNIT 5	**DRIVER CIRCUITS AND THERMAL PROTECTION**	**9**	**3**	**0**	**12**	**24**	**-**	**7,11**
Design considerations, DC coupled drive circuits for IGBT and power MOSFET, Necessity of isolation, Pulse transformer and optocoupler based electrically isolated circuits, Gate drive circuit for thyristor (SCR), Over voltage and current protection, Heat sinks - Electrical analogy of thermal components. **Activities:** Case study on protection circuits.								
COURSE OUTCOMES:								
At the end of the course, the students will be able to: **CO1:** Analyze the characteristics of modern power semi-conductor devices. **CO2:** Analyze the performance of phase-controlled rectifiers. **CO3:** Analyze the performance of inverters. **CO4:** Examine the performance of various types of multi-level inverters. **CO5:** Design driver circuits for various semi-conductor devices.								
Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%								
Assessment Methodology: Internal Examinations (30%), Practical (10%), Activities (10%)								

REFERENCES:	
1.	P.S.Bimbra, “Power Electronics”, Eleventh Edition, Khanna Publishers, Reprint 2025.
2.	Rashid M.H., “Power Electronics Circuits, Devices and Applications”, Fourth Edition Pearson education, Tenth edition 2021.
3.	Bimal.K.Bose “Modern Power Electronics and AC Drives”, Second Edition, Pearson Education, Reprint 2017.
4.	Ned Mohan, Undeland and Robbin, “Power Electronics: converters, Application and design” (An Indian Adaptation), Wiley India Pvt Ltd, Third Edition, 2022
5.	M D. Singh, K B. Khanchandani, Power Electronics, Mc Graw hill education India, Second Edition , Reprint 2015.
E-RESOURCES/E-MATERIALS:	
1.	https://onlinecourses.nptel.ac.in/noc26_ee32/preview
2.	https://onlinecourses.nptel.ac.in/noc26_ee15/preview

Mapping of Course Outcomes to Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	3	2	1	1
CO2	2	2	3	2	3	2
CO3	2	2	3	2	3	2
CO4	3	2	3	2	2	2
CO5	3	2	2	2	2	2
CO	**2**	**2**	**3**	**2**	**2**	**2**

<table>
<tr><td rowspan="2">PE26103</td><td rowspan="2">SYSTEM DESIGN USING MICROCONTROLLER</td><td>L</td><td>T</td><td>P</td><td>TW/SL</td><td>Total</td><td>C</td><td>SDG</td></tr>
<tr><td>45</td><td>0</td><td>0</td><td>45</td><td>90</td><td>3</td><td>4,7,9,12,13</td></tr>
</table>

COURSE OBJECTIVES:

- To provide in-depth knowledge of PIC microcontroller architecture, memory organization, instruction set, and programming using Assembly and C for embedded control applications.
- To develop competency in interrupt handling and interfacing techniques including ADC, DAC, sensors, LCD, and keyboard for real-time control systems.
- To design microcontroller-based control systems for power electronic converters and motor drive applications using PWM and related peripherals.
- To introduce ARM processor architecture, programming model, and development tools for advanced embedded system design.
- To analyze ARM organization, pipeline architecture, and instruction execution for high-performance embedded applications in power electronics and drives.

COURSE CONTENT:

UNIT 1	**INTRODUCTION TO PIC MICROCONTROLLER**	**9**	**0**	**0**	**9**	**18**		**4,7,9**

PIC Architecture – Memory organization – Instruction set – Addressing modes - PIC programming in Assembly & C – Simple operations – I/O port – Timer programming
Activity: Develop Assembly programs to demonstrate: Immediate addressing, Direct addressing and Indirect addressing.

UNIT 2	**INTERRUPTS AND INTERFACING**	**9**	**0**	**0**	**9**	**18**		**9,12**

Interrupt Programming – LCD and keyboard Interfacing – ADC Characteristics – DAC Interfacing – Sensor Interfacing and Signal Conditioning
Activity: Interface an LCD display or Keyboard or any sensor with PIC.

UNIT 3	**APPLICATIONS OF PIC MICROCONTROLLER**	**9**	**0**	**0**	**9**	**18**		**7,13**

Relays and Opto isolators – Stepper Motor – DC Motor – PWM Motor Control with CCP(Capture/ Compare/PWM) – DC Motor Control with ECCP(Enhanced-CCP).
Activity: Write and experiment an assembly program for Full-step operation and Half-step operation of stepper motor.

UNIT 4	**INTRODUCTION TO ARM PROCESSOR**	**9**	**0**	**0**	**9**	**18**		**4,9**

ARM Architecture – ARM programmer's model – ARM Development tools - Memory Hierarchy – ARM Assembly Language Programming – Simple Examples – Architectural Support for Operating systems.

Activity: Install and explore Keil ARM development tool. Develop simple programs and compile to develop a executable hex file.

UNIT 5	**ARM ORGANIZATION**	**9**	**0**	**0**	**9**	**18**		**7,9,13**

3-Stage Pipeline ARM Organization – 5-Stage Pipeline ARM Organization – ARM Instruction Execution – ARM Implementation – ARM Instruction Set – Architectural support for High Level Languages – Embedded ARM Applications.

Activity: Develop a literature review on ARM based control of power electronic devices.

COURSE OUTCOMES:

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

CO1: Analyse different addressing modes by developing simple programs in PIC Microcontroller.

CO2: Analyse interrupt programming in PIC microcontrollers to examine its role in interfacing devices.

CO3: Develop PIC microcontroller based control strategies for motors in real time applications.

CO4: Apply ARM development tools to construct and compile executable programs for embedded systems.

CO5: Apply ARM architecture concepts to design embedded applications in real-world scenarios.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Activities (40%) & Internal Examinations (60%)

REFERENCES:

1.	Muhammad Ali Mazidi, Rolin D.Mckinlay, Danny Causey, "PIC Microcontroller and Embedded Systems using Assembly and C for PIC18", Pearson Education, 2nd edition, 2021.
2.	Steve Furber, "ARM system on chip architecture", Pearson, 2nd edition, 2000.
3.	Andrew N. Sloss, Dominic Symes, Chris Wright, John Rayfield, "ARM System Developer's Guide Designing and Optimizing System Software", Elsevier, 2011.
4.	John Iovine, "PIC Microcontroller Project Book", McGraw Hill, 2000.
5.	William Hohl, "ARM Assembly Language" Fundamentals and Techniques", 2009

E-RESOURCES/E-MATERIALS:	
1.	https://www2.keil.com/docs/default-source/default-document-library/mdk5-getting-started.pdf
2.	https://developer.arm.com/documentation/109350/latest/
3.	https://www.microchip.com/en-us/tools-resources

Mapping of Course Outcomes to Programme Outcomes

Course Outcomes	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	2	2	1	1
CO2	1	-	2	2	1	1
CO3	1	-	2	2	1	1
CO4	1	-	2	2	1	1
CO5	1	1	2	2	1	1
Average	**1**	**1**	**2**	**2**	**1**	**1**

RM26C02	RESEARCH TOOL LABORATORY	L	T	P	TW/SL	Total	C	SDG
		0	0	60	0	60	2	4,9,16,17

COURSE OBJECTIVES:

- To provide hands-on training in modern research and project management tools.
- To develop skills in literature review, reference management, and plagiarism checking.
- To train students in research paper formatting, writing, and publication workflow.
- To introduce data analysis and visualization tools for research applications.
- To enable preparation of professional research reports and technical presentations.

LIST OF ACTIVITIES:

1. Research Planning and Project Management
   1.1 Research lifecycle, milestones, and project planning
   1.2 Gantt chart preparation using MS Project / Notion / OneNote

2. Literature Review and Reference Management
   2.1 Advanced literature search using Google Scholar / Scopus
   2.2 Reference management using Mendeley / Zotero

3. Research Problem Identification
   3.1 Literature gap analysis, AI-assisted literature gap analysis
   3.2 Research problem, objectives, and hypothesis formulation

4. Research Paper Formatting
   4.1 IEEE / IET journal and conference templates
   4.2 Professional writing using Overleaf , Grammarly

5. Publication Workflow
   5.1 Journal selection using Elsevier Journal Finder
   5.2 Peer review process and reviewer response simulation

6. Data Analysis – Basic Tools
   6.1 Data entry, cleaning, and preprocessing
   6.2 Descriptive statistics and graphical visualization

7. Data Analysis – Advanced Tools
   7.1 Introduction to SPSS / MATLAB for research analysis
   7.2 Interpretation of results and inference

8. Plagiarism Detection and Research Ethics
   8.1 Plagiarism checking using Turnitin / Urkund
   8.2 Ethical paraphrasing and citation practices

9. Referencing and Citation Standards
   9.1 IEEE, APA referencing styles
   9.2 Automated citation generation and consistency check

10. AI in Research and Automation
   10.1 AI tools for research assistance, ChatGPT ,Perplexity AI -Automated summarization, idea generation
   10.2 Ethical use of AI in research

COURSE OUTCOMES:

At the end of the course, the students will be able to:
CO1: Plan and manage research activities using modern research tools.
CO2: Conduct systematic literature review and manage references effectively.
CO3: Analyze and interpret research data using suitable software tools.
CO4: Prepare plagiarism-free research papers and technical reports.
CO5: Present research findings professionally through reports and presentations.

Weightage: Continuous Assessment: 60%, End Semester Examinations: 40%

Assessment Methodology: Evaluation of Student’s work, Observation, Record, Activities etc.(75%), Model Practical Exam (25%)

REFERENCES:	
1.	Wayne C. Booth, Gregory G. Colomb, Joseph M. Williams, Joseph Bizup, William T. FitzGerald , The Craft of Research, Fifth Edition, University of Chicago Press, 2024.
2.	John W. Creswell, J. David Creswell, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, Fifth Edition, SAGE Publications, 2023.
3.	Mark N. K. Saunders, Philip Lewis, Adrian Thornhill , Research Methods for Business Students , Ninth Edition, Pearson Education, 2023.
4.	Herman Aguinis, Research Methodology: Best Practices for Rigorous, Credible, and Impactful Research,SAGE Publications, 2025.
5.	Jiawei Han, Micheline Kamber, Jian Pei, Data Mining: Concepts and Techniques, Third Edition, 2025
E-RESOURCES/E-MATERIALS:	
1.	Reference organization, citation generation, PDF management https://www.mendeley.com
2.	Collaborative LaTeX writing for research papers https://www.overleaf.com
3.	Plagiarism detection and originality reports https://www.turnitin.com

Mapping of Course Outcomes to Programme Outcomes

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	3	3	1
CO2	2	3	2	3	3	1
CO3	3	3	2	3	3	1
CO4	2	2	3	2	2	3
CO5	2	2	2	2	2	2

PE26104	POWER ELECTRONICS CONVERTERS LABORATORY	L	T	P	TW/SL	Total	C	SDG
		0	0	60	0	60	2	4,7,9,12,13

COURSE OBJECTIVES:

- Design and test isolated and non-isolated power electronic converters.
- Study the need for a power quality analyser.
- Demonstrate and develop a mini project of societal importance.

LIST OF EXPERIMENTS:

1. Analyze the performance and switching characteristics of GTO, MOSFET and IGBT.
2. Experimental verification of driver circuits for converters.
3. Implementation of P, PI and PID controllers using Operational amplifier.
4. Design and testing of various isolated converters.
5. Design and testing of various non-isolated converters.
6. Analysing the performance parameters of power electronic converters using power quality analyser.
7. Simulation of converters.

COURSE OUTCOMES:

At the end of the course, the students will be able to:
CO1: Analyze the switching characteristics of various semiconductor devices.
CO2: Select suitable components for the design of power electronics circuits.
CO3: Design and test isolated power electronics converter circuits.
CO4: Design and test Non-isolated power electronics converter circuits.
CO5: Analyze the quality of power in power electronic circuits using power quality analyser.

Weightage: Continuous Assessment: 60%, End Semester Examinations: 40%

Assessment Methodology: Record and Observation (25%) & Model Examination (75%)

Mapping of Course Outcomes to Programme Outcomes

Course Outcomes	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	1	1	1	2
CO2	2	-	2	1	1	2
CO3	2	-	2	1	1	2
CO4	2	-	3	1	2	1
CO5	2	-	3	3	3	3
Average	**2**	**-**	**2**	**1**	**2**	**2**

PE26105	TECHNICAL SEMINAR	L	T	P	TW/SL	TOTAL	C	SDG
		0	0	30	0	30	1	4,7,9,12, 13

COURSE OBJECTIVES:

To work on a specific technical topic in Power Electronics and Drives in order to acquire the skills of oral presentation and to acquire technical writing abilities for seminars and conferences

COURSE OVERVIEW

The students will work for two hours per week guided by a group of staff members. They will be asked to talk on any topic of their choice related to Power Electronics and Drives and to engage in dialogue with the audience. A brief copy of their talk also should be submitted. Similarly, the students will have to present a seminar of not less than fifteen minutes and not more than thirty minutes on the technical topic. They will also answer the queries on the topic. The students as audience also should interact. Evaluation will be based on the technical presentation and the report and also on the interaction during the seminar.

COURSE OUTCOMES:

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

CO1: Identify latest developments in the field of Power Electronics and Drives

CO2: Develop technical writing abilities for seminars, conferences and journal publications

CO3: Make use of modern tools to present the technical details

Mapping of Course Outcomes to Program Outcomes

Course Outcomes	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	-	-	-	-
CO2	-	3	3	-	-	-
CO3	-	-	-	-	-	-
CO	3	3	3	-	-	-

<table>
<tr><td rowspan="2">PE26201</td><td rowspan="2">ELECTRIC VEHICLES AND POWER MANAGEMENT</td><td>L</td><td>T</td><td>P</td><td>TW/SL</td><td>TOTAL</td><td>C</td><td>SDG</td></tr>
<tr><td>45</td><td>0</td><td>0</td><td>45</td><td>90</td><td>3</td><td>7,9,12,13</td></tr>
<tr><td colspan="9">COURSE OBJECTIVES:</td></tr>
<tr><td colspan="9">1. To provide students with a clear understanding of the overall architecture of electric vehicles, including propulsion systems, energy storage systems, and power electronic components.
2. To study different EV propulsion methods and battery technologies, and evaluate their performance, efficiency, and suitability for various applications.
3. To develop knowledge of power management techniques that improve vehicle performance, energy efficiency, and battery lifespan under different driving conditions.
4. To examine concepts such as regenerative braking, smart charging, and vehicle-to-grid (V2G) integration for enhancing energy utilization and sustainability.
5. To analyze how power electronic converters and control systems support efficient energy conversion and enable the development of sustainable electric transportation.</td></tr>
<tr><td colspan="9">COURSE CONTENT:</td></tr>
<tr><td>UNIT 1</td><td>INTRODUCTION TO ELECTRIC VEHICLES (EVS)</td><td>9</td><td>0</td><td>0</td><td>9</td><td>18</td><td></td><td>7,9,12,13</td></tr>
<tr><td colspan="9">EV evolution and classification (BEV, HEV, PHEV, FCEV) - EV configurations and architecture -Vehicle dynamics: tractive effort, energy consumption, gradability - Driving cycles: EPA, NEDC, WLTP, and custom profiles
Activities: Quiz on BEV, HEV, PHEV, FCEV features -Team design activity: Design its architecture (battery, motor, converter, controller layout)</td></tr>
<tr><td>UNIT 2</td><td>ELECTRIC PROPULSION AND DRIVE SYSTEMS</td><td>9</td><td>0</td><td>0</td><td>9</td><td>18</td><td></td><td>7,9,12,13</td></tr>
<tr><td colspan="9">Types of electric motors used in EVs: PMSM, BLDC, IM, SRM - Motor characteristics and drive selection - Motor control strategies: Field-Oriented Control (FOC), Direct Torque Control (DTC) - Regenerative braking – Torque Vs. Speed Control
Activities: Group Discussion/Debate: Types of electric motors used in EVs (Pros/cons in EVs ,Torquespeed curve sketch ,strengths/limitations and real-world use of each motor.) Simulation:Run and observe simulations for Field-Oriented Control (FOC) vs. Direct Torque Control (DTC)</td></tr>
</table>

UNIT 3	**ENERGY STORAGE SYSTEMS AND BATTERY MANAGEMENT**	**9**	**0**	**0**	**9**	**18**		**7,9,12,13**
Battery types: Li-ion, NiMH, Lead-acid – comparison and characteristics - Battery modeling and performance parameters - Battery Management Systems (BMS): SoC, SoH, cell balancing - Supercapacitors and hybrid storage systems **Activities**: Technical seminar: Compare Li-ion, NiMH, and Lead-acid batteries based on key parameters Modelling: Estimate required battery size, discharge rate, and range for an EV								
UNIT 4	**POWER ELECTRONICS AND ENERGY CONVERSION**	**9**	**0**	**0**	**9**	**18**		**7,9,12, 13**
DC-DC converters, inverters, and onboard chargers - Bidirectional power flow and energy recuperation - Charging infrastructure: AC vs DC, wireless charging, V2G systems - Safety, thermal management, and EMI issues **Activities**: Simulation: Simulation or flowchart design during drive and regenerative braking (e.g., motor ↔ battery ↔ grid) Group Discussion/Debate:Compare AC charging vs DC fast charging (e.g., speed, efficiency, cost, grid impact)								
UNIT 5	**POWER MANAGEMENT STRATEGIES AND FUTURE TRENDS**	**9**	**0**	**0**	**9**	**18**		**7,9,12,13**
Power flow optimization and energy scheduling in EVs - Smart energy management using AI and predictive algorithms - Integration with smart grids and renewable sources - Trends in EV policy, standardization, and sustainable mobility **Activities**: Case Study: Analyze and optimize power flow between battery, motor, regenerative braking, and auxiliary systems during different drive conditions Team design activity: Propose an EV charging solution using solar/wind, including storage and grid backup.								
COURSE OUTCOMES:								
At the end of the course, the students will be able to: **CO1:** Analyze the architecture of EV powertrains and identify the role of various subsystems in power and energy flow management. **CO2:** Analyze battery systems, charging infrastructure, and battery management techniques to ensure safety, efficiency, and longevity of EVs.. **CO3:** Apply power electronics converters and control strategies for energy conversion, bidirectional charging, and regenerative braking in electric vehicles. **CO4:** Evaluate real-time power management strategies under different driving conditions using performance metrics such as efficiency, thermal stability, and cost-effectiveness. **CO5:** Design intelligent energy management systems using rule-based, fuzzy logic, and optimization based algorithms for hybrid and battery electric vehicles..								

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%	
Assessment Methodology: Activity (40%) & Internal Examinations (60%)	
REFERENCES:	
1.	Shichun Yang, Xinhua Liu, Shen Li, Cheng Zhang,, ”Advanced Battery Management System for Electric Vehicles”,Sringer,2023.
2.	Jain, Parita ,Aggarwal, Puneet Kumar, Shailendra Rathore, Mandeep Singh, Sushil Kumar, ”Optimized Energy Management Strategies for Electric Vehicles, John Wiley & Sons,2024.
3.	Yiqing Yuan, ”Electric Vehicles: Theory and Design”, SAE International,2024.
4.	Shuai Jiang, “Power Electronics for Electric Vehicles and Energy Storage Systems”, Springer, 2022.
5.	Iqbal Hussain, “Electric and Hybrid Vehicles: Design fundamentals”, CRC press/Routledge, Third Edition, 2021.
E-RESOURCES/E-MATERIALS:	
1.	https://afdc.energy.gov › files › publication › EV.
2.	https://www.energy.ca.gov › CEC-500-2021-055
3.	https://univ-eiffel.hal.science › hal-03842775 › file

Mapping of Course Outcomes to Programme Outcomes

Course Outcomes	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	3	3	1	1	1
CO2	3	1	3	1	1	1
CO3	3	2	3	1	1	1
CO4	3	2	3	1	1	1
CO5	2	2	3	1	1	1
Average	**3**	**2**	**3**	**1**	**1**	**1**

PE26202	SPECIAL ELECTRICAL MACHINES	L	T	P	TW/SL	TOTAL	C	SDG
		45	0	0	45	90	3	4,9

COURSE OBJECTIVES:

- To study the construction, working, characteristics and speed control methods of synchronous reluctance motors.
- To understand the working, characteristics and speed control principles of stepper motor.
- To study the construction, working, characteristics and speed control methods of switched reluctance motors.
- To know the principle of operation, construction, characteristics and speed control methods for the permanent magnet brushless DC motors.
- To understand the concepts related with permanent magnet synchronous motors

COURSE CONTENT:

UNIT 1	SYNCHRONOUS RELUCTANCE MOTORS	9	0	0	9	18		4,9

Constructional features – Types – Axial and Radial flux motors – Operating principles – Variable Reluctance Motors – Voltage and Torque Equations - Phasor diagram - performance characteristics – Applications.
Activity: Group Discussion

UNIT 2	STEPPER MOTORS	9	0	0	9	18		4,9

Constructional features – Rotary and Linear SRM - Principle of operation – Torque production – Steady state performance prediction- Analytical method -Power Converters and their controllers Methods of Rotor position sensing – Sensor less operation – Characteristics and Closed loop control Applications
Activity: Mini Project

UNIT 3	SWITCHED RELUCTANCE MOTORS	9	0	0	9	18		4,9

Constructional features – Rotary and Linear SRM - Principle of operation – Torque production – Steady state performance prediction- Analytical method -Power Converters and their controllers Methods of Rotor position sensing – Sensor less operation – Characteristics and Closed loop control Applications.
Activity: Mind Mapping

UNIT 4	PERMANENT MAGNET BRUSHLESS D.C. MOTORS	9	0	0	9	18		4,9

Permanent Magnet materials – Minor hysteresis loop and recoil line-Magnetic Characteristics

– Permeance coefficient -Principle of operation – Types – Magnetic circuit analysis – EMF and torque equations –Commutation - Power Converter Circuits and their controllers – Motor characteristics and control– Applications

Activity: Technical Quiz

UNIT 5	**PERMANENT MAGNET SYNCHRONOUS MOTORS**	**9**	**0**	**0**	**9**	**18**		**4,9**

Principle of operation – Ideal PMSM – EMF and Torque equations – Armature MMF – Synchronous Reactance – Sine wave motor with practical windings - Phasor diagram – Torque/speed characteristics - Power controllers - Converter Volt-ampere requirements– Applications

Activity: Seminar Presentation

COURSE OUTCOMES:

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

CO1: Analyze the performance characteristics of synchronous reluctance motors.
CO2: Evaluate the excitation modes of stepping motors.
CO3: Design power converter circuits for switched reluctance motors.
CO4: Analyze the magnetic characteristics of brushless DC motors.
CO5: Evaluate control methods of permanent magnet synchronous motors.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Activity (40%) & Internal Examinations (60%)

REFERENCES:

1.	V. Rajini and V.S. Nagarajan,’ Special Electrical Machines‘, Pearson India, New Delhi, 2024.
2.	Jigneshkumar P. Desai, ‘Special Electrical Machinery‘, John Wiley & Sons, 2024.
3.	Simmi P. Burman, ‘Special Electrical Machines‘, S.K. Kataria & Sons, New Delhi, 2023
4.	Rakesh Kumar Srivastava, ‘Electrical Machines‘, Springer Nature Singapore Private Limited, Singapore, 2022.
5.	V. Rajini and V.S. Nagarajan, ‘Special Electrical Machines‘, McGraw Hill Education (India) Private Limited, New Delhi, 2021.

E-RESOURCES/E-MATERIALS:	
1.	https://onlinelibrary.wiley.com/doi/book/10.1002/9781394193912
2.	https://nit-edu.org/wp-content/uploads/2021/09/ch-39-Special-motors.pdf
3.	https://infinite-research.org/products/special-electrical-machines

Mapping of Course Outcomes to Programme Outcomes

Course Outcomes	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	-	2	1	1
CO2	1	-	-	2	1	1
CO3	1	-	-	2	1	1
CO4	1	-	-	2	1	1
CO5	1	-	-	2	1	1
Average	**1**	**-**	**-**	**2**	**1**	**1**

PE26203	ANALYSIS OF ELECTRICAL DRIVES (LAB INTEGRATED)	L	T	P	TW/SL	TOTAL	C	SDG
		45	0	30	45	120	4	7,9,11, 12,13

COURSE OBJECTIVES:

- To analyse the speed–torque and performance characteristics of a DC Motor under various load conditions.
- To analyse the performance of converter control and chopper control fed DC Motor drives.
- To design a closed loop controllers for the current and speed control operations of DC Motor drive system
- To analyse the operation of VSI &CSI fed Induction Motor control and pulse width modulation techniques
- To analyse the speed control of rotor-controlled Induction Motor drives.

COURSE CONTENT:							
UNIT 1	DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS	9	0	0	9	18	7,9,11,12
DC motor- speed-torque relations, Speed control – Armature and field speed control; Ward Leonard control – Constant torque and constant horse power operation. Characteristics of mechanical system– dynamic equations, components of torque, types of load; Requirements of drives characteristics – stability of drives–multi-quadrant operation; Drive elements, types of motor duty and selection of motor rating **Activities:** Case Study on DC drives in Industries							
UNIT 2	CONVERTER AND CHOPPER CONTROLLED DRIVES	9	0	5	9	23	7,9,11,12
Principle of phase control – Fundamental relations; Analysis of series and separately excited DC motor with single-phase and three-phase converters –performance parameters, performance characteristics. Introduction to time ratio control and frequency modulation; chopper-controlled DC motor – performance analysis, multi-quadrant control; Related problems **Activities**: Problem solving to determine the performance parameters of converters and choppers. **Practical:** Speed control of converter fed DC Motor.							
UNIT 3	CLOSED LOOP CONTROL OF DC DRIVES	9	0	20	9	38	7,9,11,12
Modeling of drive elements – Equivalent circuit, transfer function of self, separately excited DC motors; Linear Transfer function model of power converters; Sensing and feeds back elements – Closed loop speed control – current and speed loops. **Activities**: Comparative study on modeling and transfer function of different types of self-excited DC Motor **Practical**: 1. Speed control of Permanent Magnet DC Motor 2. Speed control of Permanent Magnet Synchronous Motor 3. Speed control of Brushless DC Motor. 4. Microcontroller based speed control of Stepper Motor.							

<table>
<tr><td>UNIT 4</td><td>VSI AND CSI FED STATOR CONTROLLED INDUCTION MOTOR DRIVES</td><td>9</td><td>0</td><td>5</td><td>9</td><td>23</td><td>7,9,11,12,13</td></tr>
<tr><td colspan="8">AC voltage controller – six step inverter voltage control-closed loop variable frequency PWM inverter fed induction motor (IM) with braking-CSI fed IM variable frequency motor drives.
Activities: Two real-world applications of VSI and CSI fed Induction Motor drives.
Practical: V/F control of Three Phase Induction Motor.</td></tr>
<tr><td>UNIT 5</td><td>ROTOR CONTROLLED INDUCTION MOTOR DRIVES</td><td>9</td><td>0</td><td>0</td><td>9</td><td>18</td><td>7,9,11,12,13</td></tr>
<tr><td colspan="8">Static rotor resistance control – injection of voltage in the rotor circuit – static scherbius drives – static and modified Kramer drives – sub-synchronous and super-synchronous speed operation of induction machines
Activities: Comparison of dynamic performance of a slip-ring Induction Motor under sub-synchronous and super-synchronous operation with an application.</td></tr>
<tr><td colspan="8">COURSE OUTCOMES:</td></tr>
<tr><td colspan="8">At the end of the course, the students will be able to:

CO1: Analyse the speed–torque and performance characteristics of a DC motor under various load conditions.
CO2: Analyse the performance of converter control and chopper control fed DC motor drives.
CO3: Design a closed loop controllers for the current and speed control operations of DC motor drive system
CO4: Analyse the operation of VSI &CSI fed induction motor control and pulse width modulation techniques
CO5: Analyse the speed control of rotor-controlled induction motor drives</td></tr>
<tr><td colspan="8">Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%</td></tr>
<tr><td colspan="8">Assessment Methodology: Internal Assessment Test(30%),Practical(10%),Activities(10%)</td></tr>
<tr><td colspan="8">REFERENCES:</td></tr>
</table>
<table>
<tr><td>1.</td><td>Gopal K Dubey, “Power Semiconductor controlled Drives”, Prentice Hall Inc., New Jersy, 21 Mar 2025.</td></tr>
</table>

2.	R.Krishnan, "Electric Motor Drives - Modeling, Analysis and Control", Prentice-Hall of India Pvt. Ltd., New Delhi, Second edition, 2015.
3.	Bimal K Bose, "Modern Power Electronics and AC Drives", Pearson Education Asia, Second Edition, 2017.
4.	Gopal K.Dubey, "Fundamentals of Electrical Drives", Narosa Publishing House, New Delhi, Second Edition, 2009.
5.	Vedam Subramanyam, "Electric Drives – Concepts and Applications", Tata McGraw- Hill publishing company Ltd., New Delhi, second edition,1st July 2017.
6.	W.Leonhard, "Control of Electrical Drives", Narosa Publishing House, 2010.
E-RESOURCES/E-MATERIALS:	
1.	https://ieeexplore.ieee.org/document/4157698/
2	https://nptel.ac.in/courses/108104140
3	https://nptel.ac.in/courses/108104011

Mapping of Course Outcomes to Programme Outcomes

Course Outcomes	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	3	1	1
CO2	3	3	3	3	1	1
CO3	3	3	3	3	2	1
CO4	3	3	3	3	1	2
CO5	3	3	3	3	1	1
Average	**3**	**3**	**3**	**3**	**1.2**	**1.2**

PROFESSIONAL ELECTIVE I

		L	T	P	TW/SL	TOTAL	C	SDG
PE26001	**SOFT COMPUTING TECHNIQUES**	**45**	**0**	**0**	**45**	**90**	**3**	**3,4,7,9,11, 13**

COURSE OBJECTIVES:

- To apply soft computing techniques to solve engineering and intelligent system problems.
- To analyze the design and function of ANN and fuzzy set theory
- To analyze and implement the ANN and Fuzzy logic for modeling and control of Non-linear system and to get familiarized with the MATLAB toolbox
- To solve optimization problems using genetic algorithms
- To analyze various optimization techniques and hybrid control schemes using the ANFIS toolbox for intelligent system applications.

COURSE CONTENT:

UNIT 1	**FUNDAMENTALS OF ARTIFICIAL INTELLIGENCE**	**9**	**0**	**0**	**9**	**18**		**3.4.7.9**

Introduction to intelligent systems- Soft computing techniques- Conventional Computing versus Swarm Computing - Classification of meta-heuristic techniques - Properties of Swarm intelligent Systems -Application domain - Discrete and continuous problems – Single objective and multi-objective problems-Neuron- Nerve structure and synapse- Artificial Neuron and its model- activation functions- Neural network architecture- single layer and multilayer feed forward networks- Mc Culloch Pitts neuron model perceptron model- Adaline and Madaline-multilayer perception model- back propagation learning methods- effect of learning rule coefficient -back propagation algorithm- factors affecting back propagation training-applications

Activity: Implement and Compare Perceptron & Adaline for a Binary Classification Problem

UNIT 2	**ARTIFICIAL NEURAL NETWORKS AND ASSOCIATIVE MEMORY**	**9**	**0**	**0**	**9**	**18**		**3.4.7.9**

Counter propagation network- architecture- functioning & characteristics of counter Propagation network- Hopfield/ Recurrent network configuration - stability constraints associative memory and characteristics- limitations and applications- Hopfield v/s Boltzman machine- Adaptive Resonance Theory- Architecture- classifications- Implementation and training - Associative Memory..

Activity: Implementation of Hopfield Network for Associative Memory

UNIT 3	FUZZY LOGIC SYSTEM	9	0	0	9	18		3.4.7.9
Introduction to crisp sets and fuzzy sets- basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control- Fuzzification inferencing and defuzzification-Fuzzy knowledge and rule bases-Fuzzy modeling and control schemes for nonlinear systems. Self organizing fuzzy logic control- Fuzzy logic control for nonlinear time delay system **Activity:** Design of a Fuzzy Logic Temperature Controller.								
UNIT 4	**GENETIC ALGORITHM**	**9**	**0**	**0**	**9**	**18**		**3,4,7.9. 11.13**
Evolutionary programs – Genetic algorithms, genetic programming and evolutionary programming - Genetic Algorithm versus Conventional Optimization Techniques – Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators – Optimization problems using GA-discrete and continuous – Single objective and multi-objective problems – Procedures in evolutionary programming. **Activity:** Develop and implement a Genetic Algorithm (GA) model to optimize a real-world engineering problem such as economic load dispatch, scheduling, or path optimization.								
UNIT 5	**HYBRID SCHEMES**	**9**	**0**	**0**	**9**	**18**		**3,7,9,11**
Fuzzification and rule base using ANN–Neuro fuzzy systems-ANFIS – Fuzzy Neuron - Optimization of membership function and rule base using Genetic Algorithm – Introduction to Support Vector Machine- Evolutionary Programming-Particle Swarm Optimization – Case study – Familiarization of NN, FLC and ANFIS Tool Box.. **Activity:** Design and Optimization of ANFIS Model.								
COURSE OUTCOMES:								
At the end of the course, the students will be able to: **CO1:** Analyze the fundamental principles and comparative roles of Artificial Neural Networks (ANN), Fuzzy Logic, Genetic Algorithms, and hybrid control techniques in intelligent systems. **CO2:** Analyze and interpret various ANN architectures, learning paradigms, fuzzy set theories, and associated algorithms for solving complex engineering problems. **CO3:** Design and develop ANN- and fuzzy logic-based models and advanced control strategies for nonlinear and real-world dynamic systems. **CO4:** Assess and apply operations on fuzzy sets and neural network mechanisms to enhance system performance and decision-making accuracy. **CO5:** Formulate and optimize engineering problems using Genetic Algorithms and hybrid intelligent control schemes, and evaluate their effectiveness in practical applications.								
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%								
Assessment Methodology: Activity (40%), & Internal Examinations (60%)								

REFERENCES:	
1.	Laurene V. Fausett,"Fundamentals of Neural Networks": Architectures, Algorithms And Applications||", Pearson Education. 2025
2.	Timothy J. Ross,"Fuzzy Logic with Engineering Applications||", Wiley India, 2021.
3.	Zimmermann H.J, "Fuzzy set theory and its Applications" Springer international edition, 2011.
4.	David E.Goldberg,"Genetic Algorithms in Search, Optimization and Machine Learning||", Pearson Education, 2025.
5.	W.T.Miller,R.S.Sutton and P.J.Webrose,,"Neural Networks for Control", MIT Press, 1996.

E-RESOURCES/E-MATERIALS:	
1.	https://www.scribd.com/document/577025460/1916210
2.	https://ijarcs.info/index.php/Ijarcs/article/view/5911
3.	https://www.sandgarden.com/learn/anfis-adaptive-neuro-fuzzy-interface-system

Mapping of Course Outcomes to Programme Outcomes

Course Outcomes	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	2	3	3	3
CO2	3	-	2	3	3	3
CO3	3	-	2	3	3	3
CO4	2	-	2	3	3	3
CO5	2	-	2	3	3	3
Average	**3**	**-**	**2**	**3**	**3**	**3**

<table>
<tr><td rowspan="2">PE26002</td><td rowspan="2">SYSTEM THEORY</td><td>L</td><td>T</td><td>P</td><td>TW/SL</td><td>TOTAL</td><td>C</td><td>SDG</td></tr>
<tr><td>45</td><td>0</td><td>0</td><td>45</td><td>90</td><td>3</td><td>4,9</td></tr>
<tr><td colspan="9">COURSE OBJECTIVES:</td></tr>
<tr><td colspan="9">• To educate on modeling and representing systems in state variable form
• To train on solving linear and non-linear state equations
• To illustrate the properties of control system
• To classify non–linearities and examine stability of systems in the sense of Lyapunov‘s theory
• To educate on modal concepts, design of state, output feedback controllers and estimators</td></tr>
<tr><td colspan="9">COURSE CONTENT:</td></tr>
<tr><td>UNIT I</td><td>STATE VARIABLE REPRESENTATION</td><td>9</td><td>0</td><td>0</td><td>9</td><td>18</td><td colspan="2">4</td></tr>
<tr><td colspan="9">Introduction-Concept of State-Space equations for Dynamic Systems -Time invariance and linearity -Non uniqueness of state model- Physical Systems and State Assignment - free and forced responses- State Diagrams.
Activity: State diagram construction, state-space modeling applications review from refereed journals</td></tr>
<tr><td>UNIT 2</td><td>SOLUTION OF STATE EQUATIONS</td><td>9</td><td>0</td><td>0</td><td>9</td><td>18</td><td colspan="2">4</td></tr>
<tr><td colspan="9">Existence and uniqueness of solutions to Continuous-time state equations - Solution of Nonlinear and Linear Time Varying State equations - State transition matrix and its properties – Evaluation of matrix exponential- System modes- Role of Eigen values and Eigen vectors
Activity: Concept Mapping for state transition matrix derivation, connecting mathematical eigenvalues to physical system behavior.</td></tr>
<tr><td>UNIT 3</td><td>PROPERTIES OF THE CONTROL SYSTEM</td><td>9</td><td>0</td><td>0</td><td>9</td><td>18</td><td colspan="2">9</td></tr>
<tr><td colspan="9">Controllability and Observability- Stabilizability and Detectability-Test for Continuous time SystemsTime varying and Time invariant case-Output Controllability-Reducibility-System Realizations
Activity: Comparative case study for fully controllable & observable, controllable but not observable, observable but not controllable systems</td></tr>
</table>

<table>
<tr><td>UNIT 4</td><td>NON-LINEARITIES AND STABILITY ANALYSIS</td><td>9</td><td>0</td><td>0</td><td>9</td><td>18</td><td>9</td></tr>
<tr><td colspan="8">Equilibrium Points-Stability in the sense of Lyapunov-BIBO Stability-Stability of LTI Systems-Types of nonlinearity – Phase plane analysis – Singular points – Limit cycles – Construction of phase trajectories – Describing function method – Derivation of describing functions. Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems - Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems- Lyapunov Functions for Nonlinear Continuous Time Autonomous SystemsKrasovskii and Variable-Gradiant Method
Activity:Review research article and summarize, problem statement, mathematical model, stability approach used in Lyapunov stability, BIBO stability, phase plane analysis, limit cycles</td></tr>
<tr><td>UNIT 5</td><td>MODAL ANALYSIS</td><td>9</td><td>0</td><td>0</td><td>9</td><td>18</td><td>9</td></tr>
<tr><td colspan="8">Controllable and Observable Companion Forms - SISO and MIMO Systems – Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems Full Order and Reduced Order Observers
Activity: Comparative Study of SISO and MIMO systems with real time examples</td></tr>
<tr><td colspan="8">COURSE OUTCOMES:</td></tr>
<tr><td colspan="8">At the end of the course, the students will be able to:

CO1: Apply the concept of state-state representation to dynamic systems.
CO2: Illustrate the solution techniques for state equations.
CO3: Use state-space models to analyze and demonstrate properties of control systems.
CO4: Identify non-linearities and evaluate the stability of the system.
CO5: Perform Modal analysis and design controller and observer in state space form.</td></tr>
<tr><td colspan="8">Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%</td></tr>
<tr><td colspan="8">Assessment Methodology: Activity (40%), Internal Examinations (60%)</td></tr>
<tr><td colspan="8">REFERENCES:</td></tr>
<tr><td>1.</td><td colspan="7">M. Gopal, "Modern Control System Theory", 3rd edition, New Age International Publishers, 2014.</td></tr>
<tr><td>2.</td><td colspan="7">Z. Bubnicki, "Modern Control Theory", 1st edition, Springer, 2005.</td></tr>
<tr><td>3.</td><td colspan="7">K. Ogata, "Modern Control Engineering", 5th edition, Pearson India, 2010.</td></tr>
<tr><td>4.</td><td colspan="7">J. S. Bay, "Fundamentals of Linear State Space Systems", 1st edition, McGraw-Hill, 1999.</td></tr>
</table>

5.	Roy Choudhury, "Modern Control Systems", Ist edition, New Delhi, India: New Age International, 2005.
6.	J. J. D'Azzo, C. H. Houpis, and S. N. Sheldon, "Linear Control System Analysis and Design", 6th edition, McGraw-Hill, 2010.
7.	M. Vidyasagar, "Nonlinear Systems Analysis", 2nd edition Englewood Cliffs, NJ, USA: Prentice Hall, 2002.
E-RESOURCES/E-MATERIALS:	
1.	https://www.tandfonline.com/journals/tcon20
2.	https://link.springer.com/journal/11768
3.	https://shop.elsevier.com/journals/systems-and-control-letters/0167-6911

Mapping of Course Outcomes to Programme Outcomes

Course Outcomes	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	-	2	3	2	2
CO2	2	-	2	3	2	2
CO3	2	-	2	3	2	2
CO4	2	2	2	3	2	2
CO5	2	-	2	3	2	2
Average	**2**	**2**	**2**	**3**	**2**	**2**

		L	T	P	TW/SL	TOTAL	C	SDG
PE26003	**ANALYSIS OF ELECTRICAL MACHINES AND DRIVES**	**45**	**0**	**0**	**45**	**90**	**3**	**4,7,9, 11,12**

COURSE OBJECTIVES:

- To develop a deep understanding of electromechanical energy conversion using modern analytical tools
- To analyze dynamic models of electrical machines for advanced drive applications
- To apply reference frame theory in machine modeling and control
- To study multi-phase, high-efficiency, and EV-oriented machine systems
- To integrate AI, simulation tools, and real-time analysis in machine modeling

<table>
<tr><td colspan="9">COURSE CONTENT:</td></tr>
<tr><td>UNIT 1</td><td>ELECTROMECHANICAL ENERGY CONVERSION & DC MACHINE DYNAMICS</td><td>9</td><td>0</td><td>0</td><td>9</td><td>18</td><td></td><td>4,9</td></tr>
<tr><td colspan="9">Magnetic circuits with saturation and hysteresis ,Energy conversion principles: energy, co-energy, virtual work ,Torque and force in singly & doubly excited systems ,Advanced DC machine modeling (state-space approach) ,Dynamic analysis: transient response, stability ,DC drives in modern applications (EV auxiliaries, robotics) ,Introduction to simulation tools (MATLAB/Simulink)

Activities:
• Develop DC machine models using MATLAB Simulink
• Analyze transient and steady-state responses
• Compare analytical vs simulation results</td></tr>
<tr><td>UNIT 2</td><td>ADVANCED AC MACHINE CONCEPTS & MULTI-PHASE SYSTEMS</td><td>9</td><td>0</td><td>0</td><td>9</td><td>18</td><td></td><td>9</td></tr>
<tr><td colspan="9">Distributed windings and winding functions (analytical approach) ,Space harmonics and their impact on torque ripple & losses ,Air-gap MMF and rotating field theory (space vector approach) ,Flux linkage and inductance matrix modeling ,Magnetic noise, vibration, and NVH in machines ,Modeling of multi-phase machines (5-phase, 6-phase) ,Application in electric vehicles, aerospace drives
.
Activities:
• Develop induction machine models using MATLAB Simulink
• Analyze transient and steady-state responses
• Compare analytical vs simulation results</td></tr>
<tr><td>UNIT 3</td><td>REFERENCE FRAME THEORY & VECTOR TRANSFORMATIONS</td><td>9</td><td>0</td><td>0</td><td>9</td><td>18</td><td></td><td>12</td></tr>
<tr><td colspan="9">Review of Clarke and Park transformations ,Stationary, rotor, and synchronous reference frames ,Space vector theory and complex representation ,Transformation of machine equations into dq0 variables ,Physical interpretation of reference frames ,Application in Field Oriented Control (FOC) and Direct Torque Control (DTC) ,Real-time implementation concepts

Activities: Digital twin of electrical machines using tools like Python/MATLAB</td></tr>
</table>

UNIT 4	**MODELING & CONTROL OF INDUCTION MACHINES**	**9**	**0**	**0**	**9**	**18**		**7**

Dynamic modeling of 3-phase induction machines (abc & dq models) ,Equivalent circuit and steady-state performance ,Doubly-fed induction machines (DFIM) in wind energy ,Torque-speed characteristics and stability analysis ,Vector control, sensorless control techniques ,Multi-phase induction machine modeling ,Application in EV traction and renewable systems.

Activities: Develop a mini project in Multi-phase machine modeling

UNIT 5	**MODELING & CONTROL OF SYNCHRONOUS MACHINES**	**9**	**0**	**0**	**9**	**18**		**11**

Modeling of synchronous machines (abc & dq models) ,Park's equations and dynamic analysis ,Permanent Magnet Synchronous Motors (PMSM) & BLDC,Voltage, torque equations in rotor reference frame ,Field weakening and high-speed operation ,Advanced control: vector control, predictive control ,Applications in EVs, robotics, and smart grids.

Activities:
- Study PMSM/BLDC-based EV drive systems
- Analyze torque-speed characteristics and efficiency
- Present findings on real-world EV platforms

COURSE OUTCOMES:

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

CO1 Analyze electromechanical energy conversion using modern modeling techniques
CO2 Evaluate AC machine behavior including harmonics and multi-phase systems
CO3 Apply reference frame theory for advanced control strategies
CO4 Develop and simulate induction machine models for drive applications
CO5 Design and analyze synchronous machine models for EV and smart grid systems

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology: Internal Assessment Test – 30%, Assignment – 10%, Activities– 10%

REFERENCES:

1.	Analysis of Electric Machinery and Drive Systems Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, Steven D. Pekarek, Fourth Edition, Wiley-IEEE Press, 2025.
2.	Electric Motor Drives Modeling Analysis and Control, R. Krishnan, First Edition, Pearson Education, 2015.

3.	Electric Machinery Fundamentals,Stephen J. Chapman,Fifth Edition, McGraw Hill Education, 2012.
4.	Generalized Theory of Electrical Machines, P. S. Bimbhra, Seventh Edition, Khanna Publishers, 2021.
E-RESOURCES/E-MATERIALS:	
1.	https://www.mathworks.com/academia/tutorials.html
2.	https://www.pscad.com/learning
3.	https://www.youtube.com/user/nptelhrd
4	https://www.ansys.com/academic/students
5	https://ocw.mit.edu

Mapping of Course Outcomes to Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	1	1
CO2	3	3	2	2	2	1
CO3	3	3	3	2	2	1
CO4	3	3	3	3	2	2
CO5	3	3	3	3	3	2
CO	**3**	**2**	**2**	**2**	**1**	**1**

PE26004	BATTERY MANAGEMENT SYSTEM	L	T	P	TW/SL	Total	C	SDG
		45	**0**	**0**	**45**	**90**	**3**	**7,9,11,12,13**

COURSE OBJECTIVES:

- To understand the chemistry and performance of Li-ion batteries.
- To design battery packs and BMS architectures.
- To estimate State-of-Charge (SOC) and State-of-Health (SOH).

COURSE CONTENT:							
UNIT 1	**ADVANCED BATTERIES**	**9**	**0**	**0**	**9**	**18**	**7,9,12**
Li-ion Batteries-different formats, chemistry, safe operating area, efficiency, aging. Characteristi SOC, DOD, SOH. Balancing-Passive Balancing Vs Active Balancing. Other Batteries-NCM a NCA Batteries. NCR18650B specifications. **Activity:** Battery Cell Testing - Testing a Lithium-ion cell to determine its capacity, internal resistance, and OCV (Open Circuit Voltage) curve.							
UNIT 2	**BATTERY PACK**	**9**	**0**	**0**	**9**	**18**	**7,9,11**
Battery Pack- design, sizing, calculations, flow chart, real and simulation Model. Peak power – definition, testing methods-relationships with Power, Temperature and ohmic Internal Resistance. Cloud based and Local Smart charging. **Activity:** Develop a MATLAB/Simulink or Python-based simulation model to analyze battery pack performance under different load and temperature conditions.							
UNIT 3	**BATTERY MODELLING**	**9**	**0**	**0**	**9**	**18**	**7,9,13**
Battery Modelling Methods-Equivalent Circuit Models, Electrochemical Model, Neural Network Model. ECM Comparisons- Rint model, Thevenin model, PNGV model. State space Models-Introduction. Battery Modelling software/simulation frameworks **Activity:** MATLAB/Simulink Modeling - Create a 2RC (Resistor-Capacitor) equivalent circuit model of a battery and simulate its voltage response under different load conditions.							
UNIT 4	**BATTERY STATE ESTIMATION**	**9**	**0**	**0**	**9**	**18**	**7,9,13**
SOC Estimation- Definition, importance, single cell Vs series batteries SOC. Estimation Methods - Load voltage, Electromotive force, AC impedance, Ah counting, Neural networks, Neuro-fuzzy forecast method, Kalman filter. Estimation Algorithms. **Activity:** SoC Estimation using Kalman Filter - Develop a MATLAB/Python script to estimate the SOC of a battery using EKF based on measured voltage and current data.							
UNIT 5	**BMS ARCHITECTURE AND REAL TIME COMPONENTS**	**9**	**0**	**0**	**9**	**18**	**7,9,11**
Battery Management System Functions- need, operation, classification. BMS ASIC-bq76PL536A-Q1 Battery Monitor IC- CC2662R-Q1 Wireless BMS MCU. Communication Modules- CAN Open-Flex Ray, CANedge1 package. ARBIN Battery Tester. BMS Development with Modeling software and Model Based Design. **Activity:** CAN Communication - Set up a communication link between a battery simulator and a CAN analyzer to view live data.							

COURSE OUTCOMES:	
At the end of the course, the students will be able to: **CO1:** Acquire knowledge of different Li-ion Batteries performance. **CO2:** Design a Battery Pack and make related calculations. **CO3:** Demonstrate a Battery Model or Simulation. **CO4:** Estimate State-of-Charges in a Battery Pack. **CO5:** Approach different BMS architectures during real world usage.	
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%	
Assessment Methodology: Activity (40%) & Internal Examinations (60%)	
REFERENCES:	
1.	Jiuchun Jiang and Caiping Zhang, "Fundamentals and applications of Lithium-Ion batteries in Electric Drive Vehicles'', Wiley, 1st edition, 2015.
2.	Davide Andrea,"Battery Management Systems for Large Lithium-Ion Battery Packs" Artech House, 2010.
3.	Plett, Gregory L. Battery management systems, Volume I: Battery modeling. Artech House, 2015.
4.	Plett, Gregory L. Battery management systems, Volume II: Equivalent-circuit methods. Artech House, 2015.
5.	Bergveld, H.J., Kruijt, W.S., Notten, P.H.L "Battery Management Systems -Design by Modelling" Springer Science & Business Media, 2013.
6.	Valer Pop, Henk Jan Bergveld, Dmitry Danilov, Paul P. L. Regtien, Peter H. L. Notten "Battery management systems: Accurate state-of-charge indication for battery-powered applications", Vol. 9, Springer-Verlag New York Inc, 2008.
E-RESOURCES/E-MATERIALS:	
1.	https://www.alldatasheet.com/view.jsp?Searchword=Ncr18650b&gad_source=1&gad_campaignid=177214499&gbraid=0AAAADcdDU9mhq3sGJvWF9p55BzsEKa_p&gclid=CjwKCAjwzevPBhBaEiwAplAxvjOOM_DFdzaKuvMJdSZ0vVybtY2hLYopwoZu19E5bGhGbCCahnQcFRoCZXkQAvD_BwE
2.	https://event.techsource-asia.com/whitepaper-developing-battery-management-systems-with-simulink-and-model-based-design
3.	https://www.alldatasheet.com/datasheet-pdf/pdf/1274913/TI/CC2662R-Q1.html

Mapping of Course Outcomes to Programme Outcomes

Course Outcomes	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	2	2	1
CO2	3	2	3	3	2	3
CO3	3	2	3	3	2	2
CO4	3	1	3	3	3	2
CO5	2	2	3	2	3	3
Average	**2.6**	**1.6**	**3.0**	**2.6**	**2.4**	**2.2**

OPEN ELECTIVE I

PE26901	SMART GRID	L	T	P	TW/SL	Total	C	SDG
		45	0	0	45	90	3	7,9,11, 12,13

COURSE OBJECTIVES:

- To analyze the Challenges and benefits of smart grid
- To educate on the different smart grid technologies.
- To educate on smart meters and advanced metering infrastructure
- To analyze the power quality issues in Smart Grid.
- To analyze the communication networks for Smart Grid applications.

COURSE CONTENT:

UNIT 1	INTRODUCTION TO SMART GRID	9	0	0	9	18	7,9,11,12,13

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, Comparison of Micro grid and Smart grid, Present development & International policies in Smart Grid, Smart Grid Initiative for Power Distribution Utility in India–Case Study.

Activity: Prepare a comparison table on conventional grid vs smart grid and microgrid vs smart grid.

Analyze one case study from India Smart Grid Forum and summarize its objectives, benefits, and challenges.

UNIT 2	**SMART GRID TECHNOLOGIES**	**9**	**0**	**0**	**9**	**18**	**7,9,11,13**

Technology Drivers, Smart Integration of energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Outage management, Plug in Hybrid Electric Vehicles (PHEV)–Grid to Vehicle and Vehicle to Grid charging concepts.
Activity: Draw a smart grid model showing smart substations, feeder automation, EMS/DMS, and integration of renewables.
Compare the roles of EMS, DMS, FACTS, and HVDC in improving transmission and distribution efficiency.

UNIT 3	**SMART METERS AND ADVANCED METERING INFRASTRUCTURE**	**9**	**0**	**0**	**9**	**18**	**7,9,11,12,13**

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit (PMU) & their application for monitoring & protection. Demand side management and demand response programs, Demand pricing and Time of Use, Real Time Pricing, Peak Time Pricing.
Activity: Design a simple AMI system diagram including smart meters, communication network, and control centre, and explain its working.
Study applications of PMU for grid monitoring and protection using a case study from Power Grid Corporation of India Limited.

UNIT 4	**POWER QUALITY MANAGEMENT IN SMART GRID**	**9**	**0**	**0**	**9**	**18**	**7,9,11,12,13**

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.
Activity: Conduct a mini power quality audit for a building and identify issues like harmonics, voltage sag, and interruptions, and suggest corrective measures.

UNIT 5	**COMMUNICATION NETWORK FOR SMART GRID APPLICATIONS**	**9**	**0**	**0**	**9**	**18**	**7,9,11,13**

Architecture and Standards -Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), PLC, Zigbee, GSM, IP based Protocols, Basics of Web Service and CLOUD Computing, Cyber Security for Smart Grid.

Activity: Draw a communication architecture diagram of a smart grid showing HAN, LAN, WAN with technologies like ZigBee, PLC, GSM, and IP protocols.

COURSE OUTCOMES:

At the end of the course, the students will be able to:
CO1: Examine the challenges and benefits of smart grid.
CO2: Illustrate the different smart grid technologies.
CO3: Examine the necessity of smart meter and AMI.
CO4: Demonstrate the power quality management in Smart Grid.
CO5: Illustrate the different communication networks for smart grid applications

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Activities (40%) & Internal Examinations (60%)

REFERENCES:

1.	Stuart Borlase ,"Smart Grid: Infrastructure", Technology and Solutions', CRC Press 2017.
2.	Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications'" Wiley, 2012.
3.	Mini S. Thomas, John D McDonald, "Power System SCADA and Smart Grids", CRC Press,2015.
4.	Kenneth C.Budka, Jayant G. Deshpande, Marina Thottan, "Communication Networks for Smart Grids", Springer, 2014
5.	James Momoh,"Smart Grid Fundamentals of Design and Analysis", IEEE press, A John Wiley & Sons, Inc., Publication, 2012.

E-RESOURCES/E-MATERIALS:

1.	https://www.indiasmartgrid.org/
2.	https://smartgrid.ieee.org/
3.	https://www.nsgm.gov.in/

Mapping of Course Outcomes to Programme Outcomes

Course Outcomes	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	-	1	2	2	1
CO2	-	1	2	2	2	2
CO3	-	1	2	2	1	1
CO4	1	1	2	3	2	2
CO5	-	1	2	2	2	2
Average	**1**	**1**	**2**	**2**	**2**	**2**