JSS SCIENCE AND TECHNOLOGY UNIVERSITY
MYSURU

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

HANDBOOK

M.Tech in AUTOMOTIVE ELECTRONICS

JSS TECHNICAL INSTITUTIONS CAMPUS

MYSURU - 570 006

Dean Academic
JSS STU, Mysuru

2022-2024

Dean (Engg. & Tech.)
JSS Science & Technology University
MYSURU-570 006

Registrar
JSS Science & Technology University

About JSS Science and Technology University

JSS Science and Technology University is one of the recent additions to the institutions administered by JSS Mahavidyapeetha, and is the second University being established besides a Medical University at Mysuru. India's higher education system is on the verge of major reforms and JSS Science and Technology University has been established envisioning creating a bright future and a desired learner centric eco-system and transforming into a futuristic global University. The Availability of skilled human resources and trained technical manpower in engineering and technology is a major reason for growing investments in the state. In this context higher education system has a key role and more particularly JSS S&T U with an objective of transforming the students at all levels of higher education including research and innovation with measures to improve quality of workforce.

National Focus:

We will orient our efforts towards overall development of students, aligning our investments with our strategic priorities to cater to the Nations' Vision. We will streamline our systems and processes to make the most of our resources, and minimize bureaucracy.

Global reach:

We will broaden our efforts to meet the global needs of the larger world community with focused priorities including a multi-cultural community of students and staff and become a truly international university. We will prepare students for diversified technological environments worldwide, and develop international alliances and partnerships.

Multi-disciplinary approaches.

We will strategically provide encouragement to multi-disciplinary approaches by supporting and developing networks of students, faculty, and researchers worldwide. We will create world leading, multi-disciplinary, learning centers, research institutes that meet our Industries and funders' strategic needs.

The vision of JSS Science and Technology University is to be an effective instrument in enhancement of knowledge in the Society and thus the social transformation.

Our Strategic priority includes:

1. Prominent National Status
2. Quality Teaching & Learning
3. Research of International Repute
4. State of the art infrastructure of International Standard
5. Open access to knowledge through Distance Education
6. Collaborations & MOU

JSS Science and Technology University strategies to utilize the very best of education technology, optimize teaching methods, and encourage new inter-disciplinary research programs that help connect teaching and research, including applied and action research projects.

Vision of JSS Science and Technology University

1. **Advancing JSS S&T University as a leader in education, research, and technology on the international arena.**
2. **To provide the students a universal platform to launch their careers, vesting the industry and research community with skilled and professional workforce.**
3. **Accomplishing JSS S&T University as an epicentre for innovation, centre of excellence for research with state-of-the-art lab facilities.**
4. **Fostering an erudite, professional forum for researchers and industrialist to coexist and to work cohesively for the growth and development of science and technology for betterment of society.**

Mission of JSS Science and Technology University

1. **Education, research, and social outreach are the core doctrines of JSS S&T University that are responsible for accomplishment of in-depth knowledge base, professional skill and innovative technologies required to improve the socio-economic conditions of the country.**
2. **Our mission is to develop JSS S&T University as a global destination for cohesive learning of engineering, science and management which are strongly supported with interdisciplinary research and academia.**
3. **JSS S&T University is committed to provide world class amenities, infrastructural and technical support to the students, staff, researchers, and industrial partners to promote and protect innovations and technologies through patents and to enrich entrepreneurial endeavors.**
4. **JSS S&T University core mission is to create knowledge led economy through appropriate technologies, and to resolve societal problems by educational empowerment and ethics for better living.**

Vision of Sri Jayachamarajendra College of Engineering

Be an international leader in engineering education, research, and application of knowledge to benefit society globally.

Mission of Sri Jayachamarajendra College of Engineering

1. **To synergistically develop high-quality manpower and continue to stay competitive in tomorrow's world.**
2. **To foster and maintain mutually beneficial partnerships with our alumni, industry, state and central governments through public services assistance and collaborative research.**
3. **To create empower individuals with sense of identity.**

Vision of the Department of Electronics and Communication Engineering

Be a leader in providing globally acceptable education in electronics and communication engineering with emphasis on fundamentals-to-applications, creative-thinking, research and career-building.

Mission of the Department of Electronics and Communication Engineering

1. **To provide best infrastructure and up-to-date curriculum with a conducive learning environment.**
2. **To enable students to keep pace with emerging trends in Electronics and Communication Engineering.**
3. **To establish strong industry participation and encourage student entrepreneurship.**
4. **To promote socially relevant eco-friendly technologies and inculcate inclusive innovation activities.**

ABOUT THE DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

The department of Electronics and Communication Engineering was established in 1968. The department offers an undergraduate program in Electronics and Communication Engineering, three PG programs namely M.Tech in Industrial Electronics, M.Tech in Network and Internet Engineering and M.Tech in Automotive Electronics. In addition to these, it also offers M.Sc. Engineering by research and Ph.D. programs which provide a platform for bright graduates and postgraduates to conduct research in state-of-the-art technologies. The department is composed of well qualified teaching and technical staff with good retention.

The Department is also a recognized centre under the Quality Improvement Program (QIP) of the Government of India. The well-designed curriculum lays a strong foundation in both the analytical and technological aspects of Electronics and Communication Engineering. It also provides ample opportunities to students to work on mini-projects, develop communication skills, explore internship opportunities in industry and take part in national and international design contests like PACE, Aero-JC, cultural and sports activities etc.

The BE degree in Electronics and Communication Engineering at SJCE, JSSSTU is one of the most sought-after programs in the state and attracts top ranking students. It has a very good placement record and almost 100% of the eligible students get placement in top companies with a very good package. Department also encourages students to pursue higher studies and to become entrepreneurs. The department has a very active IEEE student chapter which organizes National level paper presentation competitions and other events such as Vacation Project Mania, Latex workshops, and mini project competitions, etc.

Apart from teaching, the department also guides UG and PG students for getting Internships at renowned Industries and premier Institutes like IISc, IIT's and NIT's, organizes Industrial visits, conducts expert lectures and workshops. The department also has special labs namely Nano Dielectric and devices lab, Visual TCAD and research lab and e-yantra lab which provides space for researchers to carry out experimental investigations and UG and PG students to implement project ideas.

Programmes offered:

UG Programme:

1. Bachelor of Engineering in Electronics and Communication Engineering: 4 years duration

PG Programme:

1. Master of Technology in Industrial Electronics: 2 Years duration
2. Master of Technology in Networking and Internet Engineering: 2 Years duration
3. Master of Technology in Automotive Electronics: 2 Years duration

Research Programme:

1. Doctoral Program
2. M.Sc. (Engineering) by research.

Department faculty Details:

Sl. No.	Name	Qualification	Area of specialization	Designation
1	Dr. Shankaraiah	Ph.D.	Wireless Communication and networking	Professor
2	Dr. Mahadevaswamy U B	Ph.D.	Wireless Sensor Networks, VLSI Circuits and Signal processing	Professor and Head
3	Dr. Gayathri S	Ph.D.	VLSI, Image and signal Processing	Associate Professor
4	Thyagaraja Murthy A	M.Tech	Communication & Networking	Associate Professor
5	Sujathakumari B A	M.Tech	Industrial Electronics	Associate Professor
6	Renuka B S	M.Tech	Industrial Electronics	Associate Professor
7	Dr. Rudraswamy S B	Ph.D.	Microelectronics and Nanotechnology	Assistant Professor
8	Halesh M R	M.Tech	Analog and Digital VLSI	Assistant Professor
9	Dr. SudharshanPatil Kulkarni	Ph.D.	Signals and system and Signal Processing	Professor
10	Dr. Veena M G	Ph.D.	Nano-Dielectric Materials & MEMS Sensors	Professor
11	Dr. Gayitri H M	Ph.D.	Nanotechnology	Associate Professor
12	Anitha S Prasad	M.Tech	Signal Processing and VLSI	Assistant Professor
13	Pavithra D R	M.Tech	Signal and digital image processing	Assistant Professor
14	Shivaprasad N	M.Tech	Nanoelectronics	Assistant Professor
15	Supreetha M	M.Tech	Digital Electronics	Assistant Professor

16	Puneeth K M	M.Tech	IoT and Mobile Computing	Assistant Professor
17	Eshwari A Madappa	M.Tech	Power Electronics	Assistant Professor
18	Yashwanth S D	M.Tech	Automotive Electronics	Assistant Professor
19	Vinay Prasad M S	M.Tech	Communication & Networking	Assistant Professor
20	KavyaShree M K	M.Tech	Digital electronics and Communication	Assistant Professor
21	Dr. Shashidhar R	Ph.D.	Signal Processing, VLSI and Embedded Systems	Assistant Professor
22	Chandrashekar Murthy B N	M.Tech	Digital Electronics and Communication	Assistant Professor
23	Praveen Kumar M S	M.Tech	VLSI Design, Microelectronics and Nanotechnology	Assistant Professor
24	Anupama S	M.Tech	Computer Network and Engineering	Assistant Professor
25	Madhu Sudan M P	M.Tech	Biomedical Signal Processing and Instrumentation	Assistant Professor
26	Megha K M	M.Tech	Digital communication and networking	Assistant Professor
27	Rakesh M D	M.Tech	VLSI Design and Embedded Systems	Assistant Professor
28	Rohith M N	M.Tech, MBA	Digital Electronics and Communication Systems	Assistant Professor
29	Priyanka D S	M.Tech	Networking and Internet Engineering	Assistant Professor
30	Roopa M	M.Tech	Computer Networks and Engineering	Assistant Professor
31	Dr. Rakshith B	Ph.D.	VLSI Design and Embedded Systems	Assistant Professor

Laboratory facilities:

Sl No	Name of the Lab	Major facility
1	E-Yantra Lab	FireBird-V3 Robot, Robotics Atmega - 16A platform, Robotics Atmega - 2600 platform, Servo motor-based gripper kit, programmable 32-bit ARM 9 Robotic platform, Robotic arm, depth sensor camera with adapter.
2	Networking and Simulation Lab	Computers, switches, routers, WIFI access, Exata simulator
3	Automotive Controls Lab	dSpace, computers, Power Supplies, CRO.
4	Power Electronics Lab	CRO, Power supplies, multimeters, motors, Choppers, Inverters.
5	Communication Lab	CRO, LCR meter, Spectrum Analyzer, Power Supplies breadboards, Active and Passive Components Digital Storage Oscilloscopes.
6	VLSI and DSP Lab	Computers, Cadence, TCAD software, ARM, MSP, FPGA/CPLD, DSP boards.
7	Nano dielectrics & Devices Lab	Spin coater, Megohmmeter, Electrospinning Espinnano, HV tester, analytical balance, inclined plane tracking, Vacuum Oven, Contact angle meter.
8	Data Sciences and Machine Learning facility (Central Computing facility)	10 High end client systems, 1 PARAM-SHAVAK C-DAC Server. Systems preloaded with software for deep learning and high-performance computing.

Power Electronics Lab

Automotive Electronics Lab

E-Yantra Lab - Robotics and Embedded Systems Labs

Structure of Board of Studies:

Sl. No.	Category	Designation	Name of the Person	
1.	The Dean(s) of the faculties	Ex-Officio Members	Dr. S B Kivade Principal, SJCE Mysore.	
2.	Dean (Academics)	Ex-Officio Members	Dr. B Manoj Kumar Professor, Dept of Environmental, Dean (Academics), JSS STU	
3.	Head of the Department	Chairperson	Dr. U B Mahadevaswamy Professor and Head, Department of E&C, SJCE-JSSSTU, Mysuru	
4.	All Professors of the Department	Members	1.	Dr. Shankaraiah N
			2.	Dr. Sudarshan Patil Kulkarni
			3.	Dr. M G Veena
5.	Two Senior Associate Professors of the concerned Department by Rotation	Members	1.	Dr S. Gayathri
			2.	Renuka B S
6.	One Senior Assistant Professor of the concerned Department by Rotation	Member	1.	Dr. Rudraswamy S B
7.	One external Subject Expert from any reputed academic/Research Institution/other universities Nominated by the Academic council	Members	1.	Dr. Hariprasad S A. Designation: Director - Faculty of Engineering and Technology Jain (Deemed-to-be University), Bengaluru-560069
			2.	Dr Ravish Aradya H V, Professor & Head, Department of Electronics and Communication Engineering, RVCE, Bengaluru -560059
8.	One external Subject Expert from any reputed academic/Research Institution/other universities Nominated by the vice Chancellor upon recommendation by the Dean of Respective Faculty	Members	1.	Dr. Sushil Kumar Pandey Assistant Professor, Department of ECE, NITK, Surathkal - 575 025
			2.	Dr. P. C. Srikanth Professor & Head, Dean Planning &Development, MCE Hassan-573202.
9.	Two external Members from Concerned Industry/Government Departments/Public sectors	Members	1.	Mr. Raghavendra B R Domain Manager, Intel, Bengaluru – 560103

	undertakings/allied area relating to placement, nominated by the academic council upon recommendation by the Dean of respective faculty		2.	Mr. Venkatasubramanian B Senior Systems Architect, Distinguished Member of Technical Staff (DMTS) at Nokia, Bengaluru – 560045
			3.	Dr. T Shreekanth Project Manager - Automotive, L&T Technology Services, Mysore.
10.	One postgraduate meritorious alumnus, to be nominated by the Head of the Department	Member	1.	Dr. Parameshwara S. Associate Professor & HoD, Dept. of Electronics & Communication Engineering, National Institute of Engineering, Mysuru. 570008
11.	The chairperson, Board of studies, may with the approval of the vice chancellor, co-opt as members: a) One external Subject Expert from reputed academic/Research Institution/other universities/industry/Government Departments/Public Sector undertakings, whenever special Courses of studies or to be formulated. b) Two other members of faculty of the concerned department.	Members	1.	Dr. Basavaraj Talawar Assistant Professors, Dept of CSE, NITK, Surathkal - 575 025
			2.	Dr. Suresh K V Professor, Dept. of Electronics & Communication Engineering Siddaganga Institute of Technology, Tumkur– 572103
			1.	B. A. Sujatha Kumari Associate Professor E&C Dept. SJCE-JSSSTU
			1.	A. Thyagaraja Murthy Associate Professor E&C Dept. SJCE-JSSSTU

M. Tech. Program Structure 2022-23

Scheme of Teaching and Examination for I to IV semester

Semester	Credits
I	27
II	27
III	10
IV	16
TOTAL	**80**

Credit Pattern

Semester	Type of Course	Number	Credits
I	Professional Core Professional Elective Professional Core Laboratory Mini Project with Seminar/ Lab	04 02 01 01	16 credits 08 credits 1.5 credits 1.5 credits **Sub Total = 27 credits**
II	Professional Core Professional Elective Open Elective Research Methodology and IPR Professional Core Laboratory	03 02 01 01 01	12 credits 08 credits 04 credits 1.5 credits 1.5 credits **Sub Total = 27 credits**
III	Internship/ Industrial Training Project work (Phase 1)	01 01	04 credits 06 credits **Sub Total = 10 credits**
IV	Project work (Phase 2)	01	**16 credits**
TOTAL			**80 credits**

Grading System

Marks	Grade
90 – 100	**S**
75 – 89	**A**
66 – 74	**B**
56 – 65	**C**
50 – 55	**D**
45 – 49	**E**
< 45	**F**

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Semester Wise Credits

Semester	Credits	Total Marks
I	27	700
II	27	700
III	10	100
IV	16	300
Total	**80**	**1800**

Notation in the Scheme

CIE	**Continuous Internal Evaluation**
SEE	**Semester End Examination**
L	**Lecture**
T	**Tutorial**
P	**Practical**

Programme Outcomes:

PO1: Research skills: An ability to independently carry out research/investigation and development work to solve practical problems.

PO2: Presentation Skills: An ability to write and present a substantial technical report/ document.

PO3: Domain-specific knowledge: An ability to demonstrate a degree of mastery in the field of Automotive electronics.

PO4: Engineering solution: Analyse the problem, design, and demonstrate solutions in the area of automotive techniques, control, and computing systems.

PO5: Modern tools usage: Investigate real-time automotive problems and provide solutions using modern tools.

PO6: Life-long learning: Create an ability to address multidisciplinary research challenges and develop skills for management and entrepreneurship, adhering to ethics.

Programme Educational Objectives:

PEO1: To empower graduates to formulate, analyze, design, and provide innovative solutions in the field of automotive and controls engineering for real life problems.

PEO2: To ensure that graduates have adequate exposure to research and emerging technologies through industry interaction

PEO3: To enable graduates to pursue successful professional career with ethics and social responsibilities of the engineering profession.

Quality Policy

The Department of Electronics and Communication Engineering is committed to provide highest quality education and training in the field of higher education

1. To inculcate moral and ethical values among the students and the staff.
2. To provide a sound academic and research environment to students for a complete learning experience.
3. To develop strong Industry-Institute –Interaction to enrich the teaching learning process and exploring career opportunities for students.
4. To train and develop faculty members for imparting quality education, to satisfy the industrial and societal needs of the aspirants
5. Implementation of feedback responses from the stakeholders on quality related processes in curriculum enhancement.
6. Enhancing skillset in the identified thrust areas of the department.

JSS MAHAVIDYAPEETHA

JSS SCIENCE AND TECHNOLOGY UNIVERSITY

SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING, MYSURU

Scheme of Teaching and Examination 2022-23

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

M. Tech. AUTOMOTIVE ELECTRONICS PROGRAM

SEMESTER I

Sl. No.	Code	Course Title	Course	Teaching Hours per Week				Credits	Examination			
				L	T	P/ S/ SDA	Total Contact Hours		CIE	SEE	Total Marks	Duration in Hours
1	22PAE110	Hybrid and Electric Vehicles	PCC 1	4	0	0	4	4	40	60	100	3
2	22PAE120	Digital Control Systems	PCC 2	3	2	0	5	4	40	60	100	3
3	22PAE130	Linear Algebra	PCC 3	3	2	0	5	4	40	60	100	3
4	22PAE140	Advanced Embedded Systems	PCC 4	4	0	0	4	4	40	60	100	3
5	22PAE15X	Professional Elective 1	PEC 1	4	0	0	4	4	40	60	100	3
6	22PAE16X	Professional Elective 2	PEC 2	4	0	0	4	4	40	60	100	3
7	22PAE170L	Digital Control Systems Lab	PCCL	0	0	3	3	1.5	50	-	50	-
8	22PAE180	Design and implementation Lab	Mini Project with Seminar (MPS)/ Lab (PCCL)	0	0	3	3	1.5	50	-	50	-
TOTAL								27	340	360	700	

Note: L: Lecture/ Theory; T: Tutorial; P: Integrated Practical/ Practice; S: Seminar; SDA: Skill Development Activities PCC: Professional Core Course; PEC: Professional Elective Course; PCCL: Professional Core Course Laboratory; MPS: Mini Project with Seminar

Professional Elective 1	
Course Code	Course Title
22PAE151	Automotive Sensors and Actuators
22PAE152	Battery Technology
22PAE153	Robotics and Industrial Automation

Professional Elective 2	
Course Code	Course Title
22PAE161	Design of Mechanical Systems
22PAE162	Vehicle Body Engineering and Safety
22PAE163	Agile Manufacturing

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Scheme of Teaching and Examination 2022-23

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

M. Tech. AUTOMOTIVE ELECTRONICS PROGRAM

SEMESTER II

Sl. No.	Code	Course Title	Course	Teaching Hours per Week				Credits	Examination			
				L	T	P/ S/ SDA	Total Contact Hours		CIE	SEE	Total Marks	Duration in hours
1	22PAE210	Autotronics	PCC 5	4	0	0	0	4	40	60	100	3
2	22PAE220	Automotive Instrumentation	PCC 6	3	2	0	5	4	40	60	100	3
3	22PAE230	Automotive Networking	PCC 7	3	2	0	5	4	40	60	100	3
4	22PAE24X	Professional Elective 3	PEC 3	4	0	0	4	4	40	60	100	3
5	22PAE25X	Professional Elective 4	PEC 4	4	0	0	4	4	40	60	100	3
6	22PAE26OE	Open Elective	OEC	4	0	0	4	4	40	60	100	3
7	22PAE270	Research Methodology and IPR	MC	2	0	0	2	1.5	50	-	50	-
8	22PAE280L	Automotive Embedded Systems Lab	PCCL	0	0	3	3	1.5	50	-	50	-
TOTAL								27	340	360	700	

Note: L: Lecture/ Theory; T: Tutorial; P: Integrated Practical/ Practice; S: Seminar; SDA: Skill Development Activities
PCC: Professional Core Course; PEC: Professional Elective Course; OEC: Open Elective Course; MC: Mandatory Course; PCCL: Professional Core Course Laboratory

Professional Elective 3	
Course Code	Course Title
22PAE241	Automotive Electrical and Electronic system
22PAE242	Machine learning
22PAE243	Automotive Cybersecurity

Professional Elective 4	
Course Code	Course Title
22PAE251	Vehicle Engineering
22PAE252	Automotive Materials
22PAE253	Drives and control systems for automation

Professional Open Elective	
Course Code	Course Title
22PAE26OE	Nano Dielectrics
22PIE26OE	Deep Learning for Speech Processing
22PNI26OE	Advanced Wireless Technology

M. Tech. AUTOMOTIVE ELECTRONICS PROGRAM

SEMESTER III

Sl. No.	Code	Course Title	Course	Teaching Hours				Credits	Examination			
				L	T	P/ S/ SDA	Total Contact Hours		CIE	SEE	Total Marks	Duration in hours
1	22PAE310P	Internship/ Industrial Training	INT	Minimum 08 weeks* commencing from intervening vacation of II and III semesters				4	50	-	50	-
2	22PAE320P	Project Work (Phase-1)	PROJ	-	-	12 weeks**	12 weeks**	6	50	-	50	-
TOTAL								10	100		100	

Note: L: Lecture/ Theory; T: Tutorial; P: Integrated Practical/ Practice; S: Seminar; SDA: Skill Development Activities
INT: Internship/ Industrial Training; PROJ: Project Work

***22PAE310P - 42hrs/ weeks = (40 hours / week in Industry + 2 hours / week in college)**
****22PAE320P - 12 Weeks: 40 Hours / week**

SEMESTER IV

Sl. No.	Code	Course Title	Contact hours	Total credits	CIE	SEE	Total Marks	Exam Duration in hours
1	22PAE410P	Project Work (Phase-2)	22 weeks***	16	100	200	300	3
Total				16				

*****22PAE410P - 22 Weeks: 40 Hours / week**

Detailed Syllabus

First Semester

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 110**	*Total Credits*	**4**	*Course Type*	*Professional Core Course*		
Course Title	**HYBRID AND ELECTRIC VEHICLES**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**52**	**4**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	**0**	**0**	*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	**52**	**4**	*Minimum Marks*	*20 marks*	*25 marks*	*45 Marks*

Course Prerequisite: Basic concepts of Power Electronics

Course Objective:

1. To understand about the history, various architecture and working of hybrid and electric vehicles
2. To explain the energy sources for hybrid and electric vehicles

Course Outcomes (COs): After completing this course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Explain the knowledge of fundamental concepts, principles, and history of Hybrid and Electric vehicles.	L2
CO2	Analyse various architectures and Electrical Machines of Hybrid and Electric Vehicles.	L3
CO3	Asses the energy storage systems and alternate energy sources for vehicle propulsion.	L3
CO4	Carry out the task individually making use of simulation and analytical tools, document and give an effective presentation.	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours	
		Lecture	Tutorial
1	**Introduction to Hybrid Electric Vehicles:** History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy	**10**	**0**

	supplies. **Conventional Vehicles:** Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance.		
2	**Hybrid Electric Drive-trains:** Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. **Electric Drive-trains:** Basic concept of electric traction, introduction to various electric drive- train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.	**12**	**0**
3	**Electric Propulsion unit:** Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.	**10**	**0**
4	**Energy Storage:** Batteries in Electric and Hybrid Vehicles, Battery Basics and Parameters, Electrochemical Cell Fundamentals - electrochemical reactions, thermodynamic voltage, specific energy, specific power, energy efficiency, Traction Batteries - lead acid batteries, nickel-based batteries, lithium-based batteries, and Ultra-capacitors.	**10**	**0**
5	**Alternative and Novel Energy Sources and Stores:** Solar Photovoltaic, Flywheels, and Fuel Cells - Hydrogen Fuel Cells, Fuel Cell Thermodynamics, Hydrogen storage system	**10**	**0**

Text Books:

1. Iqbal Hussein, " Electric and Hybrid Vehicles: Design Fundamentals," 3rd edition, CRC Press, 2021.
2. Mehrdad Ehsani, Yimi Gao, Stefano Longo, Kambiz Ebrahimi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design," 3rd edition CRC Press, 2018.
3. James Larminie, John Lowry, "Electric Vehicle Technology Explained," 2nd edition, Wiley, 2012.

Reference Books:

1. Tom Denton, " Electric and Hybrid Vehicles," 2nd edition, Taylor and Francis, 2020.

SWAYAM/NPTEL:

1. https://nptel.ac.in/courses/108106170

Self-Learning Exercises:

1. Case Study projects
2. Mini Projects

Course Articulation:

COURSE OUTCOMES↓	PROGRAM OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1				3		
CO2			2	3		
CO3			2	3		
CO4	2	2	3	3	3	2

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 120**	*Total Credits*	**4**	*Course Type*	*Professional Core Course*		
Course Title	**DIGITAL CONTROL SYSTEMS**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**39**	**3**		**CIE**	**SEE**	**Total**
	Tutorial	**26**	**1**	*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	**0**	**0**	*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	**65**	**4**	*Minimum Marks*	*20 marks*	*25 marks*	*45 Marks*

Course Prerequisite: Analog Control Systems, Calculus, Linear Algebra

Course Objective:

1. To introduce students to digital control systems fundamentals.
2. To develop design techniques for digital controllers for both transfer function and state space models.

COURSE OUTCOMES (COs): After completing this course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Analyze discrete time signals and systems using z-transforms	L4
CO2	Analyze discrete time systems and its properties using transfer function and state-space model	L4
CO3	Design digital controllers for transfer function and state-space models.	L6
CO4	Simulate and validate the design of digital control systems using modern tools and present the results.	L6

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 – Create

Course Content / Syllabus:

UNIT No.	Content	Hours	
		Lecture	Tutorial
1	Basic digital control systems, examples of digital control systems, revision of Laplace and Z-Transforms, sampling, ideal sampler, evaluation of F*(S), properties of F*(S), zero order hold, first order hold, Z-transform properties, inverse Z-Transform methods, solution of difference equations, mapping from S-Plane to Z-Plane.	**8**	**5**

2	Open loop discrete time systems with and without zero order hold, pulse transfer function of interconnected sampled data systems, closed loop systems, transfer function using signal flow graph and block diagram reduction, system time response, system characteristic equation, steady state error. State-space model of sampled data system, state solution of discrete time system.	**8**	**5**
3	BIBO Stability definition, theorems, Routh-Hurwitz and Jury's stability tests, stability analysis using root locus technique, stability analysis in frequency domain; Bode plot and Nyquist's plot	**8**	**5**
4	Design of Digital Controllers Indirect Method: Design of PI, PID, Phase-lead controllers. Design of Digital Controller Direct method: Ragazzini's method, Realizability of digital controllers, dead beat controllers	**8**	**5**
5	Controllability and Observability of SS models, State Variable Feedback for Discrete Time systems, Pole-placement design, State observers, closed-loop observer design, Combined system of controller and observer.	**7**	**6**

Text Books:

1. M. Gopal, "Digital Control and State Variable Methods," Mc Graw Hill India, 2012

Reference Books:

1. Charles L. Phillips, H. Troy Nagle, Aranya Chakraborthy, "Digital Control Systems, Analysis and Design," 4th Edition, McGraw Hill, 2014.
2. Gene F. Franklin, J. David Powell and Michael Workman, "Digital Control of Dynamic Systems," 3rd Edition, Ellis-Kagle Press, 2006.

Journals/Magazines:

1. IEEE Transaction on Automatic Control

Web/Digital resources:

https://www.youtube.com/watch?v=Ruxce-EdXzo&list=PLCPLSoBCDMT9oasGriNX3gPL4u2btKp_E

https://www.mathworks.com/products/control.html

SWAYAM/NPTEL:

https://nptel.ac.in/courses/108103008

PRACTICE BASED LEARNING:

No	Topics to be covered	Tools and Techniques	Expected Skill/Ability
1	Step response of DT systems	MATLAB	Numerical computing and simulation
2	Root-locus for DT system	MATLAB	Numerical computing and simulation
3	Digital controller design	MATLAB	Numerical computing and simulation
4	State Variable feedback design	MATLAB	Numerical computing and simulation

Self-Learning Exercises:

1. Case Study projects
2. Mini Projects

Course Articulation:

COURSE OUTCOME	PROGRAM OUTCOME					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1		2	3			
CO2		2	3	3		
CO3		2	3	3		
CO4	3	3	3	3	3	2

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 130**	*Total Credits*	**4**	*Course Type*	*Professional Core Course*		
Course Title	**LINEAR ALGEBRA**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**39**	**3**		**CIE**	**SEE**	**Total**
	Tutorial	**26**	**1**	*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	**0**	**0**	*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	**65**	**4**	*Minimum Marks*	*20 marks*	*25 marks*	*45 Marks*

Course Prerequisite: Basic concepts of calculus

Course Objective:

1. To understand about the theory of systems of linear equations
2. To explain linear equation transformations for real time applications.

Course Outcomes (COs): After completing this course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Solve systems of linear equations and homogeneous systems of linear equations by different methods	L3
CO2	Obtain solutions for signal processing applications using vector space concepts	L3
CO3	Analyze the concept of a linear transformation as a mapping from one vector space to another.	L3
CO4	Apply the concepts of factorization, SVD and Optimization to formulate and solve engineering problems.	L4
CO5	Carry out the task individually making use of simulation and analytical tools, document and give an effective presentation.	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours	
		Lecture	Tutorial
1	**Linear equations:** Fields, system of linear equations, and its solution sets, elementary row operations and echelon forms, matrix operations, invertible matrices, LU-factorization. **Vector spaces:** Vector spaces, subspaces, bases and dimension,	**8**	**5**

	coordinates, summary of row- equivalence, computations concerning subspaces.		
2	**Linear Transformations:** Algebra of linear transformations, singular and nonsingular linear transformation, isomorphism, representation of transformations by matrices, linear functions, transpose of a linear transformation.	**8**	**5**
3	**Canonical Forms:** Characteristic values, annihilating polynomials, invariant subspaces, direct- sum decompositions, invariant direct sums, primary decomposition theorem, cyclic bases, Jordan canonical form, Iterative estimates of characteristic values.	**8**	**5**
4	**Inner Product Spaces:** Inner products, inner product spaces, Cauchy – Schwartz Inequality, applications, orthogonality, orthogonal sets and projections, Gram-Schmidt process, QR-factorization.	**8**	**5**
5	**Symmetric Matrices and Quadratic Forms:** Digitalization, quadratic forms, singular value decomposition.	**7**	**6**

Text Books:

1. Gilbert Strang, "Linear Algebra and its Applications," 4th Edition, Cengage India Private Limited, 2005.
2. Kenneth Hoffman and Ray Kunze, "Linear Algebra," 2nd Edition, Pearson Education (Asia) Pvt. Ltd/ Prentice Hall of India, 2004.
3. David C. Lay, "Linear Algebra and its Applications," 5th Edition, Pearson Education (Asia) Pvt. Ltd, 2015.

Reference Books:

1. S. K. Jain and A. D. Gunawardena, "Linear Algebra, An Interactive Approach," Thomson, Brooks/Cole, 2004.
2. Bernard Kolman and David R. Hill, "Introductory Linear Algebra with Applications," Pearson Education (Asia) Pvt. Ltd, 7th edition, 2003.

SWAYAM/NPTEL:

1. https://nptel.ac.in/courses/111106051
2. https://nptel.ac.in/courses/111104137

Self-Learning Exercises:

1. Case Study projects
2. Mini Projects

Course Articulation:

COURSE OUTCOMES↓	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1				3		
CO2				3		
CO3				3	2	
CO4				3	2	
CO5	3	2	2	3	3	2

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 140**	*Total Credits*	**4**	*Course Type*	*Professional Core Course*		
Course Title	**ADVANCED EMBEDDED SYSTEMS**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**52**	**4**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	**0**	**0**	*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	**52**	**4**	*Minimum Marks*	*20 marks*	*25 marks*	*45 Marks*

Course Prerequisite: Fundamentals of embedded systems

Course Objective:

1. Understand the basic hardware components and their selection method based on the characteristics and attributes of an embedded system.
2. Describe the hardware software co-design and firmware design approaches
3. Explain the architectural features of ARM CORTEX M3, a 32-bit microcontroller including memory map, interrupts and exceptions.

Course Outcomes (COs): After completing this course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Explain the basic hardware components and their selection method based on the characteristics and attributes of an embedded system.	L2
CO2	Analyse the hardware software co-design and firmware design approaches.	L3
CO3	Explain the importance of the architectural features of ARM CORTEX M3 in embedded systems	L4
CO4	Relate the knowledge of Real-Time Operating System (RTOS) in Embedded System Design and Development Environment	L3

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours	
		Lecture	Tutorial
1	**Typical Embedded System:** Core of the Embedded System, Embedded vs General computing system, classification, application and purpose of ES. Memory, Sensors and Actuators, Communication Interface, Embedded Firmware, Other System Components	10	0
2	**Characteristics and Quality Attributes of Embedded Systems:** Hardware Software Co- Design and Program Modeling: Fundamental Issues in Hardware Software Co-Design, Computational Models in Embedded Design, Introduction to Unified Modeling Language, Hardware Software Trade-offs. Files generated during compilation, simulators, emulators and debugging	10	0
3	**Embedded Hardware Design and Development:** EDA Tools, How to Use EDA Tool, Schematic Design – Place wire, Bus, port, junction, creating part numbers, Design Rules check, Bill of materials, Netlist creation, PCB Layout Design – Building blocks, Component placement, PCB track routing.	10	0
4	**ARM -32 bit Microcontroller family and Embedded Firmware Design and Development:** Architecture of ARM Cortex M3 – General Purpose Registers, Stack Pointer, Link Register, Program Counter, Special Register, Nested Vector Interrupt Controller. Interrupt behavior of ARM Cortex M3. Exceptions Programming. Advanced Programming Features. Memory Protection. Debug Architecture. Embedded Firmware Design Approaches, Embedded Firmware Development Languages	12	0
5	**Real-Time Operating System (RTOS) based Embedded System Design and Development Environment:** Operating System Basics, Types of OS, Tasks, Process and Threads, Multiprocessing and Multitasking, Task Scheduling, Threads, Processes and Scheduling: Putting them altogether, Task Communication, Task Synchronization, Device Drivers, How to Choose an RTOS The Integrated Development Environment (IDE), Types of Files Generated on Cross compilation, Disassembler/ELDompiler, Simulators, Emulators and Debugging, Target Hardware Debugging, Boundary Scan.	10	0

Text Books:

1. Shibu K V, "Introduction to Embedded Systems," Tata McGraw Hill Education Private Limited, 2009
2. Joseph Yiu, "The Definitive Guide to the ARM Cortex-M3," Newnes, (Elsevier),2008.

Reference Books:

1. James K Peckol, "Embedded Systems – A contemporary Design Tool", John Weily, 2008.

Journals/Magazines:

1. https://www.inderscience.com/jhome.php?jcode=ijes

Web/Digital resources:

1. https://www.embedded.com/
2. https://www.techtarget.com/iotagenda/definition/embedded-system

SWAYAM/NPTEL:

1. https://in.coursera.org/courses?query=embedded%20systems
2. https://www.arm.com/resources/education/online-courses/efficient-embedded-systems

Practice Based Learning:

No	Topics to be covered	Tools and Techniques	Expected Skill /Ability
1	Simulation (Mini Projects)	Open-Source Tools	Programming

Self-Learning Exercises:

1. Case Study projects
2. Mini Projects

Course Articulation:

COURSE OUTCOMES↓	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1				3		
CO2				3		
CO3				3	2	
CO4		2	2	3	3	

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 151**	*Total Credits*	**4**	*Course Type*	*Professional Elective Course*		
Course Title	**AUTOMOTIVE SENSORS AND ACTUATORS**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**52**	**4**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	**0**	**0**	*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	**52**	**4**	*Minimum Marks*	*20 marks*	*25 marks*	*45 Marks*

Course Prerequisite: Basic structure of an automobile, Basic physics for sensor principle.

Course Objective:

1. Understand the sensor measuring principle.
2. Explain the working of different automotive sensors.
3. Skill to evaluate sensors for different automotive applications.
4. Explain the different actuators principles with their working.

COURSE OUTCOMES (COs): After completing this course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Explain the basic measuring principles of automotive sensors.	L2
CO2	Analyze the application of sensor measuring principles for automotive application.	L3
CO3	Outline the measuring principles and working of different types of actuators for automotive domain.	L3
CO4	Illustrate the applications on electric actuators for automobile.	L3
CO5	Develop a sensor model for automotive application using modern simulation tool through individual project and give oral presentation with Documentation.	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 – Create

Course Content / Syllabus:

UNIT No.	Content	Hours	
		Lecture	Tutorial
1	**Automotive Sensors:** Basics and overview, Automotive applications, Details of the sensor market, Features of vehicle sensors, Sensor classification, Error types and tolerance requirements, Reliability, Main requirements, trends, Overview of the physical effects, Overview and selection of sensor technologies **Sensor Measuring Principles:** Position sensors, Speed and rpm sensors, Acceleration sensors, Pressure sensors, Force and torque sensors,	**11**	**0**

	Flowmeters, Gas sensors and concentration sensors, Temperature sensors, Imaging sensors (video).		
2	**Automotive Sensor Types:** Engine-speed sensors, Hall phase sensors, Speed sensors for transmission control, Wheel-speed sensors, Micromechanical yaw-rate sensors, Piezoelectric "tuning-fork", yaw-rate sensor, Micromechanical pressure sensors, High-pressure sensors, Temperature sensors, Accelerator-pedal sensors, Steering-angle sensors, Position sensors for transmission control, Axle sensors, Hot-film air-mass meters, Piezoelectric knock sensors, SMM acceleration sensors, Micromechanical bulk silicon, acceleration sensors, Piezoelectric acceleration sensors, iBolt™ force sensor, Torque sensor, Rain/light sensor, Two-step Lambda oxygen sensors,LSU4 planar wide-band lambda oxygen sensor.	**11**	**0**
3	**Varied Types of Actuators:** Pneumatic actuators, types of pneumatic actuators, hydraulic cylinder, operation, parts of hydraulic cylinder, hydraulic cylinder design, special hydraulic cylinder, hydraulic motor types, linear actuators, types, piezo electric actuators, telescopic liner actuator, plasma actuator, rotary actuator.	**10**	**0**
4	**Actuators Technologies and Devices:** Pneumatic motor, pneumatic cylinder, hydraulic press, jackscrew, hoist, electroactive polymers, roller screw, MEMS magnetic actuators, Fluidics, Fluidic Components, Logic Components, Fluidic Motion Sensors, Fluidic Amplifiers, Fluidic Control Systems, Interfacing Considerations, Modular Laminated Construction, Applications of Fluidics.	**10**	**0**
5	**Electric Actuators:** Electromechanical actuators, Fluid-mechanical actuators, Electrical machines, Electrohydraulic Actuators, Application and Function, Requirements, Design and Operating Concept, Actuator Types, Simulations in Development.	**10**	**0**

Text Books:

1. Konrad Reif, "Automotive Mechatronics: Automotive Networking, Driving Stability Systems, Electronics", Bosch Professional Automotive Information, Springer Fachmedien Wiesbaden, 2015.
2. Princeton Brown, "Sensors and Actuators: Technology and Applications", Library Press, 2017.

Reference Books:

1. Andrzej M Pawlak, "Sensors and Actuators in Mechatronics Design and Applications," 1st Edition, CRC Press; July 28, 2006.
2. Clarence W. de Silva, "Sensors and Actuators: Engineering System Instrumentation," 2nd Edition, CRC Press, 2016.

Journals/Magazines:

1. https://ieeexplore.ieee.org/document/983469
2. https://www.mdpi.com/journal/sensors/special_issues/roadsafety
3. https://iopscience.iop.org/article/10.1088/1742-6596/76/1/012001

Web/Digital resources:

1. https://www.youtube.com/watch?v=R5YfLySWQAc
2. https://www.youtube.com/watch?v=Y18LabELpx4
3. https://blog.bosch-si.com/
4. https://www.youtube.com/watch?v=dK4mb1yS0dY
5. https://www.youtube.com/watch?v=8e4QB1DYYJU

SWAYAM/NPTEL:

1. https://onlinecourses.nptel.ac.in/noc21_ee32/preview
2. http://digimat.in/nptel/courses/video/108108147/L01.html

Practice Based Learning:

No.	Topics to be covered	Tools and Techniques	Expected Skill /Ability
1.	Simulation of sensors/ actuator working in automotive system	Open-source tool	Logical Thinking

Self-Learning Exercises:

1. Case Study projects
2. Mini Projects

Course Articulation:

COURSE OUTCOMES↓	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1			2			
CO2			2			
CO3			2	2		
CO4			3	2		
CO5	3	3	3	3	3	

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 152**	*Total Credits*	**4**	*Course Type*	*Professional Elective Course*		
Course Title	**BATTERY TECHNOLOGY**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**52**	**4**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	**0**	**0**	*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	**52**	**4**	*Minimum Marks*	*20 marks*	*25 marks*	*45 Marks*

Course Prerequisite: Knowledge in Chemistry, Physics and Mathematics

Course Objective:

1. To explain the diversity of applications for secondary batteries and the main characteristics required of them in terms of storage.
2. Fundamentals of electrochemical energy storage considering the operation and design of various battery technologies.

Course Outcomes (COs): After completing this course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Explain the underlying principles of the different battery chemistries	L2
CO2	Analyze the key parameters used to characterize battery technologies	L3
CO3	Apply knowledge of key performance parameters to select an appropriate battery chemistry for automotive application	L3
CO4	Outline the requirements of battery systems for automotive applications and understand the modelling of different battery systems	L3
CO5	Simulate the battery operation using modern simulation tool through individual project and give oral presentation with Documentation.	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 – Create

Course Content / Syllabus:

UNIT No.	Content	Hours	
		Lecture	**Tutorial**
1	History of Vehicle Electrification, The History of the Modern Storage Battery, An Electrical Industry Emerges, Early Electric Vehicle Development, Modern Vehicle Electrification, Basic Terminology, Vehicle and Industry Terms, Stationery and Grid Terminology, Battery Terms, Battery Pack Design Criteria and Selection, Ohm's Law and Basic Battery Calculations, Converting Customer Requirements into Pack Designs, Power to Energy Ratios, Large Stationery and Grid Systems	**11**	**0**

2	Introduction - Galvanic Cells, Types of Batteries, Energy Conversion in Batteries, Battery Components, Principle of Operation, Electrode Selection, Calculating Battery Cell Voltage, Battery Cell Voltage and Nernst Equation, Electrolyte for Batteries, Gibbs-Free Energy and Battery Voltage, Theoretical Battery Capacity, Practical Energy of a Battery, Specific Energy and Power, Battery Testing, Operational Factors of Battery Systems Performance Parameters - Battery Voltage, Secondary Battery Systems, Battery-Limiting Factors, Battery Current, Modes of Discharge, Discharge Current Effect on Voltage, Discharge Current Effect on Capacity, The Effect of Temperature on Battery Performance, Self-Discharge, Calendar and Cycle Life, Internal Resistance, Safety, Battery Selection	**11**	**0**
3	Lead–Acid Batteries - Overview and Characteristics, Principle of Operation, Types of Lead–Acid Batteries, Cell Components and Fabrication, Failure Modes, Charge Process, Discharge Process, Electrolyte, State of Charge, Cycle Life, Self-Discharge. Nickel–Cadmium Batteries - Overview and Characteristics, Principle of Operation, Reactions During Overcharge, Voltage During Charge and Discharge, Charge, Discharge, Effect of Temperature on Discharge, Polarity Reversal, Cycle Life, Self-Discharge, Memory Effect, Cell Components and Failure Modes.	**10**	**0**
4	Nickel–Metal Hydride Batteries - Introduction, Principle of Operation, Negative Electrode, Charge. Lithium Batteries - Introduction, Early Lithium Batteries: Li Metal, Current Lithium Batteries (Li–Ion), Future Lithium System (Li–Air and Li–S), Cell Components and Fabrication, Charging, Discharge, Cycle Life, Self-Discharge, Operational Challenges	**10**	**0**
5	Energy Storage by Means of Supercapacitors, General Characteristics on Supercapacitors, Modeling Supercapacitors, Design of a Super capacitive Bank, Charging and Discharging Procedure of Supercapacitors, Design Example of a Super capacitive Bank, Power Electronics Converters, Application Examples	**10**	**0**

Text Books:

1. Slobodan Petrovic, "Battery Technology Crash Course: A Concise Introduction," Springer, 2021.
2. Alfred Rufer, "Energy Storage Systems and Components," CRC Press, Taylor & Francis Group, 2018

Reference Books:

1. John Warner, "The Handbook of Lithium-Ion Battery Pack Design Chemistry, Components, Types and Terminology," Elsevier, 2015
2. Bruno Scrosati, Jürgen Garche and Werner Tillmetz, "Advances in Battery Technologies for Electric Vehicles," Elsevier, 2015.

Journals/Magazines:

1. https://www.mdpi.com/journal/batteries
2. https://www.sciencedirect.com/journal/journal-of-power-sources
3. https://pubs.rsc.org/en/journals/journalissues/ta#!recentarticles&adv

Web/Digital resources:

1. https://www.udemy.com/course/complete-battery-technology-course-level-1-the-basics/
2. https://indianinstituteofsolarenergy.com/courses/ev-battery-technology-course-online/
3. https://skill-lync.com/electrical-engineering-courses/battery-technology-electric-vehicles-matlab-simulink
4. https://alison.com/course/battery-technologies

SWAYAM/NPTEL:

1. https://onlinecourses.nptel.ac.in/noc21_mm34
2. https://nptel.ac.in/courses/108106170

Practice Based Learning:

No.	Topics to be covered	Tools and Techniques	Expected Skill /Ability
1.	Modelling and simulation of simple battery	Open-source tool	Logical Thinking

Self-Learning Exercises:

1. Case Study projects
2. Mini Projects

Course Articulation:

COURSE OUTCOMES↓	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1			2			
CO2			2			
CO3			2	2		
CO4			3	2		
CO5	3	3	3	3	3	

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 153**	*Total Credits*	**4**	*Course Type*	*Professional Elective Course*		
Course Title	**ROBOTICS AND INDUSTRIAL AUTOMATION**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**52**	**4**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	**0**	**0**	*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	**52**	**4**	*Minimum Marks*	*20 marks*	*25 marks*	*45 Marks*

Course Prerequisite: Basic concepts of control system

Course Objective:

1. To impart knowledge on various electrical and electronics used in robotics
2. To enable students to learn about various sensors, actuators and hybridization methods.

Course Outcomes (COs): After completing this course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Explain the Robot anatomy, required background material for Robotics and to describe mathematically the position and orientation in 3-space.	L2
CO2	Analyze the inverse kinematics of robot arms and solve related problems.	L4
CO3	Investigate the kinematics of velocities and static forces and model the dynamics of manipulators.	L3
CO4	Analyze the motions of manipulators in terms of trajectories through space and understand the methods of controlling a manipulator.	L4
CO5	Apply and demonstrate the knowledge on the state of the art in external robot sensors, control using modern tools.	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours	
		Lecture	Tutorial
1	**Introduction to Robotics:** Definitions, Laws of Robotics, Robot anatomy, Design and control issues, Manipulation and Control, Sensors and Vision, Programming Robots. **Coordinate Frames, Mapping and Transforms:** Mapping Frames, Description of objects in Space, Transformation of Vectors, Inverting a Homogeneous Transform, Fundamental Rotation Matrices.	**10**	**0**
2	**Modelling of Robots:** Direct Kinematics, Mechanical Structures and Notations, Description of Links and Joints, Kinematic Modeling of Manipulator, Denavit-Hartenberg notation, Kinematic Relationship between Adjacent Links, Manipulator Transformation Matrix. Inverse Kinematics, Manipulator Workspace, Solvability of Inverse Kinematic Model, Solution Techniques and Closed form Solution.	**11**	**0**
3	**Manipulator Differential Motion and Statics:** Linear and Angular Velocity of a Rigid body, Relationship between Transformation Matrix and Angular Velocity, Mapping Velocity Vector, Velocity Propagation along Links, Manipulator Jacobian, Jacobian Inverse and Singularities, Static Analysis. **Dynamic Modelling:** Lagrangian Mechanics, Two-degree of Freedom Manipulator, Lagrange- Euler Formulation and Newton-Euler Formulation and their Comparison, Inverse Dynamics	**11**	**0**
4	**Trajectory Planning:** Definitions and Planning Tasks, Joint Space Techniques and Cartesian Space Techniques and their Comparison. **Control of Manipulators:** Open and Closed loop control, Manipulator Control problem, Linear Control Schemes, Linear Second Order SISO Model of a Manipulator Joint, Joint Actuators, Partitioned PD Control	**10**	**0**
5	**Robotic Sensors and Vision:** Meaning of Sensors, Sensors in Robotics, Kinds of Robotic Sensors, Robotic Vision, Applications of Vision-Controlled Robotic Systems. Process of Imaging, Architecture of Robotic Vision Systems, Image Acquisition and Other Components of Vision System. **Industrial Applications of Robots:** Material Handling, Processing Applications – Arc Welding, Assembly Applications, Inspection Applications, Robot Safety.	**10**	**0**

Text Books:

1. R. K. Mittal and I. J. Nagarath, “Robotics and Control,” 6th Reprint, Tata Mcgraw-Hill Education, Delhi 2007.

2. K. S, Fu, R. C. Gonzalez, and C. S. G. Lee, "Robotics: Control, Sensing, Vision, and Intelligence," 8th Ed, Pearson Education 2007.

Reference Books:

1. John J. Craig, "Introduction to Robotics: Mechanics and Control," 3rd Ed, Pearson Education, New Delhi 2006.

Self-Learning Exercises:

1. Case Study projects
2. Mini Projects

Course Articulation:

	PROGRAM OUTCOMES					
COURSE OUTCOMES↓	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1		2		3		
CO2		2	3	3		
CO3		2	3	3		
CO4		2	3	3	3	
CO5	3	3	3	3	3	3

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 161**	*Total Credits*	**4**	*Course Type*	*Professional Elective Course*		
Course Title	**DESIGN OF MECHANICAL SYSTEMS**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**52**	**4**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	**0**	**0**	*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	**52**	**52**	*Minimum Marks*	*20 marks*	*25 marks*	*45 Marks*

Course Prerequisite: Engineering Mechanics and Mechanics of Materials

Course objective:

1. To study the designing of machine parts such as shafts, riveted joints, welded joints.
2. To understand the application of threaded fasteners and power screws.

Course Outcomes (COs): After completing this course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Explain basic stress and strain concepts for machine components using codes and standards based on failure theories.	L2
CO2	Assess torsional strength and rigidity of shafts as per ASME & BIS codes.	L4
CO3	Analyse riveted and weld joints as per ASME and IBR codes.	L4
CO4	Illustrate threaded fasteners, power screws and their locking arrangements for various applications.	L3

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours	
		Lecture	Tutorial
1	**Introduction:** Mechanical engineering design, Phases and principles of design process, Design considerations, Selection of materials, Standards and Codes, Factor of safety. Design for Static Strength. Theories of Failure: Maximum Normal Stress Theory, Maximum Shear Stress Theory, Distortion Energy Theory. Stress concentration, Determination of Stress concentration factor.	**12**	**0**

2	**Design of shafts**: Types of shafts, Torsion of shafts. Design for strength and Rigidity with steady loading. ASME & BIS codes for design of transmission–shafting. Shafts under Bending, Torsion, Axial, fluctuating loads and combined loads. Design of Cotter joints, Knuckle joints couplings and various types of keys.	**10**	**0**
3	**Gears:** Gear tooth geometry, tooth systems, gear trains, design of spur gear, helical gear, bevel and worm gears from strength and wear considerations.	**10**	**0**
4	**Riveted Joints:** Failures of Riveted joints, Design of Boiler joints as per IBR, eccentrically loaded riveted joints. **Welded Joints:** Types, Strength of Butt and Fillet welds, eccentrically loaded welded joints.	**10**	**0**
5	**Threaded Fasteners and Power Screws:** Stresses in threaded fasteners, Effect of initial tension, Design of threaded fasteners under static loads, Design of eccentrically loaded bolted joints. Types of power screws, efficiency and self-locking, Design of power screw, Design of screw jack.	**10**	**0**

Text Books:

1. V.B. Bhandari, "Design of Machine Elements," 2nd Edition, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2007.
2. Joseph E Shigley and Charles R. Mischke, "Mechanical Engineering Design," 6th Edition, McGrawHill International edition, 2009.
3. Juvinall R.C, and Marshek K.M., "Fundamentals of Machine Component Design," student edition, John Wiley & Sons 2007
4. V B Bhandari, "Design of Machine Elements," McGraw Hill Education India Private Limited, 4th edition

Reference Books:

1. Robert L. Norton, George E. Dieter, Linda C Schmidt, "Engineering Design," Indian Edition, McGraw Hill Education, 2013.
2. Hall, Holowenko, Laughlin (Schaum's Outline series) adapted by S.K Somani, "Machine Design," Special Indian edition, Tata McGraw Hill Publishing company Ltd., New Delhi, 2008.
3. P C Sharma, D K Aggrawal, "Machine design," S.K. Kataria & Sons

Data Hand Book:

1. Design Data Hand Book, K. Lingaiah, McGraw Hill, 2nd edition, 2003.
2. Design Data Hand Book, K. Mahadevan and Balaveera Reddy, CBS Publication.
3. Design Data Hand Book, H.G. Patil, I.K. International Publisher, 2010.

Journals/Magazines:

1. ASME Design Journal.
2. Mechanisms and machine theory.

Web/Digital resources:

1. https://www.coursera.org/learn/machine-design1
2. https://freevideolectures.com/course/2363/design-of-machine-elements-1

SWAYAM/NPTEL:

1. https://nptel.ac.in/courses/112105124

Self-Learning Exercises:

1. Case Study projects
2. Mini Projects

Course Articulation:

COURSE OUTCOMES↓	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1				3		
CO2			2	3		
CO3			2	3		
CO4			2	3		2

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 162**	*Total Credits*	**4**	*Course Type*	***Professional Elective Course***		
Course Title	**VEHICLE BODY ENGINEERING AND SAFETY**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**52**	**4**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	**0**	**0**	*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	**52**	**4**	*Minimum Marks*	*20 marks*	*25 marks*	*45 Marks*

Course Prerequisite: Concepts of Elements of Mechanical Engineering

Course Objective:

1. To make students understand about the different vehicle chassis-built type
2. To study about vehicle dynamics and safety

Course Outcomes (COs): After completing this course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Explain different car body types, visibility and instrumentation.	L2
CO2	Illustrate vehicle aerodynamics and explain optimization techniques for minimum drag.	L3
CO3	Analyse different commercial vehicle body types, layout, materials and constructional details.	L4
CO4	Assess importance of vehicle safety design and their concepts	L4
CO5	Carry out the task individually making use of simulation and analytical tools, document and give an effective presentation.	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours	
		Lecture	Tutorial
1	**Car body details Types:** saloon, convertibles, limousine, estate car, racing and sports car. Visibility: regulations, driver's visibility, tests for visibility, methods of improving visibility and space in cars. Safety: safety design, safety equipment's for cars. Car body	**10**	**0**

	construction; design criteria, prototype making, initial tests, crash tests on full scale model, Dummies and Instrumentation		
2	**Vehicle aerodynamics:** Objectives. Vehicle drag and types; various types of forces and moments, effects of forces and moments, side wind effects on forces and moments, Various body optimization techniques for minimum drag, wind tunnel testing: flow visualization techniques, scale model testing, component balance to measure forces and moments.	**11**	**0**
3	**Bus body details:** Types: mini bus, single decker, double-decker, two level and articulated bus. Bus body layout; floor height, engine location, entrance and exit location, seating dimensions. Constructional details: frame construction, double skin construction, types of metal sections used, Regulations, Conventional and integral type construction.	**10**	**0**
4	**commercial vehicle details:** Types of body; flat platform, drop side, fixed side, tipper body, tanker body, Light commercial vehicle body types. Dimensions of driver's seat relation to controls. Drivers cab design. **Body materials, trim and mechanisms:** Steel sheet, timber, plastic, GRP, properties of materials; Corrosion, anticorrosion methods. Selection of paint and painting process, Body trim items. Body mechanisms.	**11**	**0**
5	**Safety design and concepts:** Design of the body for safety, engine location, deceleration of vehicle inside passenger compartment, deceleration on impact with stationary and movable obstacle, concept of crumble zone, safety sandwich construction. **Active safety:** driving safety, conditional safety, perceptibility safety, operating safety- passive safety: exterior safety, interior safety, deformation behavior of vehicle body, speed and acceleration characteristics of passenger compartment on impact.	**10**	**0**

Text Books:

1. Kohli P. L, "Automotive Chassis & Body," Papyrus Publishing House, New Delhi, 2010.
2. J. Powloski, "Vehicle Body Engineering," Business Books Ltd, London -1989
3. Giles J Cm, "Body construction and design," Liiffe Books Butterworth & Co. - 1971

Reference Books:

1. John Fenton, "Vehicle Body layout and analysis," Mechanical Engg. Publication Ltd., London 1982.
2. Braithwaite J B, "Vehicle Body building and drawing," Heinemann Educational Books Ltd., London 1977.

SWAYAM/NPTEL:

1. https://nptel.ac.in/courses/107106088
2. https://nptel.ac.in/courses/107106080
3. https://nptel.ac.in/courses/107103084

Self-Learning Exercises:

1. Case Study projects
2. Mini Projects

Course Articulation:

COURSE OUTCOMES↓	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1				3		
CO2			3	3		
CO3			3	3		
CO4			3	3		
CO5	3	3	2	3	3	2

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 163**	*Total Credits*	**4**	*Course Type*	*Professional Elective Course*		
Course Title	**AGILE MANUFACTURING**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**52**	**4**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	**0**	**0**	*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	**52**	**4**	*Minimum Marks*	*20 Marks*	*25 marks*	*45 Marks*

Course Prerequisite: Concepts of Elements of Mechanical Engineering.

Course Objective:

1. To get an overview of Agile Manufacturing, their needs and strategies
2. To know the process of developing an agile manufacturing/enterprise and Integration of Product /Process
3. To impart the skill and knowledge of design in enhancing manufacturing technology.

Course Outcomes (COs): After completing this course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Explain the conceptual strategies of agile manufacturing and their needs.	L2
CO2	Development of Integration of Product /Process in an agile manufacturing	L3
CO3	Get insight into Supply Chain Management and Enterprise design process to apply interdisciplinary design concepts.	L3
CO4	Develop the knowledge of usage of computer control systems in agile manufacturing	L3

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours	
		Lecture	Tutorial
1	**Agile Manufacturing:** Definition, business need, conceptual framework, characteristics, generic features. Four Core concepts: Strategy driven approach-integrating organization, People technology, interdisciplinary design methodology.	**10**	**0**

2	**Developing Agile Manufacturing:** Enterprise design, System concepts as the basic manufacturing theory-joint technical & Organizational design and a model for the design of agile manufacturing enterprise. Integration of Product /Process Development: Principles, Robust design approach, Approaches to enhance ability in manufacturing, Role of QFD, Managing People in Agile organization, Approaches	**12**	**0**
3	**Application of IT/IS Concepts in Agile Manufacturing:** Strategies, Management of complexities and information. Flow, approaches, applications of multimedia to improve agility in manufacturing. Agile Supply Chain Management: Principles, IT/IS concepts in supply chain management, enterprise integration and management in agile manufacturing, concepts, Agility, Adaptability, and learners – comparison of concepts	**10**	**0**
4	**Computer Control of Agile Manufacturing:** CAPP for capacity planning and production line design / redesign manufacturing, concepts, examples. Corporate Knowledge Management In Agile Manufacturing: Strategies, strategic options in agile manufacturing, Role of standards.	**10**	**0**
5	**Design of Skill & Knowledge:** Enhancing technology for Machine tool system, Resumption of design requirement geometry, definition, methods, decision support for selection of cutting Parameters, design enhancements, parametric approach only	**10**	**0**

Textbooks:

1. Poul T Kidd "Agile Manufacturing - Forging Mew Frontiers," Amagow Co. UK, ISBN-0 201-63163-6, 1994.
2. A Gunasekharan "Agile Manufacturing: The 21st Century Competitive strategy," ISBN - 13978-0-08-04 3567-1, Elsevier Press, India, 2001.

Reference Books:

1. Joseph C Moutigomery and Lawrence "Levine Transitions to Agile Manufacturing, Staying Flexible for competitive advantage," ASQC quality press, Milwaukee. Wisconsin, USA, 1996.
2. David M Anderson and B Joseph Pine, Irwin "Agile Development for Mass Customization," Professional Publishing, Chicago, USA, 1997.

Journals/Magazines:

1. https://www.sciencedirect.com/science/article/abs/pii/S0925527398002229

Web/Digital resources:

1. https://www.uwtsd.ac.uk/msc-lean-agile-manufacturing/
2. https://www.coursera.org/lecture/lean-manufacturing-services/introduction-to-the-course-wdQtp

SWAYAM/NPTEL:

https://www.coursera.org/courses?query=agile

Self-Learning Exercises:

1. Mini Projects

Course Articulation:

COURSE OUTCOMES↓	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1			2	2		2
CO2		2	2	2		
CO3			2	2		2
CO4		2	2		2	

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 170L**	*Total Credits*	**1.5**	*Course Type*	*Professional Core Course*		
Course Title	**DIGITAL CONTROL SYSTEMS LAB**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**0**	**0**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*100 %*	*---*	*100 %*
	Practical	**39**	**1.5**	*Maximum Marks*	*50 Marks*	*---*	*50 Marks*
	Total	**39**	**1.5**	*Minimum Marks*	*25 Marks*	*---*	*25 Marks*

Course Prerequisite: Control Systems, Matlab

Course Objective:

1. To verify Digital Control Systems concepts using MATLAB/SIMULINK
2. To design, simulate digital controllers
3. To implement digital controller as hardware

Course Outcomes (COs): After completing this course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	To analyze digital control systems using MATLAB/SIMULINK	L4
CO2	To design and validate digital controller for transfer function and state space model	L6
CO3	To implement digital controller for a real time hardware system	L6
CO4	To document the experiments and present in a group adhering to ethics.	L2

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

Week	List of Experiments/ Programs	No. of Hours
1	Discretization of transfer function and observing step response by varying damping factor.	3
2	Verification of steady state error for Type-0, 1, 2 systems	3
3	Verification of transfer function and state-space model of a DC motor	3

4	Design and verification of PI controller for DC motor model	3
5	Design and verification of phase-lead compensator for DC motor model	3
6	Design and verification of state-variable feedback controller using pole placement technique	3
7	Design and verify closed-loop observer for a DC motor	3
8	Design and verify an LQR controller for a DC motor.	3
9-12	Mini Project: Implementation of real time control system	3 x 4
13	Laboratory Test	3

Text Books:

1. M. Gopal, "Digital Control and State Variable Methods," Mc Graw Hill India, 2012

Reference Books:

1. Charles L. Phillips, H. Troy Nagle, Aranya Chakraborthy, "Digital Control Systems, Analysis and Design," 4th Edition, McGraw Hill, 2014.
2. Gene F. Franklin, J. David Powell and Michael Workman, "Digital Control of Dynamic Systems," 3rd Edition, Ellis-Kagle Press, 2006.

Journals/Magazines:

IEEE Transaction on Automatic Control

Course Articulation:

COURSE OUTCOME	**PROGRAM OUTCOME**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1		2	3	3	3	
CO2		2	3	3	3	
CO3		2	3	3	3	
CO4	3	3	3	3	3	2

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 180**	*Total Credits*	**1.5**	*Course Type*	*Mini-project with seminar*		
Course Title	**DESIGN AND IMPLEMENTATION LAB**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**0**	**0**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*100 %*	*---*	*100 %*
	Practical	**39**	**1.5**	*Maximum Marks*	*50 Marks*	*---*	*50 Marks*
	Total	**39**	**1.5**	*Minimum Marks*	*25 Marks*	*---*	*25 Marks*

Course Prerequisite:

To be enthusiastic to work in groups, identifying new problems and proposing solutions by exploring new tools.

Course Objective:

1. To generate innovative domain specific /interdisciplinary ideas
2. To design a method to realize the ideas and build the prototype.
3. To carry out tests, prepare report and write article

Course Outcomes (COs): After completing this course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Survey the literature, identify gaps and innovatively give a renewed solution.	L4
CO2	Construct prototype, verify the results, prepare report and publish article adhering to standards.	L6

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 – Create

Course Content / Syllabus:

Week	List of Experiments/ Programs	No. of Hours
1	Idea generation	3
2	Literature survey	3
3	Literature survey, Problem statement	3

4	Synopsis preparation and presentation	3
5	Design and implementation	3
6	Design and implementation	3
7	Mid phase evaluation	3
8	Develop and implement solution	3
9	Integrate designed modules/circuits	3
10	Test, verify and validate the results	3
11	Report and articles preparation	3
12	Final Demo	3
13	Laboratory Test	3

Reference Books:

1. Web resources
2. Company websites and white papers

Journals/Magazines:

1. IEEE Publications
2. Journals and Magazines

Course Articulation:

COURSE OUTCOMES↓	**PROGRAM OUTCOMES**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	2	2		
CO2	3	3	3	3	3	3

High – 3, Medium – 2, Low – 1

Second Semester

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 210**	***Total Credits***	**4**	***Course Type***	***Professional Core Course***		
Course Title	**AUTOTRONICS**						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	**52**	**4**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	***Weightage***	***40 %***	***60 %***	***100 %***
	Practical	**0**	**0**	***Maximum Marks***	***40 Marks***	***60 Marks***	***100 Marks***
	Total	**52**	**4**	***Minimum Marks***	***20 marks***	***25 marks***	***45 Marks***

Course Prerequisite:

1. Basic electronics engineering
2. Basic Automobile engineering

Course Objective:

1. To make the students understand the evolution of electronics in automobiles.
2. To provide student with knowledge on ignition and injection systems.
3. To make the students learn about various sensors and actuators for controlling engine parameters.

Course Outcomes (COs): After completing this course, students will be able to:

COs	**Course Outcomes**	**Highest Cognitive Domain**
CO1	Examine the operation of the ICE fuel injection and ignition system.	L2
CO2	Demonstrate the measuring principles involved in sensors and evaluate for automotive applications	L3
CO3	Exemplify the knowledge of working of power converters and vehicular communication systems.	L3
CO4	Work efficiently as an individual and complete the assigned task by demonstrating skills related to documentation and oral communication.	L3

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours	
		Lecture	Tutorial
1	**ELECTRONIC FUEL INJECTION AND IGNITION SYSTEM:** Introduction -Fuel System Components-Electronic Fuel System-Fuel Injection-Types-Throttle Body Versus Port Injection-Electronic Control Fuel Injection-Operation-Different Types-Fuel Injectors-Idle Speed Control-Continuous Injection System-High Pressure Diesel Fuel Injection -MPFI System - Electronic Ignition System-Operation-Types-Electronic Spark Timing Control.	**10**	**0**
2	**AUTOMOTIVE SENSORS:** Position Sensors, Speed and Rpm Sensors, Acceleration Sensors, Pressure Sensors, Force and Torque Sensors, Flowmeters, Temperature Sensors, Engine-Speed Sensors, Hall Phase Sensors, Speed Sensors for Transmission Control, Wheel Speed Sensors, Micromechanical Yaw-Rate Sensors, Piezoelectric "Tuning-Fork" Yaw-Rate Sensor	**12**	**0**
3	**VEHICLE MOTION CONTROL SYSTEMS:** Cruise Control System, Cruise Control Electronics, ABS, Electronic Suspension System, Electronic Steering Control, TCS, ESP and Adaptive Lighting System.	**10**	**0**
4	**POWER CONVERTERS:** Overview of Elementary Power Converter Switches and Power Converters (Non-Isolated): BJT, Thyristors, MOSFETS, IGBT, IPM, IGCT. AC/DC Converters Single Phase and Three Phase: Line Commutated, Uncontrolled and Phase Controlled Converters (Half Bridge and Full Bridge) and Battery Management Systems.	**10**	**0**
5	**AUTOMOTIVE NETWORKING AND BUS SYSTEMS:** Cross-system functions, Requirements for bus systems, Classification of bus systems, Applications in the vehicle, Coupling of networks, Examples of networked vehicles, LIN Bus, Flex and MOST Bus architecture.	**10**	**0**

Text Books:

1. Tom Denton, "Automobile electrical and electronic systems," Third edition, BH Publication, 2004.
2. Willium B. Ribbens, "Understanding Automotive Electronics," Sixth edition, Elsevier Science 2003.
3. Jack Erjavec, Robert Scharff, "Automotive Technology," Delmar publications Inc 1992.

Reference Books:

1. Ronald K. Jurgen, "Sensors and Transducers," SAE 2003
2. Ichiro Masaki, "Vision-based Vehicle Guidance," Springer Verlag, Newyork 1992.
3. Ronald K. Jurgen, "Electric and Hybrid-electric Vehicles," SAE 2002.
4. Jay Webster, Class Room Manual.

SWAYAM/NPTEL:

- Fundamentals of Automotive Systems: https://nptel.ac.in/courses/107106088

PRACTICE BASED LEARNING:

No	Topics to be covered	Tools and Techniques	Expected Skill/Ability
1	Sensors and Actuators	Multisim	Simulation

Self-Learning Exercises:

1. Case Study projects
2. Mini Projects

Course Articulation:

COURSE OUTCOMES↓	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		3	3		
CO2	3		3	3	3	
CO3	3		3	3		
CO4	3	3	3	3	3	

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 220**	*Total Credits*	**4**	*Course Type*	*Professional Core Course*		
Course Title	**AUTOMOTIVE INSTRUMENTATION**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**39**	**3**		**CIE**	**SEE**	**Total**
	Tutorial	**26**	**1**	*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	**0**	**0**	*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	**65**	**4**	*Minimum Marks*	*20 marks*	*25 marks*	*45 Marks*

Course Prerequisite: Basic concepts of Electronic Instrumentation

Course objective:

1. To understand instrumentation concept applied to automotive systems
2. To make students familiar with the mechanical measuring systems in engineering applications.

Course Outcomes (COs): After completing this course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Explain the instrumentation concept applied to automotive systems	L2
CO2	Analyze sensing and measuring methods for electronic applications	L4
CO3	Develop open / closed loop and computer-based instrumentation system	L3
CO4	Apply theory of metrology for selecting suitable mechanical measuring instruments for basic and special requirements in the industries.	L3

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours	
		Lecture	Tutorial
1	Basic concept of measurements, need of inspection, Classification of methods of measurements, Selection of instruments, Sources of errors, international system of units, Establishing calibration system, Standards of measurements,	**7**	**5**
2	Construction, principle, working of instruments for measuring force, pressure, temperature, fluid flow, viscosity, humidity and moisture, Fiber optic transducers, microsensors and smart sensors.	**8**	**5**

3	Concept of open loop and closed loop control systems for instrumentation system, General instrumentation block diagram, Computer aided measurements: Fuel quantity, coolant temperature, Oil pressure and vehicle speed measurement and Display devices,	**8**	**5**
4	Metrology: Limits, fits and gauges, Slip gauges, Comparators: Mechanical, electrical and pneumatic comparators, Measurement by light wave interference.	**8**	**5**
5	Angular measurement and circular division, Inspection of Straightness, Flatness, Squareness, Parallelism, Circularity and Rotation, Measurement of surface finish.	**8**	**6**

Text Books:

1. B.C.Nakra & K.K. Choudhary, "Instrumentation, Measurement & Analysis", Tata McGraw-Hill Publications
2. William B Ribbens, "Understanding Automotive Electronics," Butterworth–Heinemann Publications, 5th edition
3. R K Jain, "Engineering Metrology," Khanna Publishers, 21st edition

Reference Books:

1. J. Holman, *"*Experimental methods for engineers*,"* McGraw-Hill, 6th edition
2. E.O. Doeblin, "Measurement systems, Application & Design," McGraw-Hill 4th edition

SWAYAM/NPTEL:

1. https://www.youtube.com/watch?v=HpIEeBtJupY&list=PLbMVogVj5nJSZiwuh_tp50dKry8mCxzKA

Self-Learning Exercises:

1. Case Study projects
2. Mini Projects

Course Articulation:

COURSE OUTCOMES↓	**PROGRAM OUTCOMES**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1				3		
CO2				2		
CO3	2			2	2	2
CO4				3		3

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 230**	*Total Credits*	**4**	*Course Type*	*Professional Core Course*		
Course Title	**AUTOMOTIVE NETWORKING**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**39**	**3**		**CIE**	**SEE**	**Total**
	Tutorial	**26**	**1**	*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	**0**	**0**	*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	**65**	**4**	*Minimum Marks*	*20 marks*	*25 marks*	*45 Marks*

Course Prerequisite: Introduction to automotive systems.

Course Objective:

1. To understand the various communication protocol such as CAN, LIN etc., used in Automotive industries.

Course Outcomes (COs): After completing this course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Explain the principles and functionalities of various Automotive Communication Protocols (ACPs)	L2
CO2	Design, simulate/emulate and analyze CAN and LIN based automotive embedded networks	L3
CO3	Design automotive communication protocol based In-Vehicle Networks (IVNs).	L3
CO4	Make use of CANoe tool to develop IVN applications as well as to simulate, analyze and Troubleshoot ACP based IVNs	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours	
		Lecture	Tutorial
1	**Basics of Data Communication Networks and Automotive Communication Protocols:** Need for networks, Types of networks, Need for standards, TCP/IP model, Topologies, Error detection and correction mechanisms, Encoding schemes, Serial/parallel transmission, Bits, Baud and bandwidth, Synchronous and asynchronous, Need and benefits of IVN, Classes of IVN protocols,	**8**	**5**

	Multiplexed electrical systems, Vehicle multiplexing, Bitwise contention, Network elasticity, Error processing and management and Case Study.		
2	**Controller Area Network (CAN) Protocol:** History and foundation of CAN, CAN Applications, Main characteristics of CAN, CAN in OSI Reference Model, CAN Data Link Layer, Principles of data exchange in CAN, Arbitration, Data Frame, Remote Frame, Error detection and management in CAN, CAN physical Layer, Bit encoding, Bit timing and synchronization, Relationship between data rate and bus length, Single wire and twin wire media, CAN repeaters, Medium-to-medium gateway, Protocol handlers, Micro-controllers and line drivers, Time Triggered CAN (TTCAN), Comparison with other IVN protocols, CANoe based applications development.	**8**	**5**
3	**CAN Higher Layer Protocols and LIN:** CAN Higher Layer Protocols: CAN in Automation (CiA), CANopen, CANopen device model, CAN open features, DeviceNet, DeviceNet Model, Device Object Model, DeviceNet Features, SAEJ1939, SAE J1939 Reference Model, CAN Kingdom and Case Study Local Interconnect Network (LIN) Protocol: Introduction to LIN, LIN consortium, LIN specification, LIN features, Technical overview, Work flow concept, LIN operation, LIN frame format, Scheduling table, Network management of LIN cluster, LIN Transport Layer, LIN node configuration and identification.	**8**	**5**
4	**FlexRay and MOST Protocol:** FlexRay Protocol: Future on board systems, Need for FlexRay, Origin of FlexRay, FlexRay consortium, FlexRay Objectives, FlexRay Features, Application requirements, Working of FlexRay, Network topologies, ECU architecture, Segment Configuration, Communication Cycles, FlexRay frame format, Timing of configuration protocol, Error control, and FlexRay core mechanisms, Coding and Decoding, Medium Access Control, Frame and Symbol Processing, Clock Synchronization, FlexRay Components, Comparison with other IVN protocols and Case Study, Media Oriented System Transport (MOST) Protocol: Emerging in car systems, Introduction to MOST, MOST goals, Features, Cables and Connectors, Data Types, Topology, Frame Format, Application Areas, System Description, Specification, Device Model, Device Implementation, Diagnostics and Case Study.	**8**	**5**
5	**In Vehicle Network Diagnostics:** Process of Automotive Fault Diagnostics, Fault Codes, Vehicle Systems (open-loop and closed-loop) On- and Off- Board Diagnostics, OBD-I, OBD-II, Engine Analyzers, Steps taken to diagnose a fault, Diagnostics Protocol-KWP2000, SAE-J1587, SAE-J1708 and Case Study	**7**	**6**

Text Books:

1. Gilbert Held, "Inter- and Intra-Vehicle Communications," CRC Press, 2007
2. Ronald k. Jurgen, "Automotive Electronics Handbook," McGraw-Hill. 1999

Reference Books:

1. Behrouz Forouzan, "Data Communications and Networking," McGraw-Hill. 2003

Web Resources:

1. https://www.udemy.com/course/can-protocol-basic-to-advance/
2. https://www.udemy.com/course/automotive-networks-foundation-classes/

SWAYAM/NPTEL:

1. https://onlinecourses.nptel.ac.in/noc22_de02/preview

Practice Based Learning:

No	Topics to be covered	Tools and Techniques	Expected Skill/Ability
1	Demonstration of in-vehicle Protocols (IVP) using appropriate tools	Open-source tools	Modern Tools usage

Self-Learning Exercises:

1. Case Study projects
2. Mini Projects

Course Articulation:

COURSE OUTCOMES↓	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3	3		
CO2			3	3		
CO3			3	3		
CO4	3	3	3	3	3	

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 241**	*Total Credits*	**4**	*Course Type*	***Professional Elective Course***		
Course Title	**AUTOMOTIVE ELECTRICAL AND ELECTRONIC SYSTEM**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**52**	**4**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	**0**	**0**	*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	**52**	**4**	*Minimum Marks*	*20 marks*	*25 marks*	*45 Marks*

Course Prerequisite:

1. Basic electronics engineering
2. Basic Automobile engineering

Course Objective:

1. To understand the function and construction of various electrical and electronic components and systems.
2. To learn the principles of operation, constructional details of various Automotive Electrical and Electronic Systems.

Course Outcomes (COs): After completing this course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Analyze various energy storage technologies, ignition and lighting systems used in automobiles.	L4
CO2	Explain the working of Motoronic engine management	L2
CO3	Examine the working of different electric and hybrid vehicle configurations and analyse their performance	L4
CO4	Take part in an individual activity by demonstrating skills related to implementation, documentation and presentation.	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours	
		Lecture	Tutorial
1	**Storage Battery:** Principle of lead acid cells, plates and their characteristics containers and separators, electrolyte and their preparation, effect of temperature on specific gravity of electrolyte,	**10**	**0**

	battery capacity and efficiency, battery rating, battery testing, methods of charging from D.C. mains, defects and remedies of batteries, care of idle and new batteries, different types of batteries and their principles like alkaline, lithium and zinc air etc.,		
2	**Ignition systems:** Ignition fundamentals, working of battery and magneto ignition systems, comparison of battery and magneto ignition system, advantages and disadvantages of conventional ignition systems, Types of solid-state ignition systems, components, construction and working, high energy ignition distributors, electronic spark timing control. Lighting system and Dashboard Instruments. Principle of automobile illumination, head lamp mounting and construction, sealed beam auxiliary lightings, horn, windscreen-wipers, signaling devices, electrical fuel pump, fuel, oil and temperature gauge, speedometer, odometer, etc. (Dash board instruments)	**12**	**0**
3	**Engine management Systems:** Combined ignition and fuel management systems. Exhaust emission control, Digital control techniques – Dwell angle calculation, Ignition timing calculation and Injection duration calculation. Artificial intelligence and engine management. Hybrid vehicles and fuel cells. Chassis Electrical systems: Antilock brakes (ABS), Active suspension, Traction control, electronic control of automatic transmission, other chassis electrical systems, Central locking, Air bags and seat belt tensioners, seat heaters.	**10**	**0**
4	**Electrical and hybrid vehicles:** Components of an EV, EV batteries, chargers, drives, transmission, and power devices. Advantages and disadvantages of EVs. Hybrid electric vehicles, HEV drive train components, advantages of HV. Transduces and sensors Definition and classification, principle of working and application of various light sensors, proximity sensors and Hall effect sensors.	**10**	**0**
5	**Starting System:** Condition at starting, Behavior of starter during starting, Series motor and its characteristics, Principle & construction of starter motor, Working of different starter drive units, care and maintenance of starter motor. Starter Switches. **Charging System:** Generation of direct current. Shunt generator characteristics. Armature reaction. Third brush regulation. Cut-out. Voltage and current regulators. Compensated voltage regulator alternators principle & constructional aspects and bridge benefits.	**10**	**0**

Text Books:

1. Tom Denton, “Automobile Electrical and Electronic systems,” SAE publication, 2000.
2. P.M. Kohli, “Automotive Electrical Equipments,” Tata McGraw Hill, New Delhi, 2017.
3. S. S. Thipse, “Alternative Fuels,” JAICO Publishing House, New Delhi.
4. W. Bolton, Longman, “Mechatronics,” 2nd edition, Pearson publications, 2007.

Reference Books:

1. Judge. A.W., "Modern Electrical Equipment of Automobiles," Chapman & Hall, London, 1992.
2. Erjvec, Jack, Thompson, Rob, "Automotive Technology: A System Approach," Cengage Learning, 6th Edition, Delmar-USA (2014), ISBN-13:978-1-133-61231-5
3. Vinal. G.W., "Storage Batteries," John Wiley & Sons Inc., New York, 1985.
4. William B. Ribbens, "Understanding Automotive Electronics," 5th Edition, Butterworth, Heinemann Woburn, 1998.
5. Robert Bosch, "Automotive Hand Book," Bently Publishers, 1997, Reprint 2012

SWAYAM/NPTEL:

1. Fundamentals of Automotive Systems: https://nptel.ac.in/courses/107106088

Self-Learning Exercises:

1. Case Study projects
2. Mini Projects

A suggestive list of mini-projects is given here.

a) Prepare the display board for electrical/electronic aggregates with specifications and relevant application. Following steps to be strictly followed.
   i. Student should visit shops/garage for survey.
   ii. Collect components and know the specification.
   iii. Study application of component.
   iv. Prepare the display board with labeled components and their applications.

b) Prepare a demonstration kit to check the faults: short-circuit [open circuit/ ground circuit. Following steps to be strictly followed.
   i. Student should select relevant wires and electrical loads.
   ii. Draw layout of electrical mountings.
   iii. Mount the components so as to demonstrate one of the above said fault.
   iv. Study and note the effect of faults in the kit.
   v. Prepare relevant document for results.

c) Collect and mount starter motor/alternator components on the board. Following steps to be strictly followed.
   i. Student should visit shops/garage for survey.
   ii. Collect components and know the specification.
   iii. Study application of component.
   iv. Prepare the display board and label components.

d) Prepare charts relevant to diagnosis of sensors/actuators. Following steps to be strictly followed.
   i. Student should visit shops/garage for survey.
   ii. Observe and note techniques used for diagnosis of sensors/actuators.
   iii. Select one sensor/actuator for case-study.
   iv. Prepare the chart for diagnosis of selected component.

Course Articulation:

COURSE OUTCOMES↓	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		3	3		
CO2	3		3	3		
CO3	3	3	3	3		
CO4	3	3	3	3	3	

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 242**	*Total Credits*	**4**	*Course Type*	***Professional Elective Course***		
Course Title	**MACHINE LEARNING**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**52**	**4**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	**0**	**0**	*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	**52**	**4**	*Minimum Marks*	*20 marks*	*25 marks*	*45 Marks*

Course Prerequisite: Basic mathematics.

Course Objective:

1. To learn the concepts of neural network architecture and algorithms.
2. To understand supervised and unsupervised machine learning algorithms.

Course Outcomes (COs): After completing this course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Explain the theoretical foundation of neural networks and machine Learning.	L2
CO2	Analyze neural network architecture and algorithms.	L4
CO3	Analyze supervised and unsupervised machine learning algorithms.	L4
CO4	Demonstrate the implementation of real-world applications using neural networks and Machine Learning algorithms	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 – Create

Course Content / Syllabus:

UNIT No.	Content	Hours	
		Lecture	**Tutorial**
1	**Linear Regression and Classification:** Problem Formulation, Parameter Estimation: Maximum Likelihood Estimation, Overfitting in Linear Regression, Maximum A Posteriori Estimation, MAP Estimation as Regularization, Bayesian Linear Regression, Confusion matrix, Classification matrix.	**10**	**0**

2	**Dimensionality Reduction with Principal Component Analysis:** Problem Setting, Maximum variance perspective: Direction with maximal variance, M-dimensional subspace with Maximal variance, Projection Perspective: Setting and objective, Finding Optimal Coordinates, Finding the Basis of the Principal Subspace, Eigenvector Computation, and Low –Rank Approximations, PCA in High Dimensions, Optimization, Optimization techniques, Contractual, nonstructural.	**10**	**0**
3	**Neural Network:** Introduction, Network Architectures, learning process, Rosenblatt perceptron, algorithm for linearly separable data, implementation of Boolean functions using neurons. Multilayer Perceptrons: Batch Learning and On-Line Learning, The Back-Propagation Algorithm, Back Propagation and differentiations, The Minimum Description-Length Principle, Convolutional Networks, Small-scale Versus Large-Scale Learning Process.	**10**	**0**
4	**Kernel Methods and Radial-Basis Function Networks:** Cover's Theorem on the separability of patterns, The Interpolation Problem, Radial-Basis-Function Networks, K-means Clustering, Recursive Least-squares estimation of the Weight Vector, Hybrid Learning Procedure for RBF Networks, Interpretations of the Gaussian Hidden Units, Kernel Regression and Its Relation to RBF Networks, The Support Vector Machine Viewed as a Kernel Machine, Design of Support Vector Machines.	**10**	**0**
5	**Regularization Theory:** Regularization Networks, semi supervised Learning, Manifold Regularized: Preliminary Considerations, Differentiable Manifolds, Spectral Graph Theory, Laplacian Regularized Least mean squares algorithm.	**12**	**0**

Text Books:

1. Christopher M. Bishop "Pattern Recognition and Machine Learning," Springer, Second Indian Reprint, 2015.
2. Simon Haykin "Neural networks and Learning Machines," Pearson, 3rd Edition. 2016.

Reference Books:

1. Tomm. Mitchell "Machine Learning," McGraw Hill Education, 22nd reprint 2018.
2. Bekkerman, Ron, Mikhail Bilenko, and John Langford, eds. "Scaling up machine learning: Parallel and distributed approaches," Cambridge University Press, 2011.
3. Frank Pane, "Hands-On Data Science and Python Machine Learning," Packt Publishers 2017.

Journals/Magazines:

1. Machine Learning, Springer, https://www.springer.com/journal/10994.
2. IEEE Transactions on Neural Networks and Learning Systems, IEEE. https://ieeexplore.ieee.org/xpl/aboutJournal.jsp?punumber=5962385.

SWAYAM/NPTEL:

1. https://nptel.ac.in/courses/117105084
2. https://onlinecourses.nptel.ac.in/noc22_cs29/preview
3. https://nptel.ac.in/courses/106105152

Self-Learning Exercises:

1. Case Study projects
2. Mini Projects

Course Articulation:

COURSE OUTCOMES ↓	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3			
CO20			3	3		
CO3			3	3		
CO4	3	3	3	3	3	

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 243**	*Total Credits*	**4**	*Course Type*	*Professional Elective Course*		
Course Title	**AUTOMOTIVE CYBERSECURITY**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**52**	**4**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	**0**	**0**	*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	**52**	**4**	*Minimum Marks*	*20 marks*	*25 marks*	*45 Marks*

Course Prerequisite: Basics of computer networks.

Course Objective:

1. To understand the importance of cyber security and its competencies in automotive industry.
2. To learn all areas around automotive development impacted by cyber security.
3. To implement appropriate cyber security measures for vehicles.

Course Outcomes (COs): After completing this course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Explain the security requirements in IT/computer and embedded systems.	L3
CO2	Apply the knowledge of security architecture, HW and SW solutions for security challenges in automotive domain.	L3
CO3	Analyze and model the security feature use cases.	L4
CO4	Demonstrate the threats and risks in security feature requirement using case study.	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours	
		Lecture	Tutorial
1	**Introduction to Cryptography and related Infrastructure**; Motivation Security Basics: Current trends and Development, Safety and Security, Cryptography Concepts: Encoding, Encryption, Hash, Security services, Examples of Algorithm (AES 128, RSA)	10	0
2	**Signature and Encryption**, Symmetric and Asymmetric signatures. Public Key Infrastructure: Digital Certificate, Functions of PKI, Certifying Authority, Hierarchy of Certifying Authority Layered automotive security, CIA Triad.	10	0
3	**Security Architecture:** Software and Hardware Solutions - Introduction to Hardware Security Module (HSM), HSM and Software Crypto Libraries, Software and Hardware Encryption. Autosar Software Architecture overview, Introduction to Autosar Communication stack Crypto stack and Diagnostic Stack.	10	0
4	**Automotive Security Features:** Challenge- Response Protocol, Secure Access, Secure Flashing. Secure On-Board Communication, Secure Boot, Secure storage, Secure Logging.	10	0
5	**Security Functional Testing**- Overview; Security Features Validation: Penetration Testing-Overview, Methodology, Types of Penetration Testing. Threat and Risk Analysis in Security	12	0

Text Books:

1. Stallings, W., "Cryptography and Network Security," Pearson, 2016.
2. Lemke, K., Paar, C., Wolf, M., "Embedded Security in Cars: Securing Current and Future Automotive IT Applications," Springer Berlin Heidelberg, 2006.

Reference Books:

1. Kleidermacher, D., and Kleidermacher, M., "Embedded systems security: Practical methods for safe and secure software and systems development," Newnes (An Imprint Of Butterworth-Heinemann Ltd, 2012.
2. Godbole, N. S., "Information systems security: security management, metrics, frameworks and best practices," Wiley India, 2009.

Web/Digital resources:

1. https://link.springer.com/chapter/10.1007/978-981-16-2217-5_3

Self-Learning Exercises:

1. Project work on development of security feature prototype.

2. Application development on Linux or in any user-friendly environment.
3. Analyze and present the case study topics provided by industry.

Course Articulation:

COURSE OUTCOMES↓	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3	3		
CO2			3	3		
CO3	3		3	3		
CO4	3	3	3	3	3	

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 251**	*Total Credits*	**4**	*Course Type*	***Professional Elective Course***		
Course Title	**VEHICLE ENGINEERING**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**52**	**4**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	**0**	**0**	*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	**52**	**4**	*Minimum Marks*	*20 marks*	*25 marks*	*45 Marks*

Course Prerequisite: Elements of Mechanical Engineering

Course Objective:

1. To understand the vehicle transmission system
2. To Learn the working of different Engine and their auxiliary systems.

Course Outcomes (COs): After completing this course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Explain the construction and working of different engines and review the cooling lubricating system.	L2
CO2	Asses the working principle of different auxiliary systems and transmission mechanisms with their constructional details	L3
CO3	Develop the knowledge on steering, suspension, and braking systems.	L4
CO4	Analyze different alternative energy sources available for the energy application in automobiles	L4
CO5	Carry out a group task making use of simulation and analytical tools, document and give an effective presentation.	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours	
		Lecture	Tutorial
1	**Vehicle structure and engines:** Types of Automobiles, Vehicle Construction, Chassis Frame and Body aerodynamics, Components of Engine their forms, Functions and Materials, Review of Cooling and lubrication systems in Engine, Turbo	**10**	**0**

	Chargers, Engine Emission Control by 3–Way Catalytic Controller, Electronic Engine Management System.		
2	**Engine auxiliary systems:** Carburetor working principle, electronic fuel injection system, Mono-point and Multi – Point Injection Systems Construction, Operation and Maintenance of Lead Acid Battery, Electrical systems, Battery generator, Starting Motor and Drives Lighting and Ignition (Battery, Magneto Coil and Electronic Type) Regulators-cut outs.	**10**	**0**
3	**Transmission systems:** Clutch, Types and Construction, Gear Boxes, Manual and Automatic Simple Floor Mounted Shift Mechanism, Over Drives Transfer Box Fluid flywheel -Torque convertors, Propeller shaft Slip Joint Universal Joints, Differential and Rear Axle Hotchkiss Drive and Torque Tube Drive.	**12**	**0**
4	**Steering, brakes and suspension:** Wheels and Tyres – Wheel Alignment Parameters - Steering Geometry and Types of steering gear box Power Steering – Types of Front Axle – Suspension systems – Braking Systems – Types and Construction – Diagonal Braking System – Antilock Braking System.	**10**	**0**
5	**Alternative energy sources:** Use of Natural Gas, LPG, Biodiesel, Gasohol and Hydrogen in Automobiles - Electric and Hybrid Vehicles, Fuel cells.	**10**	**0**

Text Books:

1. Sethi H.M, "Automobile Technology," Tata McGraw-Hill, 2003
2. Kirpal Singh, "Automobile Engineering Vol. 1& 2", Standard Publishers, New Delhi.
3. Crouse and Anglin, "Automotive Mechanism," 9th Edition. Tata McGraw-Hill, 2003.

Reference Books:

1. Newton, Steeds and Garet, "Motor vehicles," Butterworth Publishers, 1989.
2. Srinivasan S, "Automotive Mechanics" 2nd edition, Tata McGraw-Hill, 2003.
3. Joseph Heitner, "Automotive Mechanics," 2nd edition, East-West Press, 1999.

SWAYAM/NPTEL:

1. https://nptel.ac.in/courses/107106088

Self-Learning Exercises:

1. Case Study projects
2. Mini Projects

Course Articulation:

COURSE OUTCOMES↓	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1				3		
CO2			2	3		
CO3			2	3		
CO4			2	3		
CO5	3	3	2	3	3	2

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 252**	*Total Credits*	**4**	*Course Type*	***Professional Elective Course***		
Course Title	**AUTOMOTIVE MATERIALS**						
Teaching Learning Process		*Contact Hours*	*Credits*				
	Lecture	**52**	**4**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	**0**	**0**	*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	**52**	**4**	*Minimum Marks*	*20 marks*	*25 marks*	*45 Marks*

Course Prerequisite: Knowledge on the mechanics of materials

Course Objective:

1. To get acquainted with different types of materials applicable to automotive industry.
2. To study the processing of materials.
3. To characterize the materials based on their mechanical properties.

COURSE OUTCOMES (COs): After completing the course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Explain different material structures.	L2
CO2	Design and performance analysis of heat treatment technique.	L3
CO3	Apply the knowledge of metallic, non-metallic and composites materials to structural design.	L3
CO4	Analyze the mechanical properties of composite materials.	L4
CO5	Engage in an independent study as a member of a team and make an effective oral presentation on the usage of software tools/mini project.	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours	
		Lecture	Tutorial
1	**Review Crystal structure**: BCC, FCC and HCP structure, unit cell, crystallographic planes and directions, miller indices, crystal imperfections, point, line, planar and volume defects, Grain size,	**10**	**0**

	ASTM grain size number. **Constitution of alloys and phase diagrams:** Constitution of alloys, Solid solutions, substitutional and interstitial, phase diagrams, isomorphous, eutectic, peritectic, eutectoid and peritectroid reactions, Iron – Iron carbide equilibrium diagram. Classification of steel and cast-iron microstructure, properties and application.		
2	**Heat treatment:** Definition, Full annealing, stress relief, recrystallization and heroidizing normalizing, hardening and tempering of steel. Isothermal transformation diagrams, cooling curves superimposed on I.T. diagram CCR - Hardenability, Jominy end quench test, Austempering, martempering, case hardening, carburising, nitriding, cyaniding, carbonitriding, Flame and Induction hardening.	**10**	**0**
3	**Ferrous and non-ferrous metals:** Effect of alloying additions on steel (Mn, Si, Cr, Mo, V Ti & W) - stainless and tool steels, HSLA, maraging steels, Gray, White malleable, spheroidal -Graphite - alloy castirons. Copper and Copper alloys, Brass, Bronze and Cupronickel– Aluminium and Al-Cu – precipitation strengthening treatment, Bearing alloys.	**10**	**0**
4	**Non-metallic materials and composites:** Polymers – types of polymers, commodity and engineering polymers – Properties and applications of PE, PP, PS, PVC, PMMA, PET, PC, PA, ABS, PI, PAI, PPO, PPS, PEEK, PTFE Polymers – Urea and Phenol formal deliydes – Engineering Ceramics – Properties and applications of Al_2O_3, SiC, SiN, Si_3N_4, PSZ and Sialon – Fibre and particulate reinforced composites.	**10**	**0**
5	**Mechanical properties and testing:** Mechanism of plastic deformation, slip and twinning Types of fracture – Testing of materials under tension, compression and shear loads – Hardness tests (Brinell, Vickers and Rockwell) Impact test Izod and charpy, fatigue and creep test.	**12**	**0**

Text Books:

1. Kenneth G. Budinski and Michael K. Budinski, "Engineering Materials," Prentice-Hall of India Private Limited, (2002).
2. William D Callsber, "Material Science and Engineering," John Wiley and Sons, (1997).
3. Sydney H. Avner, "Introduction to Physical Metallurgy", McGraw-Hill Book Company, (1994).

Reference Books:

1. Raghavan. V, "Materials Science and Engineering," Prentice Hall of India Pvt, Ltd, (1999).

Journals/Magazines:

1. https://www.automotivemanufacturingsolutions.com/magazine
2. https://www.sciencedirect.com/science/article/pii/S2214785322028954

SWAYAM/NPTEL:

1. https://nptel.ac.in/courses/107106088

Practice Based Learning:

No	Topics to be covered	Tools and Techniques	Expected Skill /Ability
1	Journal articles / simulations on automotive materials	Open-source software tools	Program/simulation

Self-Learning Exercises:

Characterization of electrical properties of composite materials.

Course Articulation:

COURSE OUTCOMES↓	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1				2		
CO2			3	3		
CO3			2	2		
CO4			2	3		
CO5	3	3	3	3	3	1

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 253**	*Total Credits*	**4**	*Course Type*	*Professional Elective Course*		
Course Title	**DRIVES AND CONTROL SYSTEMS FOR AUTOMATION**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**52**	**4**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	**0**	**0**	*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	**52**	**4**	*Minimum Marks*	*20 Marks*	*25 marks*	*45 Marks*

Course Prerequisite: Basics of control Systems

Course Objective:

1. To understand the fundamental concepts of industrial automation systems and their control.

Course Outcomes (COs): After completing the course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Explain industrial processes practiced and selection of various electrical drive systems	L2
CO2	Differentiate various control process involved in automation	L3
CO3	Analyse different motor control circuits incorporated in automation process	L4
CO4	Illustrate computer based industrial control techniques	L3

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours	
		Lecture	Tutorial
1	**Introduction:** Working principle of synchronous, Asynchronous & stepper motors, Difference between Induction and servo motors, Torque v/s speed characteristics, Power v/s. Speed characteristics, Vector duty induction motors, Concepts of linear and frameless motors, Selection of feedback system, Duty cycle.	**10**	**0**
2	**Industrials Drives:** DC and AC motors operation and selection, method of control and application of brushless DC motor, PMSM, stepper motor, A.C servomotor, selection criteria for servo motor	**11**	**0**

	and servo amplifier, universal motor, electric drive, types of industrial drives, the characteristics of drive, advantages of drives over other prime movers, motor rating, heating effects		
3	**Motion Laws for Rotary and Linear Systems:** converting rotary to linear system, concepts and principles of ball screws, rack and pinion, belt and pulley, chain drives, gear drives, Selection of converting systems, Dynamic response gearing, and control approaches of Robots, Control loops using Current amplifier	**11**	**0**
4	**Introduction to Programmable Logic Controllers:** Definitions of PLC, basic structure of PLC, working principles, data storage methods, inputs / outputs flag processing's, types of variables, definition of firmware, software.	**10**	**0**
5	**Logic, Instructions & Application of PLC:** What is logic, Conventional Ladder v/s PLC ladder, series and parallel function of OR, AND, NOT logic, Ex Or logic, Analysis of rung. Timer and Counter Instructions; on delay and Off delay and retentive timer instructions, PLC counter up and down instructions, combining counters and timers, Comparison and data handling instructions, Sequencer instruction, Visualization Systems.	**10**	**0**

Textbooks:

1. Johnson Curties, "Process Control Instrumentation Technology," 8th edition, Pearson Education (US), 2005
2. Gopal K. Dubey, "Fundamentals of electrical drives," 2nd edition, Alpha Science International Limited, 2001
3. William Bolton "Programmable Logic Controllers," 6th edition, Newnes publishers, 2015

Reference Books:

1. Garry Dunning "Introduction to Programmable Logic Controllers," 2nd edition, Thomson, ISBN:981-240-625-5
2. Bela G Liptak, "Instrumentation Engineers Hand Book - Process Control," Chilton book company, Pennsylvania
3. A.E. Fitzerald, C. Kingsley and S.D Umans, "Electric Machinery," McGraw Hill Int. Student edition

Journals/Magazines:

https://www.sciencedirect.com/science/article/abs/pii/S0925527398002229

Web/Digital resources:

1. https://www.researchgate.net/publication/329175786_Electrical_drives_and_control_for_automation
2. https://dicsglobal.com/

SWAYAM/NPTEL:

1. https://nptel.ac.in/courses/108105063

Self-Learning Exercises:

1. Case Study Projects
2. Mini Projects

Course Articulation:

COURSE OUTCOMES↓	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1			2			
CO2		2	2	2		
CO3			2	2	2	
CO4		2	2	2	2	

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 280L**	*Total Credits*	**1.5**	*Course Type*	*Professional Core Course*		
Course Title	**AUTOMOTIVE EMBEDDED SYSTEMS LAB**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**0**	**0**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*100 %*	*---*	*100 %*
	Practical	**39**	**1.5**	*Maximum Marks*	*50 Marks*	*---*	*50 Marks*
	Total	**39**	**1.5**	*Minimum Marks*	*25 marks*	*---*	*25 Marks*

Course Prerequisite:

1. Control systems
2. Embedded systems

Course objective:

1. To introduce students to automotive embedded systems for various sensing and control applications.

Course Outcomes (COs): After completing the course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Explain Automotive sensors and embedded systems	L2
CO2	Analyze Automotive embedded control systems using modern tools	L4
CO3	Design and simulate Automotive embedded control systems using modern tools	L4
CO4	Document and present the analysis and design as a group/ Individual	L3

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

Week	List of Experiments/ Programs	No. of Hours
1	Demonstrate the working of various Automotive sensors	3
2	Demonstrate the working of DAC and ADC blocks using dSpace tool	3
3	Demonstrate the mass-spring system using dSpace tools	3
4	Demonstrate temperature controller using dSpace tools	3
5	Demonstrate DC motor position control using Quanser QUBE Servo	3
6	Demonstrate DC motor speed control using Quanser/dspace	3

7	PMSM/BLDC motor control & algorithm development	3
8	Configure timer block for signal generation (with given frequency)	3
9	Analog to digital conversion (ADC) peripheral configuration and programming	3
10	Design and implementation of a Bayes classifier for two-class and multi-class classification	3
11	Universal asynchronous receiver and transmitter (UART) configuration and programming	3
12	Mini project using ATMEGA/Raspberry Pi Microcontroller	3
13	Laboratory Test	3

Text Books:

1. M. Gopal, "Digital Control and State Variable Methods," McGraw Hill India, 2012

Reference Books:

1. Muhammad Ali Mazidi, "STM32 Arm Programming for Embedded Systems," 2019.
2. Donald Norris, "Programming with STM32: Getting Started with the Nucleo Board and C/C++," McGraw-Hill Education, 2018.
3. "STM32F446xx advanced Arm®-based 32-bit MCUs," Reference Manual, 2020.

Journals/Magazines:

1. https://www.sciepub.com/journal/jes

Web/Digital resources:

1. https://www.oreilly.com/library/view/programming-embedded-systems/0596009836/ch01.html
2. https://www.oreilly.com/library/view/programming-embedded-systems/0596009836/ch01.html

Course Articulation:

COURSE OUTCOME	**PROGRAM OUTCOME**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1		2	3			
CO2		2	3	3		
CO3		2	3	3		
CO4		3	3	3	3	

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 26OE**	*Total Credits*	**4**	*Course Type*	*Open Elective Course*		
Course Title	**NANO DIELECTRICS**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**52**	**4**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	**0**	**0**	*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	**52**	**4**	*Minimum Marks*	*20 marks*	*25 marks*	*45 Marks*

Course Prerequisite: Fundamentals concepts of dielectric materials used in capacitors.

Course Objective:

1. To familiarize on the characteristics, testing and measurement of insulation materials and equipments.
2. To gain knowledge on the advanced computer simulation techniques.

Course Outcomes (COs): After completing the course, students will be able to:

COs	**Course Outcomes**	**Highest Cognitive Domain**
CO1	Describe the fundamentals of nanodielectrics in various applications.	L2
CO2	Apply the different methods to study the structural behavior of nanocomposites.	L4
CO3	Analyze the performance of nanocomposites.	L3
CO4	Demonstrate the skill sets using various tools for experimental/simulation of composite films towards research.	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	**Content**	**Hours**	
		Lecture	**Tutorial**
1	**Introduction**: Dielectrics and nanodielectrics, structure, preparation, and characterization of nanodielectrics, attractiveness of polymer	**10**	**0**

	nanocomposites.		
2	**Preparation and structure:** Methods of mixing a quasi-spherical nanofillers into a polymer, surface modification of nanoparticles and its effects. Changes in the movement and structure of atoms and molecules represented by the dielectric properties, Structure of polymer/nanofiller interfaces.	**11**	**0**
3	**Compatibility with other engineering performances:** Electrical conductivity contrast between nanofillers and polymer matrix, electronic conduction effect on polymer/metallic nanoparticles, effect on dielectric breakdown strength, need of high-k and low-k materials, thermal and mechanical characteristics.	**11**	**0**
4	**Computer simulation methods:** Quantum mechanics with electronic states, molecular dynamics and Monte Carlo simulation with the collective motion of atoms and molecules, finite element method and statistical thermodynamics calculation with bulk materials, and phase-field method.	**10**	**0**
5	**Epilogue:** Nanodielectrics research challenges, environmental concerns and future prospects.	**10**	**0**

Text Books:

1. Tanaka, T., & Imai, T., "Advanced nanodielectrics: fundamentals and applications," Pan Stanford Publishing, 2017.
2. Murthy, B. S., Shankar, P., Raj, B., Rath, B. B., & Murday, J., "Textbook of Nanoscience and Nanotechnology," Springer Science & Business Media, 2013.

Reference Books:

1. Kulkarni, S. K., "Nanotechnology: Principles and Practices," Springer, 2019.

Journals/Magazines:

1. https://www.springer.com/journal/12274
2. https://onlinelibrary.wiley.com/journal/21983844
3. https://ietresearch.onlinelibrary.wiley.com/journal/25143255

Web/Digital resources:

https://bajkulcollegeonlinestudy.in/StudyMaterialFinal/Chemistry/6th%20sem-DSE3 Nano%20structure%20%20-%20Dr.%20Sunirban%20Das.pdf

SWAYAM/NPTEL:

1. https://nptel.ac.in/courses/118102003

Practice Based Learning:

No	Topics to be covered	Tools and Techniques	Expected Skill /Ability
1	Nano dielectrics in energy storage	Open-source software tools	Program/simulation
2	Nano dielectrics in power sectors	Open-source software tools	Program/simulation
3	Aging behavior of Nano dielectrics	Open-source software tools	Program/simulation

Course Articulation:

COURSE OUTCOMES↓	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3			
CO2	3		3	3		
CO3	3		3	3		
CO4	3	2	3	3	3	2

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PIE 26OE**	*Total Credits*	**4**	*Course Type*	*Open Elective Course*		
Course Title	**DEEP LEARNING FOR SPEECH PROCESSING**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**52**	**4**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	**0**	**0**	*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	**52**	**4**	*Minimum Marks*	*20 marks*	*25 marks*	*45 Marks*

Course Prerequisite: Basic mathematics and signal processing.

Course Objective:

1. To understand the fundamental concepts of speech processing and deep learning
2. To learn about feature extraction and classification techniques using deep learning algorithms.

COURSE OUTCOMES (COs): After completing the course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Explain the theoretical concepts of speech processing and deep learning.	L2
CO2	Analyze speech feature extraction and recognition techniques.	L4
CO3	Apply deep learning and CNN Architecture algorithms for Speech recognition.	L3
CO4	Analyze neural network and machine learning algorithms for speech applications.	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 – Create

Course Content / Syllabus:

UNIT No.	Content	Hours	
		Lecture	**Tutorial**
1	**Phonetics:** Speech Sounds and Phonetic Transcription, Articulatory Phonetics, Phonological Categories, and Pronunciation variation, Acoustic Phonetics, and Signals, Phonetic Resources, Advanced: Articulatory and Gestural Phonology, Text Normalization, Phonetic Analysis, Prosodic Analysis, Diphone Waveform Synthesis, Unit Selection Synthesis.	**11**	**0**

2	**Automatic Speech Recognition:** Speech Recognition Architecture, The Hidden Markov Model Applied to Speech, Feature Extraction: MFCC Vectors, Acoustic Likelihood Computation, Embedded Training, Evaluation: Word Error Rate.	**10**	**0**
3	**Basics of Deep Learning:** Introduction, Perceptron Algorithm Explained**,** Multilayer Perceptron, Deep Learning, Model Training, Unsupervised Deep Learning, Framework Considerations.	**10**	**0**
4	**Convolutional Neural Networks:** Basic Building Blocks of CNN, Forward and Backpropagation in CNN, Text Inputs and CNNs, Classic CNN Architectures, Modern CNN Architectures, Applications of CNN in NLP, Fast Algorithms for Convolutions.	**11**	**0**
5	**Applications and User Interfaces:** Application Architecture, Typical Applications, Computer Command and Control, Telephony Applications, Dictation, Accessibility, Handheld Devices, Automobile Applications, Speaker Recognition **Speech Interface Design:** General Principles, Handling Errors, Dialog Flow. Internationalization	**10**	**0**

Text Books:

1. Daniel Jurafsky, James H. Martin "Speech and Language Processing," Pearson, Second Edition, 2017.
2. Uday Kamath, John Liu, James Whitaker "Deep Learning for NLP and Speech Recognition," Springer, 2019
3. Xuedong Huang, Alex Acerd, Hsiad-wuen Hon "Spoken Language Processing: A Guide to Theory, Algorithm and System Development," PH PTR, 2001.

Reference Books:

1. Lawrence Rabinerand Biing-Hwang Juang, "Fundamentals of Speech Recognition," Pearson Education, 2003.
2. Tomm. Mitchell "Machine Learning," McGraw Hill Education, 22nd reprint 2018.
3. Nilanjan Dey "Intelligent Speech Signal Processing,"-Academic Press, 2019.
4. Umberto Michelucci "Applied Deep Learning. A Case-based Approach to Understanding Deep Neural Networks," Apress, 2018.

Journals/Magazines:

1. IEEE Transactions on Neural Networks and Learning Systems, IEEE, https://ieeexplore.ieee.org/xpl/aboutJournal.jsp?punumber=5962385.
2. IEEE Transactions on Pattern Analysis and Machine Intelligence, IEEE, https://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=34
3. IEEE / ACM Transactions on Audio, Speech, and Language Processing, IEEE,

https://signalprocessingsociety.org/publications-resources/ieeeacm-transactions-audio-speech-and-language-processing/about-taslp.

4. Speech Communication, Science Direct (Elsevier). https://www.sciencedirect.com/journal/speech-communication/about/aims-and-scope.

SWAYAM/NPTEL:

1. http://www.digimat.in/nptel/courses/video/117105145/L37.html
2. https://nptel.ac.in/courses/106106184

Self-Learning Exercises:

1. Mini Projects

Course Articulation:

COURSE OUTCOMES ↓	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3			
CO2			3	3		
CO3			3	3		
CO4	3	3	3	3	3	

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PNI 26OE**	*Total Credits*	**4**	*Course Type*	*Open Elective Course*		
Course Title	**ADVANCED WIRELESS TECHNOLOGY**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**52**	**4**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	**0**	**0**	*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	**52**	**4**	*Minimum Marks*	*20 marks*	*25 marks*	*45 Marks*

Course Prerequisite:

1. Analog and Digital communication systems
2. Antennas and propagation

Course Objective:

1. To understand the basics and technology of advanced communication system

Course Outcomes (COs): After completing the course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Explain the Satellite fundamentals and types of satellite.	L2
CO2	Illustrate the working of mobile radio system and its subsystems.	L3
CO3	Identify the applications of cellular Technology and system capacity.	L3
CO4	Outline the working principle of propagation model in Mobile communication	L2
CO5	Demonstrate the working principle of GSM Services and Applications	L2

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours	
		Lecture	**Tutorials**
1	**Introduction to Satellite:** Satellite sub systems, Antennas, Transponders, earth station technology, Link calculation, Satellite systems- GEO systems, non-GEO communication systems, Satellite Applications- Global Positioning System, Very Small Aperture Terminal system, Direct to Home Satellite Systems.	**12**	**0**

2	**Evolution of mobile**: Mobile radio communications, paging systems, Cordless telephone systems, comparison of various wireless systems Introduction to Modern Wireless Communication Systems, Second generation cellular networks, third generation wireless networks, fourth generation wireless technologies Wireless in local loop, wireless local area networks, Bluetooth, and Personal Area networks, Over view of WIMAX Technologies, architecture, spectrum allocation.	**10**	**0**
3	**Capacity expansion techniques**: Cellular concept, hand off strategies, Interference, and system capacity: Cell splitting, Sectoring, Repeaters, and Microcells. Cellular System **Design Fundamentals:** Frequency reuse, channel assignment strategies, handoff Strategies, Interference, and system capacity, tracking and grade off service, improving coverage and capacity.	**10**	**0**
4	**Wireless Propagation**: Propagation mechanism, free space propagation model, ground reflection model, path loss, Introduction to fading and diversity techniques, Introduction to MIMO system Introduction to Multiple Access, FDMA, TDMA, Spread Spectrum multiple Access, space division multiple access, CDMA, OFDM Wireless Networking.	**10**	**0**
5	**GSM system and data services**: GSM architecture, radio link aspects, network aspects Introduction to new data services like High-Speed Circuit Switched Data (HSCSD), General Packet Radio Service (GPRS), Enhanced Data Rate for Global Evolution (EDGE), Ultra-wideband systems (UWB).	**10**	**0**

Text Books:

1. Dennis Roody, "Satellite communication," 4/e, McGraw Hill, 2006.
2. Herve Benoit, "Digital Television Satellite, Cable, Terrestrial, IPTV, Mobile TV in the DVB Framework," 3/e, Focal Press, Elsevier, 2008
3. Simon Haykin, Michael Mohar, "Modern wireless communication," Pearson Education, 2008

References:

4. Tomasi, "Advanced Electronic Communication Systems," 6/e, Pearson, 2015.
5. W.C.Y. Lee, "Mobile Cellular Telecommunication," McGraw Hill, 2010.

Practice Based Learning:

No	Topics to be covered	Tools and Techniques	Expected Skill/Ability
1	Mini project/case study/ field visit	Hard ware implementation Report writing on field visit	Practical experience of RE generation
2	Simulation/ virtual lab	Open-source simulation tools	Simulation

Self-Learning Exercises:

1. Case Study projects
2. Mini Projects

Course Articulation:

COURSE OUTCOMES ↓	PROGRAM OUTCOMES					
	PO1	PO2	PO3	P04	P05	PO6
CO1	3	3				
CO2	3	3				
CO3	3	3				
CO4	3	3	3	3		
CO5	3	3	3	3	3	

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 270**	*Total Credits*	**2**	*Course Type*	*Mandatory Course*		
Course Title	**RESEARCH METHODOLOGY AND IPR**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**26**	**2**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*100%*	*---*	*100%*
	Practical	**0**	**0**	*Maximum Marks*	*50 Marks*	*---*	*50 Marks*
	Total	**26**	**2**	*Minimum Marks*	*25 marks*	*---*	*25 Marks*

Course Prerequisite:

1. Knowledge of literature review
2. Software for paper formatting and plagiarism software.

Course Objective:

1. To deliver knowledge on formulation of research problem, research methodology, ethics involved and importance of patent and IPR protection.

Course Outcomes (COs): After completing the course, students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Analyze the research problem, research related information and follow research ethics.	L4
CO2	Apply the concept of report writing to an article and correlate the outcome with other published results.	L4
CO3	Describe the importance of IPR, laws, its protection and developments.	L2
CO4	Demonstrate the skill sets in writing technical report and research proposal using LaTeX.	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours	
		Lecture	Tutorial
1	**RESEARCH METHODOLOGY**: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope, and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, Plagiarism, Research ethics.	6	0
2	**DATA COLLECTION AND ANALYSIS**: Importance and scientific methodology in recording results, statics in research, analysis of data, outcome as new idea, hypothesis, concept, theory, model etc.	5	0
3	**INTERPRETATION AND REPORT WRITING:** Significance of technical writing, research report layout, different steps, how to write a manuscript/ response to reviewers comments, preparation of research article/ research report, writing a Research Proposal - presentation and assessment, precautions in writing the report.	5	0
4	**IPR**: Terminology and concept, need for Intellectual Property: Patents, Designs, Trade Mark and Copyright. Process of registration and Development: technological research, innovation, patenting, and development. Procedure for grants of patents in India and abroad.	5	0
5	**PATENT RIGHTS AND DEVELOPMENTS IN IPR**: Scope of Patent Rights, licensing, and transfer of technology. Patent information and databases, geographical indications. New Developments: Administration of patent system and associated law.	5	0

Text Books:

1. Kothari, C. R. "Research Methodology - Methods and Techniques," New Age International publishers, New Delhi, 2004.
2. Ranjit Kumar, "RESEARCH METHODOLOGY a step-by-step guide for beginners," SAGE publishers, 2011.
3. T. Ramappa, "Intellectual Property Rights Under WTO," S. Chand, 2008.

Reference Books:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students," Juta & Company, 1996.
2. Rüdiger Wolfrum and Peter-Tobias Stoll, "WTO – Trade-Related Aspects of Intellectual Property Rights," Max Planck Institute for Comparative Public Law and International Law, Boston, 2009.

Journals/Magazines:

1. http://iprmagazine.com/
2. https://www.researchgate.net/publication/321964409_Research_Methodology

SWAYAM/NPTEL:

1. https://nptel.ac.in/courses/109106137

Practice Based Learning:

No	Topics to be covered	Tools and Techniques	Expected Skill /Ability
1	Write research reports/article/ proposals	LaTeX commands/ MS office	Communication, ethics

Course Articulation:

COURSE OUTCOMES↓	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1		3				2
CO2	2	3				
CO3		2				
CO4		3	3	3	3	

High – 3, Medium – 2, Low – 1

Third Semester

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 310P**	*Total Credits*	**4**	*Course Type*	*PWC / Technical Seminar / Internship in Industry*		
Course Title	**INTERNSHIP / INDUSTRIAL TRAINING**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**0**	**0**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*100 %*	*---*	*100 %*
	Practical	**8 weeks***	**4**	*Maximum Marks*	*50 Marks*	*---*	*50 Marks*
	Total	**8 weeks***	**4**	*Minimum Marks*	*25 marks*	*---*	*25 Marks*

*** 42hrs/ weeks = (40 hours / week in Industry + 2 hours / week in college)**

Course Prerequisite:

Domain Knowledge in the professional courses.

Course Objective:

1. Explore career alternatives prior to graduation by integrating theory and practice.
2. To Develop communication, interpersonal and other critical skills in the job interview process.

Course Outcomes (COs): After completion of the course, the students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Build the knowledge by interacting with industrial personnel, follow engineering practices and discipline prescribed in industry.	L4
CO2	Function individually to implement the given task using modern tools, prepare report and present orally adhering to standard practices.	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Articulation:

COs↓	PROGRAM OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1		3	3			
CO2	3	3	3		3	3

High – 3, Medium – 2, Low – 1

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 320P**	*Total Credits*	*6*	*Course Type*	*Project work Course*		
Course Title	**PROJECT WORK (PHASE – 1)**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**0**	**0**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*100 %*	*---*	*100 %*
	Practical	**12 Weeks***	**6**	*Maximum Marks*	*50 Marks*	**---**	*50 Marks*
	Total	**12 Weeks***	**6**	*Minimum Marks*	*25 marks*	*---*	*25 Marks*

***12 Weeks: 40 Hours / week.**

Course Prerequisite: Domain Specific Knowledge.

Course Objective:

1. To generate Domain specific / interdisciplinary idea and methodology leading to product.
2. To perform feasibility analysis, budgetary analysis and schedule the execution of problem.

Course Outcomes (COs): After completion of the course, the students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Identify and formulate a problem through an adequate literature survey, taking into consideration societal, environmental and sustainability issues.	L3
CO2	Design, plan, schedule the execution, anticipate the bottleneck, examine the feasibility, prepare the budget and submit the synopsis.	L3

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Articulation:

COURSE OUTCOMES	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	
CO2	3	3	3	3	3	3

High – 3, Medium – 2, Low – 1

Fourth Semester

DEPARTMENT	**Electronics and Communication Engineering**						
Course Code	**22PAE 410P**	*Total Credits*	**16**	*Course Type*	*Project work Course*		
Course Title	**PROJECT WORK (PHASE – 2)**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	**0**	**0**		**CIE**	**SEE**	**Total**
	Tutorial	**0**	**0**	*Weightage*	*40 %*	*60%*	*100 %*
	Practical	**22 Weeks***	**16**	*Maximum Marks*	*40 Marks*	**60 Marks**	*100 Marks*
	Total	**22 Weeks***	**16**	*Minimum Marks*	*20 marks*	*25 Marks*	*45 Marks*

***22 Weeks: 40 Hours / week**

Course Prerequisite: Domain Specific Knowledge

Course Objective:

1. To function effectively as an individual for the implementation of an idea and to demonstrate the working prototype / product.
2. To prepare a comprehensive report, article and give an effective presentation.

Course Outcomes (COs): After completion of the course, the students will be able to:

COs	Course Outcomes	Highest Cognitive Domain
CO1	Develop the project idea within the stipulated time, interpret the results and apply necessary corrections.	L6
CO2	Test the working of project, validate the results, prepare technical report, and publish an article.	L6

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Articulation:

COURSE OUTCOMES	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	
CO2	3	3	3	3	3	3

High – 3, Medium – 2, Low – 1