Curriculum Structure & Detailed Syllabus

Bachelor of Technology

in

Electrical & Electronics Engineering

(Four-Year Under-Graduate Program)

Silicon University, Odisha

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https://silicon.ac.in

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Approval History

ACM#	Date	Resolutions
SU-1	27/04/2024	The curriculum structure of B. Tech. (EEE) was approved in principle by the Academic Council.
SU-2	17/08/2024	The curriculum structure of B. Tech. (EEE) and detailed syllabus of 1st Year was approved by the Academic Council.
SU-3	19/04/2025	The amendments to the curriculum structure of B. Tech. (EEE) and the detailed syllabus up to 2nd Year was approved by the Academic Council.
SU-5	07/02/2026	The detailed syllabus up to 3rd Year of B. Tech. (EEE) as recommended by the Board of Studies was approved by the Academic Council.

Knowledge and Attitude Profile (WK's)

Knowledge and Attitude Profile (WK's) are linked to the Graduates Attributes (GAs) which indicate a graduate's potential to acquire competence at the appropriate level. NBA has defined 9 (nine) Knowledge and Attitude Profile (WK's) aligned with the Washington Accord for UG Engineering programs.

WK1. A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.

WK2. Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.

WK3. A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.

WK4. Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.

WK5. Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.

WK6. Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.

WK7. Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.

WK8. Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.

WK9. Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

Program Outcomes (PO's)

Graduates Attributes (GAs) form a set of individually assessable outcomes that are the components indicative of the graduate's potential to acquire competence to practice at the appropriate level. The Program Outcomes (POs) for UG Engineering programs as defined by NBA are:

PO1. **Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).

PO2. **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).

PO3. **Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).

PO4. **Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).

PO5. **Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).

PO6. **The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).

PO7. **Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)

PO8. **Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

PO9. **Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.

PO10. **Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

PO11. **Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Program Specific Outcomes (PSOs)

PSO1. Understand, analyze, formulate and solve engineering problems of varying complexity in Electrical and Electronics Engineering by implementing the fundamental principles of electrical machines, power systems, power electronics, control systems and signal processing.

PSO2. Acquire the skills in modern methodologies, tools and platforms to become a successful professional or entrepreneur, develop a passion for innovation & higher studies, and contribute as a responsible citizen with effective communication, strong moral values & professional ethics.

PSO3. Adapt to the emerging developments in electrical sciences, apply modern practices & strategies in project development using hardware & software environments to deliver quality solutions considering green energy challenges of the future.

Program Educational Objectives (PEOs)

PEO1. *Fundamental Knowledge & Core Competence*: To apply the principles of science, applied mathematics and fundamentals of electrical & electronics engineering essential for a successful professional and inculcate competent problem-solving ability.

PEO2. *Proficiency for the Real World*: To foster creative ability and skills required to analyze, design, test, and implement emerging technologies in electronics & power systems with economic considerations, useful in the real world.

PEO3. *Leadership & Social Responsibility*: To exhibit leadership capability with professional, ethical, interpersonal skills, social & economic commitment with a sense of responsibility towards public policies, community services, humanity and environment.

PEO4. *Life-long Learning*: To grow professionally through continued education & training of technical and management skills, pursue higher studies, and engage in life-long learning.

Course Categories & Definitions

L	Lecture
T	Tutorial
P	Practical / Laboratory / Sessional
WCH	Weekly Contact Hours
UCR	University Core Course
UMC	University Mandatory Course (0-Credit)
PCR	Program Core Course
PEL	Program Elective Course
OEL	Open Elective Course
HNS	Honours (Choice-based) Course
MNR	Minor (Choice-based) Course
OOC	Open Online Course (on NPTEL / Swayam / Other)
INT	Summer Internship
PSI	Practice School / Industry Internship
PRJ	Project Work
SEC	Skill Enhancement Course
VAC	Value Addition Course

Contents

Part I

Curriculum Structure

Induction Program

It is necessary for a newly admitted student to acclimatize to the environment of a college, create a bonding between the teacher and students, equip the students with communication skills, and get them acquainted with the academic & disciplined culture of institution & human values.

All students admitted to B.Tech. programs shall undergo a mandatory induction program after joining the institute and before the commencement of classes. Regular classes of the engineering programs shall begin only after the students have completed the induction program.

The induction program shall comprise of familiarization to the rules & regulations of the institute, examinations & evaluation system, departments/branches, campus facilities, official processes & important officials, curricular/ co-curricular/ extra-curricular activity clubs, innovation & research activities, etc. The program shall also comprise of lectures by eminent persons on adopting a disciplined & healthy life-style, career planning & emerging technologies, social awareness, human values & ethics to sensitize & motivate the students to become not only a successful engineer, but also a socially responsible citizen and contribute their part for social development and nation building.

Interaction with faculty advisors, mentors, senior students, individual/group physical activities, learning or exhibiting an art form/ literature, social service initiatives, and visits to important places of the city, and any other events/ activities deemed to be necessary, may also be included in the induction program.

Every new student must diligently attend & participate in all the activities of the induction program. Attendance in the activities shall be recorded. Students have to submit a daily report in prescribed format to the concerned faculty advisor on the next day. There will be a computer-based test with multiple-choice questions on a suitable date about a week after completion of the induction program.

Evaluation of Induction Program shall be done out of 100 marks, comprising of 3 components, namely: (i) 25 marks for attendance, (ii) 25 marks for the daily reports, and (iii) 50 marks for the computer-based multiple-choice test. A student has to score at least 50 marks in total to pass the induction program.

In case of failure, the student has to attend the induction program in the next academic year along with the newly admitted students, submit daily reports, and appear the computer-based test to score a pass mark.

Curriculum Structure

1st Year B.Tech. (Common)

Semester I								
Category	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
UCR	MT1001	ODE & Matrix Algebra	3	0	0	3	0	0
UCR	CH1001 / PH1001	Engineering Chemistry / Engineering Physics	3	0	0	3	0	0
UCR	EC1001 / EE1001	Basic Electronics Engineering / Basic Electrical Engineering	3	0	0	3	0	0
UCR	ME1001 / ME1002	Engineering Mechanics / Engineering Thermodynamics	2	0	0	2	0	0
UCR	CS1001	Computer Programming	3	0	0	3	0	0
UMC	HS0001 / CH0001	Constitution of India & Professional Ethics / Environmental Science & Engineering	3	0	0	0	0	0
PRACTICAL								
UCR	EC1002 / EE1002	Basic Electronics Engineering Lab / Basic Electrical Engineering Lab	0	0	2	0	0	1
UCR	CS1002	Computer Programming Lab	0	0	4	0	0	2
SEC	HS1001	Communicative & Technical English	0	0	4	0	0	2
UCR	EE1003 / ME1003	Workbench Practices / Engineering Graphics	0	0	2	0	0	1
		SUB-TOTAL	**17**	**0**	**12**	**14**	**0**	**6**
		TOTAL	**29**			**20**		

Note: For some courses, the subjects have been mentioned as Subject-1 / Subject-2, i.e., with an OR option. Every student has to study both the subjects, however allocation of these subjects shall alternate between Semesters I and II. For example, if a student has been allocated *Engineering Chemistry* in Semester-I, then he/she will be allocated *Engineering Physics* in Semester-II, and vice-versa. The laboratory subjects will be as per the theory subjects allocated in the applicable semester. The same applies to all other courses provided with an OR option.

1st Year B.Tech. (Common)

Semester II								
Category	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
UCR	MT1002	Probability & Statistics	3	0	0	3	0	0
UCR	PH1001 / CH1001	Engineering Physics / Engineering Chemistry	3	0	0	3	0	0
UCR	EE1001 / EC1001	Basic Electrical Engineering / Basic Electronics Engineering	3	0	0	3	0	0
UCR	ME1002 / ME1001	Engineering Thermodynamics / Engineering Mechanics	2	0	0	2	0	0
UCR	CS1003	Data Structures & Algorithms	3	0	0	3	0	0
UMC	CH0001 / HS0001	Environmental Science & Engineering / Constitution of India & Professional Ethics	3	0	0	0	0	0
PRACTICAL								
UCR	EE1002 / EC1002	Basic Electrical Engineering Lab / Basic Electronics Engineering Lab	0	0	2	0	0	1
UCR	CS1004	Data Structures & Algorithms Lab	0	0	4	0	0	2
SEC	HS1002	Corporate Communication Skills	0	0	4	0	0	2
UCR	ME1003 / EE1003	Engineering Graphics / Workbench Practices	0	0	2	0	0	1
		SUB-TOTAL	**17**	**0**	**12**	**14**	**0**	**6**
		TOTAL	**29**			**20**		

Note: For some courses, the subjects have been mentioned as Subject-1 / Subject-2, i.e., with an OR option. Every student has to study both the subjects, however allocation of these subjects shall alternate between Semesters I and II. For example, if a student has been allocated *Engineering Chemistry* in Semester-I, then he/she will be allocated *Engineering Physics* in Semester-II, and vice-versa. The laboratory subjects will be as per the theory subjects allocated in the applicable semester. The same applies to all other courses provided with an OR option.

2nd Year B.Tech.(EEE)

Semester III								
Category	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
PCR	MT2003	Vector Calculus & Fourier Analysis	3	0	0	3	0	0
UCR	CS2001	OOP Using Java	3	0	0	3	0	0
UCR	MG2001 / BL2001	Management & Economics for Engineers / Biology for Engineers	3	0	0	3	0	0
PCR	EC2016	Analog Electronics	3	0	0	3	0	0
PCR	EE2001	Circuits & Signals	3	1	0	3	1	0
PCR	EE2002	Electromagnetic Theory	3	0	0	3	0	0
PRACTICAL								
UCR	CS2004	OOP Using Java Lab	0	0	2	0	0	1
PCR	EC2017	Analog Electronics Lab	0	0	2	0	0	1
PCR	EE2003	Circuits & Signals Lab	0	0	4	0	0	2
INT	IP2001	Summer Internship - I	0	0	0	0	0	1
		TOTAL	**27**			**24**		

Semester IV								
Category	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
PCR	MT2004	Complex Analysis & Numerical Methods	3	0	0	3	0	0
UCR	CS2007	Programming in Python	3	0	0	3	0	0
UCR	MG2001 / BL2001	Management & Economics for Engineers / Biology for Engineers	3	0	0	3	0	0
PCR	EC2001	Digital Electronics	3	0	0	3	0	0
PCR	EE2004	Electrical Machines	3	1	0	3	1	0
PEL		Program Elective - I	3	0	0	3	0	0
HNS/MNR		Honours / Minor - I	3	0	0	3	0	0
PRACTICAL								
UCR	CS2010	Programming in Python Lab	0	0	2	0	0	1
PCR	EE2005	Electrical Machines Lab	0	0	4	0	0	2
PCR	EC2002	Digital Electronics Lab	0	0	2	0	0	1
PCR	EE2006	Electrical & Electronics Design Lab	0	0	2	0	0	1
		TOTAL	**29**			**24**		
		TOTAL (with Honours/Minor)	**32**			**27**		

3rd Year B.Tech.(EEE)

Semester V								
Category	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
PCR	EE3001	Control Systems Engineering	3	0	0	3	0	0
PCR	EE3002	Electrical Power Transmission & Distribution	3	0	0	3	0	0
PCR	EE3003	Electrical & Electronics Measurement	3	0	0	3	0	0
PCR	EE3004	Power Electronics	3	1	0	3	1	0
PEL		Program Elective - II	3	0	0	3	0	0
PEL		Program Elective - III	3	0	0	3	0	0
HNS/MNR		Honours / Minor - II	3	0	0	3	0	0
PRACTICAL								
PCR	EE3005	Control Systems Engineering Lab	0	0	2	0	0	1
PCR	EE3006	Power Electronics Lab	0	0	2	0	0	1
PCR	EE3007	Electrical & Electronics Measurement lab	0	0	2	0	0	1
SEC	HS3001	Soft Skills for Professionals	0	0	2	0	0	1
INT	IP2001	Summer Internship - II	0	0	0	0	0	1
		TOTAL	**27**			**24**		
		TOTAL (with Honours/Minor)	**30**			**27**		

Semester VI								
Category	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
PCR	EC3038	Fundamentals of MPMC	3	0	0	3	0	0
PCR	EE3008	Power Systems Operation & Control	3	1	0	3	1	0
PCR	EC3009	Introduction to Digital Signal Processing	3	0	0	3	0	0
PEL		Program Elective - IV	3	0	0	3	0	0
PEL		Program Elective - V	3	0	0	3	0	0
PEL		Program Elective - VI	3	0	0	3	0	0
HNS/MNR		Honours / Minor - III	3	1	0	3	1	0
PRACTICAL								
PCR	EC3039	Fundamentals of MPMC Lab	0	0	2	0	0	1
PCR	EE3021	Power Systems Lab	0	0	2	0	0	1
SEC	IP3005 / IP3002	Emerging Technologies Lab / Entrepreneurship & Innovation	0	0	4	0	0	2
SEC	HS3002	Technical & Research Writing	0	0	2	0	0	1
VAC	VA0001	Yoga / NSS / NCC / PES / CPA *	0	0	2	0	0	0
		TOTAL	**31**			**24**		
		TOTAL (with Honours/Minor)	**35**			**28**		

***Value Addition Courses**: Yoga - Yoga & Meditation, NSS - National Service Scheme, NCC - National Cadet Corps, PES - Physical Education & Sports, CPA - Creative & Performing Arts. Every student must invest at least 2 hours per week in the chosen course in one semester.

4th Year B.Tech.(EEE)

(Without Practice School Option)

Semester VII								
Category	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
OEL		Open Elective - I	3	0	0	3	0	0
OOC		MOOC - I	0	0	0	3	0	0
HNS/MNR		Honours / Minor - IV	3	1	0	3	1	0
HNS/MNR		Honours / Minor - V	3	1	0	3	1	0
PRACTICAL								
PRJ	IP4010	Skill Lab & Project - I	0	0	4	0	0	2
INT	IP4005	Summer Internship - III	0	0	0	0	0	1
		TOTAL	**7**			**9**		
		TOTAL (with Honours/Minor)	**15**			**17**		

Semester VIII								
Category	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
OEL		Open Elective - II	3	0	0	3	0	0
OOC		MOOC - II	0	0	0	3	0	0
PRACTICAL								
UCR	IP4008	Presentation Skills & Technical Seminar	0	0	2	0	0	1
PRJ	IP4009	Project - II	0	0	16	0	0	8
		TOTAL	**21**			**15**		

		GRAND TOTAL	**200**	**160**
		GRAND TOTAL (with Honours/Minor)	**220**	**178**

Note:

1. Courses offered under each elective are given in “List of Electives” on Page 10.
2. Courses for Honours and Minor are given in “List of Tracks for Honours and Minor” on Page 11.
3. A 4-Credit Honours / Minor course may have L-T-P of 3-0-1 if the course requires some in-class practice or hands-on component. Refer to the detailed syllabus of the course for the allocated L-T-P.
4. MOOC - Massive Open Online Course (on NPTEL / Swayam / Other).
5. Approved list of courses for MOOC (self study) shall be published by the department. Students are advised to complete them before the end of 8th semester.
6. The Value Addition Course (Yoga / NSS / NCC) may be assigned in a different semester depending on available capacity.

4th Year B.Tech.(EEE)

(With Practice School Option in 7th Semester)

Semester VII								
Category	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
PRACTICAL								
PSI	IP4006	Practice School / Industry Internship	0	0	0	0	0	15
INT	IP4005	Summer Internship - III	0	0	0	0	0	1
		TOTAL	**0**			**16**		

Semester VIII								
Category	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
OEL		Open Elective - II	3	0	0	3	0	0
OOC		MOOC - II	0	0	0	3	0	0
HNS/MNR		Honours / Minor - IV	3	1	0	3	1	0
HNS/MNR		Honours / Minor - V	3	1	0	3	1	0
PRACTICAL								
PRJ	IP4010	Skill Lab & Project - I	0	0	4	0	0	2
		TOTAL	**7**			**8**		
		TOTAL (with Honours/Minor)	**15**			**16**		

		GRAND TOTAL	**179**	**160**
		GRAND TOTAL (with Honours/Minor)	**197**	**178**

Note:

1. Courses offered under each elective are given in “List of Electives” on Page 10.
2. Courses for Honours and Minor are given in “List of Tracks for Honours and Minor” on Page 11.
3. A 4-Credit Honours / Minor course may have L-T-P of 3-0-1 if the course requires some in-class practice or hands-on component. Refer to the detailed syllabus of the course for the allocated L-T-P.
4. MOOC - Massive Open Online Course (on NPTEL / Swayam / Other).
5. Approved list of courses for MOOC (self study) shall be published by the department. Students are advised to complete them before the end of 8th semester.
6. The Value Addition Course (Yoga / NSS / NCC) may be assigned in a different semester depending on available capacity.

4th Year B.Tech.(EEE)

(With Practice School Option in 8th Semester)

Semester VII								
Category	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
OEL		Open Elective - I	3	0	0	3	0	0
OOC		MOOC - I	0	0	0	3	0	0
HNS/MNR		Honours / Minor - IV	3	1	0	3	1	0
HNS/MNR		Honours / Minor - V	3	1	0	3	1	0
PRACTICAL								
PRJ	IP4010	Skill Lab & Project - I	0	0	4	0	0	2
INT	IP4005	Summer Internship - III	0	0	0	0	0	1
		TOTAL	**7**			**9**		
		TOTAL (with Honours/Minor)	**15**			**17**		

Semester VIII								
Category	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
PRACTICAL								
PSI	IP4006	Practice School / Industry Internship	0	0	0	0	0	15
		TOTAL	**0**			**15**		

		GRAND TOTAL	**179**	**160**
		GRAND TOTAL (with Honours/Minor)	**197**	**178**

Note:

1. Courses offered under each elective are given in “List of Electives” on Page 10.
2. Courses for Honours and Minor are given in “List of Tracks for Honours and Minor” on Page 11.
3. A 4-Credit Honours / Minor course may have L-T-P of 3-0-1 if the course requires some in-class practice or hands-on component. Refer to the detailed syllabus of the course for the allocated L-T-P.
4. MOOC - Massive Open Online Course (on NPTEL / Swayam / Other).
5. Approved list of courses for MOOC (self study) shall be published by the department. Students are advised to complete them before the end of 8th semester.
6. The Value Addition Course (Yoga / NSS / NCC) may be assigned in a different semester depending on available capacity.

List of Electives

Code	Elective # and Subjects
	Program Elective - I
EC2018	Advanced Electronic Circuits
EE2007	Soft Computing Techniques
EE2008	Renewable Energy Systems
	Program Elective - II
EC3014	IoT & Applications
EE3010	HVDC Transmission
EC3010	Microwave Engineering
	Program Elective - III
EE3011	Smart Grid
EE3012	Electrical Drives
EC3045	Communication Systems Engineering
	Program Elective - IV
EE3013	Flexible AC Transmission Systems
EE3018	Advanced Power Electronics
EC3015	Fiber Optic Communications
	Program Elective - V
EE3014	Power System Protection
EE3015	Advanced Control Systems
EC3042	Introduction to VLSI Design
EC3026	Mobile Communication & Networks
	Program Elective - VI
EE3016	Power Quality
EE3017	High Voltage Engineering
EC3022	Digital Image Processing
EE3023	PLC & SCADA
	Open Elective - I & II (Basket)
MT4001	Applied Linear Algebra
MT4002	Stochastic Processes
MT4003	Numerical Optimization
MT4004	Simulation & Modelling
ME4001	Fluid Mechanics
EE4001	Power Plant Engineering
ME4002	Project Management
HS4001	Organizational Behaviour
HS4002	Entrepreneurship Development
MG4001	Securities Analysis, Investment & Trading
MG4002	Circular Economy

List of Tracks for Honours / Minor

Code	Honours / Minor # and Subjects
Honours in Electrical & Electronics Engineering	
EE2009	Design of Electrical Apparatus
EE3019	Advanced Electrical Machines
EE3020	Advanced Power Transmission & Distribution
EE4003	Embedded System Architecture
EE4002	Electric & Hybrid Vehicles
Minor in "VLSI System Design & Verification"	
EC2013	Semiconductor Devices
EC3032	CMOS VLSI Design
EC3033	VLSI Fabrication Technology
EC4001	VLSI Chip Design & Verification
EC4002	Analog Integrated Circuit Design
Minor in "Embedded & IoT System Design"	
EC2011	Embedded C Programming
EC3034	Sensors & Transducers
EC3035	Embedded Systems & Microcontrollers
EC4003	Realtime Embedded System Design
EC4004	Industrial Internet of Things
Minor in "Information Technology"	
CS2003	Operating Systems
CS2008	Computer Organization & Architecture
CS2002	Design & Analysis of Algorithms
CS2009	Database Management Systems
CS4024	Internet Technology & Applications
Minor in "Artificial Intelligence & Machine Learning"	
CS3013	Data Mining & Data Warehousing
CS2014	Artificial Intelligence
CS3002	Machine Learning
CS4025	Human Language Processing
CS4026	Advanced Machine Learning
Minor in "Business Management"	
MG2002	Digital Marketing & SMO
MG3003	Human Resource Information Systems
MG3004	E-Commerce & Supply Chain Management
MG4005	Financial Management
MG4006	Business Strategy
Minor in "Business Analytics"	
MG2005	Introduction to Business Analytics
MG3001	Data Analytics with Python
MG3002	Business Statistics & Predictive Modelling
MG4003	Business Intelligence & Visualization
MG4004	Business Analytics using Power of AI

Note:

1. Choice for Honours or Minor must be submitted before the end of 3rd Semester.
2. A student can opt for either Honours or Minor, but not both.
3. Once opted for Honours or Minor, the same cannot be changed or converted.
4. Unless adequate number of students opt for Honours or Minor, it shall not be offered for the batch.

Part II

Detailed Syllabus

Category	Code	ODE & Matrix Algebra	L-T-P	Credits	Marks
UCR	MT1001		3-0-0	3	100

Objectives	The objective of this course is to study the concepts of solution of system of linear equations using matrix methods, Eigen values & Eigen vectors of matrices with application, ordinary differential equations with applications, and Laplace transform & its applications to ordinary differential and integral equations.
Pre-Requisites	Knowledge of elementary calculus, coordinate geometry of two & three dimensions and matrix algebra is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Matrix algebra, System of linear equations, Rank, Vector space, Existence and uniqueness of solution of a system of linear equations.	**8 Hours**
Module-2	Eigen values and Eigen vectors, Complex matrices, Diagonalization of matrices, Positive definite matrix, Singular Value Decomposition (SVD) and pseudo inverse.	**8 Hours**
Module-3	Separable ordinary differential equation and modeling, Exact ODE and Integrating factor, Linear ODE, Bernoulli's Equation, Modeling electrical circuits, Homogeneous linear ODE of second order, Second order Linear ODE with constant coefficients.	**8 Hours**
Module-4	Non-homogeneous linear ODE, Solution of Non-homogeneous linear ODE using undetermined coefficients, Euler-Cauchy ODE and applications to electrical circuits, Laplace transform, Inverse Laplace transform.	**8 Hours**
Module-5	Shifting theorems, Transform of derivatives and integrals, Unit step function and Dirac delta function, Applications to derivatives, Differentiation and integration of transforms, Convolution, Integral equation, Solution of system of differential equations.	**10 Hours**
	Total	**42 Hours**

Text Books:

T1. E. Kreyszig, ***Advanced Engineering Mathematics***, 8th *Ed.*, Wiley India, 2015.
T2. G. Strang, ***Linear Algebra and Its Applications***, 4th *Ed.*, Cengage Learning, 2015.

Reference Books:

R1. S. Pal and S. C. Bhunia, ***Engineering Mathematics***, 1st *Ed.*, Oxford University Press, 2015.
R2. B. V. Ramana, ***Higher Engineering Mathematics***, 1st *Ed.*, McGraw Hill, 2017.

Online Resources:

1. https://nptel.ac.in/courses/111105035: by Prof. P. D. Srivastava, IIT Kharagpur
2. https://nptel.ac.in/courses/122104017: by Prof. S. K. Ray, IIT Kanpur
3. https://nptel.ac.in/courses/122102009: by Prof. S. R. K. Iyengar, IIT Delhi
4. https://nptel.ac.in/courses/111107063: by Dr. S. Gakkhar, IIT Roorkee
5. https://www.coursera.org/learn/linearalgebra2

6. https://www.coursera.org/learn/differentiation-calculus
7. https://www.coursera.org/learn/single-variable-calculus
8. https://alison.com/courses/Algebra-Functions-Expressions-and-Equations

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Solve a system of linear equations by applying the appropriate method.
CO2	Apply Eigen values and Eigen vector techniques to find SVD and pseudo inverse of a matrix.
CO3	Apply first order ordinary differential equations to solve real-world problems.
CO4	Apply second order ordinary differential equations to solve problems of electrical circuits.
CO5	Apply the concept of Laplace transforms to solve differential and integral equations.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	2	2							2	1	1
CO2	3	2	1	2	2							2	1	1
CO3	3	3	2	2	3							2	1	1
CO4	3	3	2	2	3							2	1	1
CO5	3	3	2	2	3							2	1	1

Category	Code	Engineering Chemistry	L-T-P	Credits	Marks
UCR	CH1001		3-0-0	3	100

Objectives	The purpose of this course is to understand the fundamentals and applications of chemical sciences in the field of engineering. The course addresses the principles of general and engineering chemistry, so that the students can apply the knowledge in their areas of expertise.
Pre-Requisites	Preliminary knowledge of mole concept, oxidation and reduction, combustion, electromagnetic wave, and nano-materials is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on examples and applications.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Water Treatments**: Types of hardness-Units, Alkalinity of water and its significance, Softening methods and Numerical problems based on these methods, Membrane-based processes, Dissolved Oxygen, Problems with Boiler feed water and its treatments.	**9 Hours**
Module-2	**Corrosion Science**: Definition and scope of corrosion, Dry and wet corrosion, Direct chemical corrosion, Electro-chemical corrosion and its mechanisms, Types of electro-chemical corrosion (Differential aeration, Galvanic, Concentration cell), Typical Electro-chemical corrosion like Pitting, Soil, Waterline, Factors affecting corrosion, Protection from corrosion.	**8 Hours**
Module-3	**Instrumental Techniques**: Fundamentals of Spectroscopy, Principles and applications of molecular spectroscopy such as UV-visible, IR, Elementary idea about XRD, SEM & TEM.	**8 Hours**
Module-4	**Energy Sciences**: Types of fuels, Calorific value, Determination of calorific value, Combustion and its calculations, Solid fuel – Coal analysis (Proximate and ultimate analysis), Liquidfuels – Concept of knocking, Anti-knocking, Octane and Cetane Nos, Battery Technology — Fundamentals of primary & secondary cells, Rechargeable batteries – Lead acid storage battery, Lithium ion battery, Fuel cells – Principles, Applications, Solar PV Cells.	**9 Hours**
Module-5	**Nanochemistry**: Nanomaterials, Classification of nanomaterials, Synthesis and characterization of noble metal nanoparticles (Gold and oxide-based nanoparticles) using Green Synthetic route, Stabilization of nanoparticles using capping agents, Applications of nanomaterials, Carbon based nanomaterials and their applications, Brief on Graphene and Fullerene.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. Jain & Jain, ***Engineering Chemistry***, 16th *Ed.*, Dhanpat Rai Publishing Company, 2015.
T2. Wiley-India Editorial Team, ***Engineering Chemistry***, 2nd *Ed.*, Wiley India, 2011.
T3. C. N. Banwell, ***Fundamentals of Molecular Spectroscopy***, 4th *Ed.*, McGraw-Hill Education, 2017.

Reference Books:

R1. S. S. Dara, ***Engineering Chemistry***, 12th *Ed.*, S. Chand Publisher, 2014.
R2. G. A. Ozin & A. C Arsenault, ***Nanochemistry - A Chemical Approach to Nanomaterials***, 2nd *Ed.*, RSC Publishing, 2008.
R3. J. M. Lehn, L. Cademartiri, ***Concepts of Nanochemistry***, 1st *Ed.*, Wiley-VCH, 2009.
R4. Y. R. Sharma, ***Elementary Organic Spectroscopy***, S Chand & Co Ltd., 2013.

Online Resources:

1. http://nptel.ac.in/courses/103105110/ - Fuel & Combustion
2. http://nptel.ac.in/courses/105104102/hardness.htm
3. http://nptel.ac.in/courses/105106112/1_introduction/5_corrosion.pdf
4. https://chem.libretexts.org/Core/Analytical_Chemistry/Electrochemistry/Exemplars/Corrosion/Corrosion_Basics
5. https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/spectrpy/infrared/infrared.htm
6. https://alison.com - Spectroscopic Technique, Colorimetry

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Determine the hardness of water and apply difference processes to soften hard water.
CO2	Utilize the knowledge of electro-chemistry and corrosion science for prevention of corrosion.
CO3	Apply molecular spectroscopy to analyze organic compounds using spectrophotometer.
CO4	Classify various fuels based on combustion parameters and understand the working principles of various batteries and solar photovoltaic cells.
CO5	Explore synthesis & characterization of nanoparticles through green synthetic route.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

Cont'd. . .

PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	2	1	1	1	1				1	1	2	2
CO2	2	2	2	1	1	1	1	1			1	2	1	2
CO3	2	2	1	2	1	1	1	1			1	2	2	1
CO4	2	2	2	1	1	1	1	1			1	2	1	1
CO5	2	2	1	1	1	1	1				1	2	2	1

Category	Code	Engineering Physics	L-T-P	Credits	Marks
UCR	PH1001		3-0-0	3	100

Objectives	The objective of this course is to study various laws of physics and understand different phenomena using these principles. This knowledge is necessary for engineering students to understand the working of instruments and technologies, and also useful to prepare various engineering projects.
Pre-Requisites	Basic knowledge on waves, electrostatics, magnetism and mathematics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Wave Optics**: Concept of wave and wave equation, Superposition of waves (two-beam and multiple beam), Huygen's principle, Interference, Theory of Newton's rings and its applications, Diffraction, Fresnel and Fraunhofer diffraction, Fraunhofer's diffraction from a single slit, Plane diffraction grating – theory and its applications.	**9 Hours**
Module-2	**Electromagnetic Waves**: Gradient of scalar field, Divergence and curl of vector field, Gauss divergence theorem and Stoke's theorem (statement only), Gauss's law in electromagnetism, Faraday's law of electromagnetic induction, Ampere's circuital law, Displacement current, Maxwell's electromagnetic equations, Electromagnetic waves – Wave equations in free space, Dielectric and conducting medium, Poynting's theorem and Poynting's vector.	**9 Hours**
Module-3	**Quantum Mechanics**: Introduction, Need of quantum mechanics, Particle nature of radiation - Black body radiation (no derivation), Photoelectric effect, Compton's effect and pair production, Concept of de-Broglie's matter waves, Heisenberg's uncertainty principle and its applications.	**8 Hours**
Module-4	**Schrödinger's Wave Equation & Applications**: Concept of wave function ψ and interpretation of $\|\psi\|^2$, Schrödinger's time-dependent and time-independent wave equations, Expectation values, Operators in quantum mechanics, Eigenfunctions and Eigenvalues, Applications of Schrödinger's equation – Particle in a one dimensional box, Potential barrier.	**8 Hours**
Module-5	**Laser & Fiber Optics**: Radiation-matter interaction, Absorption of light, Spontaneous and stimulated emission of light, Population inversion, Types of Laser – Solid State Laser (Ruby), Gas Laser (He-Ne), Properties and applications of Laser; Optical Fiber – Structure and Principle, Types of optical fiber, Numerical aperture, Applications of optical fiber.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. D. R. Joshi, ***Engineering Physics***, 1st *Ed.*, Tata McGraw-Hill Publication, 2017.
T2. Md. M. Khan and S. Panigrahi, ***Principle of Physics***, Vol. I & II, Cambridge Univ. Press.

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Reference Books:

R1. A. Ghatak, ***Optics***, 7th *Ed.*, McGraw-Hill Education, 2020.
R2. D. J. Griffith, ***Introduction to Electrodynamics***, 4th *Ed.*, Pearson Education, 2015.
R3. A. Beiser, ***Concept of Modern Physics***, 6th *Ed.*, McGraw-Hill Education, 2009.

Online Resources:

1. https://nptel.ac.in/courses/115102026/: by Prof. M. R. Shenoy, IIT Delhi
2. https://nptel.ac.in/courses/113104012/: by Prof. M. Katiyar and Prof. D. Gupta, IIT Kanpur
3. https://ocw.mit.edu/courses/physics/8-04-quantum-physics-i-spring-2013/
4. http://www.ilectureonline.com/lectures/subject/PHYSICS
5. https://ocw.mit.edu/courses/physics

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Analyze wave properties of light like interference and diffraction and apply them in communications.
CO2	Develop Maxwell's equations from basic laws of electromagnetism and apply them to understand the properties of electromagnetic waves.
CO3	Analyze wave-particle duality to understand radiation-matter interaction.
CO4	Develop and apply Schrödinger's equations to fields like bound particle, potential barrier etc.
CO5	Investigate the basic principle, properties, operations and applications of laser & optical fiber in different fields like communication, industry, medicine, research etc.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	1	1						1	3	1	1
CO2	3	3	2	2	2						2	3	1	2
CO3	2	2	3	3	2						1	3	2	1
CO4	3	2	2	2	2						1	2	1	1
CO5	3	3	3	3	3						2	3	2	2

Category	Code	Basic Electronics Engineering	L-T-P	Credits	Marks
UCR	EC1001		3-0-0	3	100

Objectives	The objectives of this course is to study the concepts and functionalities of electronic devices, tools and instruments, general specifications and deployability of the electronic devices, and assemblies in engineering applications.
Pre-Requisites	Knowledge of physics, chemistry, and introductory idea of semiconductors studied at the higher secondary level is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, and planned lectures to make the sessions interactive with problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Semiconductor & Diodes**: Types of semiconductors, Majority and minority charge carriers, Energy Band diagram, Transport phenomena, Law of Mass Action, Drift and Diffusion Current; Semiconductor Diode – Ideal vs. Practical, Diode equivalent circuits, Diode Applications – Rectifiers, Clipper, Clamper, and Switch, Zener Diode – Operation and Applications.	**9 Hours**
Module-2	**Transistors**: Bipolar Junction Transistor (BJT) – Construction, Operation, Amplifying action, CB, CE, and CC configurations, Load line analysis, Fundamentals of biasing, Fixed biasing; Field Effect Transistor (FET) – Construction, Working principles, Characteristics of JFET & MOSFET.	**9 Hours**
Module-3	**Op-Amps, Oscillators, and Measuring Instruments**: Introduction, Characteristics of ideal Op-Amp, Virtual Ground Concept, Pin Configuration, Applications of Op-Amp – Inverting & Non Inverting Amplifier, Summing Amplifier, Differentiator, Integrator; Oscillators – Barkhausen's Criteria, RC phase shift oscillator, Wien bridge oscillator; Measuring Instruments – Construction & working of CRO, DSO, and Multimeter.	**8 Hours**
Module-4	**Digital Logic**: Number systems and its conversion, Signed & unsigned numbers, Binary arithmetic, 1's and 2's complement arithmetic, Basic & universal Logic gates, Boolean algebra and identities, Algebraic reduction using postulates of boolean algebra, Realization of boolean functions using universal logic gates.	**8 Hours**
Module-5	**Signals & Communication Systems**: Signals – Continuous & Discrete-time, Analog & Digital, Energy & Power, Spectrum of a signal, Fourier Transform (Exponential, Sine and Cosine); Communication Systems – Block diagram, Modulation, Time & Frequency domain representation of AM, Carrier & side-band power calculation, Generation (Square law modulator), Demodulation (Synchronous demodulator).	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. R. L. Boylestad and L. Nashelsky, ***Electronic Devices and Circuit Theory***, 11th *Ed.*, Pearson Education, 2015.

T2. A. Agarwal and J. Lang, ***Foundations of Analog and Digital Electronic Circuits***, 1st *Ed.*, Morgan Kaufmann, 2005.
T3. R. P. Singh and S. D. Sapre, ***Communication Systems: Analog and Digital***, 3rd *Ed.*, McGraw-Hill Education, 2014.

Reference Books:

R1. A. S. Sedra and K. C. Smith, ***Microelectronic Circuits***, 7th *Ed.*, Oxford University Press, 2009.
R2. V. K. Mehta and R. Mehta, ***Principles of Electronics***, 10th *Rev. Ed.*, S. Chand Publishing, 2006.
R3. A. Kumar, ***Fundamentals of Digital Circuits***, 3rd *Ed.*, PHI Learning, 2014.

Online Resources:

1. https://nptel.ac.in/courses/117103063/: by Prof. G. Barua, IIT Guwahati
2. https://nptel.ac.in/courses/108101091/: By Prof. M. B. Patil, IIT Bombay
3. https://nptel.ac.in/courses/122106025/: By Prof. T. S. Natarajan, IIT Madras
4. https://nptel.ac.in/courses/117107095/: Web Content by IIT Roorkee
5. https://nptel.ac.in/courses/122104013/: Web Content by IIT Kanpur
6. https://nptel.ac.in/courses/117106086/: By Prof S.Srinivasan, IIT Madras
7. https://nptel.ac.in/courses/117103064/: By Prof A. Mahanta, IIT Guwahati

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand basic principles of semiconductor diodes and their applications.
CO2	Understand the construction, characteristics, configurations, and applications of transistors.
CO3	Analyze the characteristics of Op-Amps & use them to design circuits for various applications.
CO4	Convert numbers using different number systems and apply boolean algebra on them.
CO5	Explain different types of signals and their characteristics using Fourier analysis tools.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	2	2						2	2	2	2
CO2	3	3	3	2	3						2	3	3	2
CO3	3	3	3	3	3						3	2	3	2
CO4	2	2	2	2	2						2	3	2	1
CO5	3	3	2	2	3						2	2	2	1

Category	Code	Basic Electrical Engineering	L-T-P	Credits	Marks
UCR	EE1001		3-0-0	3	100

Objectives	The objective of this course is to introduce the basic concepts of electricity and magnetism, DC & AC networks, principles of different electrical machines and measuring instruments, protection systems and safety requirements.
Pre-Requisites	Basic knowledge of intermediate physics and mathematics such as calculus, ordinary differential equations, matrices etc. is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Electric Circuits**: Charge & current, Ideal & practical sources, Source conversion, Characteristics of circuit elements, Kirchhoff's current and voltage laws, Current & voltage division rule; Resistive Network Analysis – Node voltage & Mesh current (controlled & uncontrolled sources), Thevenin's theorem, Norton's theorem, Superposition theorem, Maximum power transfer theorem; Transient Analysis – Introduction, Differential equations, Time-domain analysis of first-order RL & RC circuits, Time constant.	**12 Hours**
Module-2	**Single-phase AC Circuit Analysis**: Representation of sinusoidal waveforms, Peak and RMS values, Phasor representation, AC power analysis, Power factor, Improvement of power factor, Analysis of series & parallel AC circuits (R, L, C, RL, RC, RLC circuits), Series resonance, Q-factor.	**8 Hours**
Module-3	**Three-phase AC Circuit Analysis**: Representation of 3-phase AC voltage, Phase sequence, Balanced load and source, Voltage and current relationship in star and delta connections, AC power analysis; Introduction to generation, transmission, and distribution of power system network, Residential wiring, Earthing, Electrical safety.	**7 Hours**
Module-4	**Electromagnetism**: Magnetic flux, Reluctance, Series & parallel magnetic circuits, Magnetic materials, Hysteresis loop; Single-phase Transformer – Construction & working, Ideal and practical transformer, EMF equation, Equivalent circuit & phasor diagram of transformer on load and no-load, Shifting of impedances.	**8 Hours**
Module-5	**DC Machine**: Construction, Working of generator and motor, EMF equation of generator, Back EMF of Motor, Classification based on excitation system; **AC Machine**: Construction and working of a 3-phase induction motor, Synchronous speed, Concept of slip, Construction, working, and types of single-phase induction motor.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. C. K. Alexander and M. N. O. Sadiku, ***Fundamentals of Electric Circuits***, 6th *Ed.*, McGraw-Hill, 2017.
T2. E. Hughes, ***Electrical & Electronic Technology***, 9th *Ed.*, Pearson, 2004.
T3. G. Rizzoni, ***Principles and Applications of Electrical Engineering***, 5th *Ed.*, McGraw Hill, 2006.

Reference Books:

R1. A. E. Fitzgerald, D. E. Higginbotham, and A. Grabel, ***Basic Electrical Engineering***, 5th *Ed.*, Tata McGraw Hill.
R2. B. L. Theraja and A. K. Theraja, ***Textbook of Electrical Technology (Vol-I)***, 23rd *Ed.*, S. Chand & Co.Ltd., 2002.
R3. L. S. Bobrow, ***Foundations of Electrical Engineering***, Asian Edition, Oxford Univ. Press, 2013.

Online Resources:

1. https://nptel.ac.in/courses/108/105/108105053/: by Prof. G. D. Roy, Prof. N. K. De, and Prof. T. K. Bhattacharya, IIT Kharagpur
2. https://nptel.ac.in/courses/108/108/108108076/: By Prof. L. Umanand, IISc Bangalore
3. https://www.electrical4u.com/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand and analyze basic electrical network with direct current source.
CO2	Measure current, voltage, and power of series RLC circuit excited by single-phase AC circuit.
CO3	Analyze 3-phase electrical systems and explore the engineering of practical power systems.
CO4	Explain different concepts of magnetic fields and apply them to single-phase transformers.
CO5	Describe the working principles of rotating electrical machines.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	2	2	1						2	2	2
CO2	3	3	2	3	3	1						3	3	2
CO3	3	2	1	1	3	2						2	3	2
CO4	3	2	2	1	3	1						3	2	1
CO5	3	3	2	1	1	1						2	2	1

Category	Code	Engineering Mechanics	L-T-P	Credits	Marks
UCR	ME1001		2-0-0	2	100

Objectives	The objective of this course is to introduce engineering mechanics with the knowledge of statics, force equilibrium and free body diagrams, analysis of structures, beams and associated stresses along with elementary ideas on kinematics, dynamics, and mass moment of inertia.
Pre-Requisites	Knowledge of physics & mathematics and basic analytical skills is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Basic concepts of vector analysis, Equilibrium of forces in two and three dimensions, Rectangular components of a force and its application, Varignon's theorem; Motion of a particle – Equation of motion, D'Alembert's principle, Planar cartesian & polar coordinates, Motion with constraints.	**8 Hours**
Module-2	**Virtual Work and Energy**: Virtual displacements, Principle of virtual work for particle and ideal system of rigid bodies, degrees of freedom; **Analysis of Structures**: Trusses, Assumptions, Simple plane truss, Analysis by method of joints and method of sections.	**6 Hours**
Module-3	**Center of Gravity & Moments of Inertia**: Centroid and Centre of Gravity, Centroid of simple and composite sections, Theorems of Pappus and Guldinus, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Area moment of inertia of standard sections and composite sections, Mass moment inertia of circular plate, Cylinder, Cone, Sphere, parallelepiped.	**7 Hours**
Module-4	**Stress & Strain**: Normal stress, Shear stress, State of stress at a point, Ultimate strength, Allowable stress, Factor of safety; Relationship between elastic constants, Mechanical properties of materials, Stress-Strain behaviour; Flexural Loading – Shear force and bending moment in beams, Shear force and bending Moment Diagrams, Bending and shear stresses.	**7 Hours**
	Total	**28 Hours**

Text Books:

T1. M. K. Harbola, ***Engineering Mechanics***, 2nd *Ed.*, Cengage Learning, 2018.
T2. G. H. Ryder, ***Strength of Materials***, 3rd *Ed.*, Macmillan Press, 1969.

Reference Books:

R1. J. L. Meriam and L. G. Kraige, ***Engineering Mechanics: Statics***, 8th *Ed.*, Wiley India, 2014.
R2. R. K. Rajput, ***Strength of Materials: Mechanics of Solids***, 7th *Ed.*, S. Chand Publications, 2018.
R3. S. Timoshenko, D. H. Young, S. Pati, and J. V. Rao, ***Engineering Mechanics***, 5th *Ed.*, McGraw-Hill Education, 2013.

Online Resources:

1. https://nptel.ac.in/courses/122104015/: by Prof. M. Harbola, IIT Kanpur.
2. https://nptel.ac.in/courses/105105108/: by Prof. S. Bhatacharya, IIT Kharagpur)

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand and analyze using the principles of mechanics to solve problems in statics.
CO2	Articulate virtual work and investigate the nature of forces in the members of simple trusses.
CO3	Explain area and mass moments of inertia and their application in structural design.
CO4	Describe the mechanics of deformable bodies and mechanical properties of materials.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	1	2	3	2					2	2	2	2
CO2	3	2	1	2	3	1					2	2	2	2
CO3	2	2	1	2	3	2					2	1	2	1
CO4	2	2	1	2	3	2					2	1	2	1

Category	Code	Engineering Thermodynamics	L-T-P	Credits	Marks
UCR	ME1002		2-0-0	2	100

Objectives	The objective of this course is to introduce laws of thermodynamics with emphasis on various equilibrium processes and their applications in practical domains like power plants, refrigerators and internal combustion engines.
Pre-Requisites	Knowledge of physics & mathematics and basic analytical skills is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction, Basic concepts, System, Control volume, Surrounding, Boundaries, Universe, Types of systems, Macroscopic and microscopic viewpoints, Concept of continuum, Thermodynamic equilibrium, State, Property, Process, Exact & inexact differentials, Point & path functions, Cycle, Quasi-static process, Reversibility and irreversibility, Pressure measurement, Zeroth law of thermodynamics, Temperature, Principles of thermometry, Constant volume gas thermometer, Temperature scale.	**7 Hours**
Module-2	Pure Substances, p-v, T-v, T-s and h-s diagrams, Phase Transformations, Triple point and critical state, properties during change of phase, Dryness Fraction, Property tables. Brief discussionon the First law for cycle, closed system and open system (steady flow energy equation, SFEE), Perpetual Motion Machines, PMM1.	**7 Hours**
Module-3	Introduction to Second Law of Thermodynamics, Kelvin-Planck and Clausius' Statements and their Equivalence, Corollaries, PMM2, Carnot's Principle and Cycle, Entropy, Clausius' Inequality, Principle of Entropy and its application, T-s plot.	**7 Hours**
Module-4	Applications of Thermodynamics, Brief description and working principles of Steam Power Plant, Refrigerators and Heat pump, I.C. Engines (two-stroke and four-stroke, petrol and diesel) and Aircraft Propulsion Engines, Brayton Cycle, Rankine Cycle, Comparison.	**7 Hours**
	Total	**28 Hours**

Text Books:

T1. R. E. Sonntag and C. Borgnakke, ***Fundamentals of Thermodynamics***, 7th *Ed.*, John Wiley, 2014.
T2. Y. A. Cengel and M. A. Boles, ***Thermodynamics – An Engineering Approach***, 7th *Ed.*, McGraw-Hill Education,2011.

Reference Books:

R1. P. K. Nag, ***Engineering Thermodynamics***, 5th *Ed.*, McGraw-Hill Education, 2013.
R2. Y. V. C. Rao, ***An Introduction to Thermodynamics***, 2nd *Ed.*, University Press, 2004.

P.T.O

Online Resources:

1. https://nptel.ac.in/courses/112105123/: by Prof. S. Chakraborty, IIT Kharagpur
2. https://www3.nd.edu/~powers/ame.20231/notes.pdf
3. https://ocw.mit.edu/courses/chemistry/5-60-thermodynamics-kinetics-spring-2008/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Articulate the concepts of thermodynamic properties, equilibrium, temperature and pressure.
CO2	Apply first laws of thermodynamics to analyze turbine, compressors, heat exchangers and nozzles by using steam table and ideal gas equation.
CO3	Analyze the limitations of the First law and evaluate the available energy and irreversibility.
CO4	Analyze power cycles and refrigeration cycles and their applications in the real world.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2						2	2	2	2
CO2	3	3	2	2	1						2	3	3	2
CO3	3	3	3	3	2						3	2	3	2
CO4	3	3	3	2	2						2	3	2	1

Category	Code	Computer Programming	L-T-P	Credits	Marks
UCR	CS1001		3-0-0	3	100

Objectives	The objective of this course is to introduce fundamentals of computer programming using the C programming language starting with simple programs to advanced topics like structures, pointers, file processing and pre-processor directives for solving various engineering problems through computer programming.
Pre-Requisites	Basic analytical and logical understanding including basic knowledge and usage of computers is required for this course. Prior experience with any other programming language will be beneficial.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to computers and programming, operating system, compilers, interpreters, algorithm, flowchart, pseudocode etc., structure of C program, character set, identifier, keywords, constants, variables, data types, operators, expressions, statements, operator precedence and associativity, type conversion, input/output statements.	**8 Hours**
Module-2	Decision making and branching: if, if-else, nested if-else, else-if ladder and switch constructs, iterative execution of code using loops: while, for, do-while, nested loops, controlling loop behavior using jump statements (break, continue, goto) and exit statements.	**8 Hours**
Module-3	Arrays (1-D & 2-D), declaration and initialization of arrays, accessing array elements, operations on arrays - insertion, deletion, searching, sorting (selection sort), merging etc., character arrays and strings, initialization, input & output of strings, operations on strings, array of strings, string handling functions.	**9 Hours**
Module-4	User-defined functions, declaration and definition, parameter passing by value, functions returning values, idea on call by reference, passing arrays to functions, recursion, storage classes - auto, register, static, extern, Structures and Unions - definition, initialization, accessing members, array of structures, arrays within structures, structures and functions, self-referential structures.	**9 Hours**
Module-5	Understanding pointers, declaration, initialization, accessing variables using pointers, pointer expressions, scale factor, chain of pointers, using pointers with arrays, strings, functions and structures, dynamic memory management, pre-processor directives, command line arguments, basics of file handling.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. E. Balagurusamy, ***Programming in ANSI C***, 7th *Ed.*, McGraw-Hill Education, 2017.
T2. Y. Kanetker, ***Let Us C***, 16th *Ed.*, BPB Publications, 2018.

Reference Books:

R1. B. W. Kernighan and D. M. Ritchie, ***The C Programming Language***, 2nd *Ed.*, Pearson Education, 2015.
R2. H. Schildt, ***C: The Complete Reference***, 4th *Ed.*, McGraw-Hill, 2017.
R3. A. Kelley and I. Pohl, ***A Book on C***, 4th *Ed.*, Pearson Education, 2008.
R4. B. Gottfried, ***Schaum's Outline of Programming with C***, 3rd *Ed.*, McGraw-Hill, 2017.

Online Resources:

1. https://nptel.ac.in/courses/106104128: by Prof. S. Nandakumar, IIT Kanpur
2. https://nptel.ac.in/courses/106105171: Prof. A. Basu, IIT Kharagpur
3. https://nptel.ac.in/courses/106106210: by Prof. J. Viraraghavan, IIT Madras
4. http://www.stat.cmu.edu/~hseltman/c/CTips.html
5. http://www.c-faq.com/
6. https://www.learn-c.org/
7. http://www2.its.strath.ac.uk/courses/c/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Formulate logic of a problem and write C programs using variables, expressions and I/O.
CO2	Develop structured C programs involving decision making using different control constructs.
CO3	Solve problems involving similar set of data items and write C programs using arrays.
CO4	Design modular C programs and handle heterogeneous data items using structures & unions.
CO5	Develop complex C programs with file processing using advanced features of C programming.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	2							2	3	2	2
CO2	3	3	3	2							2	3	2	2
CO3	3	3	1	2							2	3	2	2
CO4	3	2	1	2							2	3	2	2
CO5	3	3	1	2							2	3	2	2

Category	Code	Constitution of India & Professional Ethics	L-T-P	Credits	Marks
UMC	HS0001		3-0-0	0	100

Objectives	The objective of this mandatory course is to provide understanding of basic concepts of Indian Constitution and various organs created by the constitution including their functions. This course also introduces a holistic perspective towards life by understanding of the human reality and the rest of existence.
Pre-Requisites	Basic knowledge of Indian history, overall idea on India's political system, a positive bent of mind, zeal to know the essence of human existence and nature.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required and each session is planned to be interactive.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to Indian Constitution, Preamble, Salient Features, Fundamental Rights, Fundamental Duties, Features of Federal Structure, The Union Legislature – The Parliament, The Lok Sabha and Rajya Sabha, Composition, Powers and Functions.	**9 Hours**
Module-2	Union Executive, President of India (with powers and functions), Vice-President, The Council of Ministers and the Prime Minister – Powers and Functions; State Government, The State Legislature -– Composition, Powers and Functions, State Executive – Governor, Chief Minister, and State Council of Ministers.	**9 Hours**
Module-3	Professional Ethics, Basic terms – Moral, Ethics, Ethical Dilemma, Emotional Intelligence, View on Ethics by Aristotle, Governing Factors of an Individual's Value System, Personal and Professional Ethics.	**7 Hours**
Module-4	Profession, Professional, Professionalism, Professional Accountability, Professional Risks, Profession and Craftsmanship, Conflict of Interest, Ethics in Engineering – Purpose and Concept of Engineering Ethics, Engineering as Social Experimentation, Issues in Engineering Ethics, Engineers' Responsibility – Safety & Risk, Risk-Benefit Analysis, Causes of an Accident, Preventive Measures.	**9 Hours**
Module-5	Value Education, Self-exploration as the Process for Value Education, Basic Human Aspirations – Continuous Happiness and Prosperity, Current Scenario, Method to Fulfill the Basic Human Aspirations, Harmony in the Human Being, Family, Society and Nature or Existence.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. D. D. Basu, ***Introduction of Constitution of India***, 22nd *Ed.*, LexisNexis, 2015.
T2. R. Subramanian, ***Professional Ethics***, 2nd *Ed.*, Oxford University Press, 2017.
T3. R. R. Gaur, R. Asthana, and G. P. Bagaria, ***A Foundation Course in Human Values and Professional Ethics***, 2nd *Ed.*, Excel Books, 2019..

Reference Books:

R1. M. Laxmikanth, ***Indian Polity***, 5th *Ed.*, McGraw Hill, 2011.

R2. K. Subas, ***An Introduction to India's Constitution and Constitutional Law***, 5th *Ed.*, National Book Trust India, 2011.
R3. C. E. Harris, M. S. Pritchard, and M. J. Robins, ***Engineering Ethics – Concepts and Cases***, 4th *Ed.*, Cengage Learning, 2012.
R4. A. N. Tripathi, ***Human Values***, 3rd *Ed.*, New Age International, 2019.

Online Resources:

1. https://nptel.ac.in/courses/129106411: by Prof. S. Bhat, IIT Madras
2. https://www.india.gov.in/sites/upload_files/npi/files/coi_part_full.pdf
3. https://www.india.gov.in/my-government/constitution-india/constitution-india-full-text

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe basics of Indian constitution, fundamental laws and rights of Indian citizen.
CO2	Articulate the union executive system and constitutional institutions of center and state.
CO3	Understand basic purpose of profession, professional ethics and various moral and social issues.
CO4	Realize the rights, responsibilities, and ethical principles of an Engineer at various levels.
CO5	Understand importance of human values and live with harmony in family, society, and nature.

Program Outcomes Relevant to the Course:

PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1						2	1	1	1	1	1		1	
CO2						2	2	3	2	1	2		1	
CO3						3	3	3	2	1	2		2	
CO4						2	3	3	2	2	2		2	
CO5						3	3	3	2	1	3		2	

Category	Code	Environmental Science & Engineering	L-T-P	Credits	Marks
UMC	CH0001		3-0-0	0	100

Objectives	The objective of this course is to introduce essential aspects of environmental science for engineering students. The course covers ecology, ecosystems, air and water pollution, management of municipal solid wastes, hazardous wastes and e-waste, along with environmental laws and UN conferences.
Pre-Requisites	Basic knowledge of physics, chemistry and biology is required for this course.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required with focus on importance of environment, examples and case studies.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Ecology, Ecosystems and Biogeochemical Cycles: Introduction to environmental science and engineering, Ecological perspective, Ecosystems and processes, Trophic pyramids, Biodiversity of species, Water, Oxygen, Nitrogen and Carbon cycle, Environmental gradient and tolerance levels of environmental factors.	**9 Hours**
Module-2	Water and Wastewater Treatment: Water quality standards and parameters, water table, aquifer, pre-treatment, conventional treatment processes of water, DO, BOD, COD and microbial wastewater treatment.	**9 Hours**
Module-3	Atmospheric Chemistry, Soil Chemistry and Noise Abatement: Atmospheric chemistry, air pollution and associated control equipment, climate change, soil chemistry, noise standards, noise measurement and noise abatement.	**8 Hours**
Module-4	Waste Management: Types and management of MSW (Municipal Solid Waste), hazardous waste and e-waste, Introduction to LCA (Life Cycle Assessment).	**8 Hours**
Module-5	EIA, EIS, Environmental Laws and Human Health: Environmental Audit, EIA (Environmental Impact Assessment), EIS (Environmental Impact Statement), Indian environmental laws, UN Conferences, Human population and the environment.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. G. M. Masters and W. P. Ela, ***An Introduction to Environmental Engineering and Science***, 3rd *Ed.*, PHI Learning, 2015.
T2. G. Kiely, ***Environmental Engineering***, Spl. Indian Edition, McGraw Hill, 2007.

Reference Books:

R1. M. L. Davis and S. J. Masten, ***Principles of Environmental Engineering and Science***, 2nd *Ed.*, McGraw-Hill, 2017.
R2. H. D. Kumar and U. N. Dash, ***Environmental Studies***, 2nd *Ed.*, IndiaTech Publishers, 2017.

Online Resources:

1. http://nptel.ac.in/courses/120108002/: Aquatic Biodiversity and Environmental Pollution.
2. http://nptel.ac.in/courses/120108004/: Environment Management.

3. http://nptel.ac.in/courses/120108005/: Municipal Solid Waste Management.
4. https://www.epa.gov/environmental-topics/: All Current Environmental Issues.

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe the concepts of ecology, ecosystems, and biogeochemical cycles in the environment.
CO2	Explain the process of water and wastewater treatment for prevention of water pollution.
CO3	Understand the pollutants in the environment and explore the principles for their eradication.
CO4	Explore waste minimization and management of different types of wastes generated.
CO5	Understand EIA, EIS, and other environmental laws for prevention of pollution.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	3	2	1	3	1	2		1	2		1	
CO2	2	2	3	2	1	3	1	2		1	2		1	1
CO3	2	2	3	2	1	3	1	1		1	2		1	1
CO4	2	2	3	2	1	3	2	2		1	2		1	1
CO5	2	2	3	2	1	3	3	2		1	2		1	1

Category	Code	Probability & Statistics	L-T-P	Credits	Marks
UCR	MT1002		3-0-0	3	100

Objectives	The objective of this course is to familiarize the perspective engineers with the knowledge and concepts of probability and statistics which are essential to study non-deterministic systems.
Pre-Requisites	Basics of sets, counting techniques, differential and integral calculus of one variable and coordinate geometry of two and three dimensions.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Measures of central tendencies, Elementary probability, Conditional probability, Bayes' Rule (related problems only), Random variable, Binomial & Hypergeometric distribution, Mean and variance.	**8 Hours**
Module-2	The Poisson approximation to Binomial Distribution, Poisson Process, Geometric Distribution & Multinomial Distribution, Continuous random variables, Normal Distribution, Normal Approximation to the Binomial Distribution, Uniform Distribution, Exponential Distribution, Joint Discrete Distribution.	**9 Hours**
Module-3	Populations and Samples, Sampling Distribution of Mean (σ known), Sampling Distribution of Mean (σ unknown) & Sampling Distribution of Variance; Point Estimation of mean, Interval Estimation of mean, Tests of hypotheses and errors involved, Hypotheses concerning one mean, Inference concerning two mean, Estimation of variance, Hypotheses concerning one variance, Hypotheses concerning two variances.	**10 Hours**
Module-4	Estimation of Proportions, Hypotheses Concerning proportion (one & several), Analysis of $r \times c$ table (Contingency table), Goodness of fit.	**7 Hours**
Module-5	The method of least squares, Inferences based on the least square estimation, Curvilinear Regression, Checking the adequacy of the model, Correlation, Analysis of Variance, General principle, Completely Randomized Design, Randomized Block Design.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. R. A. Johnson, ***Miller & Freund's - Probability and Statistics for Engineers***, 8th *Ed.*, PHI Learning, 2011.

Reference Books:

R1. W. Mendenhall, R. J. Beaver, and B. M. Beaver, ***Probability and Statistics***, 14th *Ed.*, Cengage Learning, 2014.

R2. R. E. Walpole, R. H. Myers, S. L. Myers, and K. E. Ye, ***Probability & Statistics for Engineers & Scientists***, 9th *Ed.*, PHI Learning, 2012.

Online Resources:

1. https://nptel.ac.in/courses/111/105/111105041/: by Prof. S. Kumar, IIT Kharagpur
2. https://ocw.mit.edu/courses/mathematics/18-440-probability-and-random-variables-spring-2014/lecture-notes/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Apply the concepts of probability and random variables to evaluate probabilities of events.
CO2	Apply different discrete and continuous probability models to solve real life problems.
CO3	Apply the concepts of sampling to estimate population parameters and test hypothesis.
CO4	Test the goodness of a model and apply it to real life problems.
CO5	Apply regression model and ANOVA to study the characteristics of data sets.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2						2	2	1	1
CO2	3	3	3	3	3						2	2	1	1
CO3	3	2	3	2	2						2	2	1	1
CO4	3	3	3	3	3						2	3	2	1
CO5	3	3	3	3	3						2	3	2	1

Category	Code	Data Structures & Algorithms	L-T-P	Credits	Marks
UCR	CS1003		3-0-0	3	100

Objectives	To understand the abstract data types and to solve problems using data structures such as stacks, queues, linked lists, hash tables, binary trees, heaps, binary search trees, graphs and writing programs for these solutions.
Pre-Requisites	Knowledge of programming in C, specifically on structures, pointers, functions, recursion etc., are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to data structures, classification of data structures, algorithmic notation, complexity of algorithms, asymptotic notations, abstract data types. Arrays - introduction, representation of arrays (row and column major representation), basic operations on array (traverse, insert, delete, search), sparse matrix, representation of sparse matrix using triplet form, operations on sparse matrix (addition, transpose)	**8 Hours**
Module-2	ADT Stack - stack model, representation of stack using array, basic operations with analysis, applications- recursion, and conversion of infix to post fix expression, evaluation of postfix expression. ADT Queue - queue model, representation using array, basic operations with analysis, circular queue, introduction to priority queue and double ended queue.	**8 Hours**
Module-3	Linked list - introduction, types of linked list (single, double, circular), representation in memory, operations on linked list (traverse, search, insert, delete, sort, merge) in each type with analysis. Representation of polynomial and its operations (addition, multiplication), implementation of stack and queue using linked list.	**9 Hours**
Module-4	Tree - terminology, representation, binary tree - tree traversal algorithms with and without recursion. Binary search tree, Operations on Binary Search Tree with analysis, threaded binary tree, general tree, Height balanced tree (AVL tree), m-way search trees, B-trees. Graph - terminology, representation (adjacency matrix, incidence matrix, path matrix, linked representation), graph traversal (BFS, DFS), Dijkstra's single source shortest path algorithm, Warshall's all pair shortest path algorithm, topological sort.	**9 Hours**
Module-5	Sorting algorithms - bubble sort, selection sort, insertion sort, quick sort, merge sort, radix sort, heap sort. Hashing- hash functions and hashing techniques. collision resolution techniques- linear probing, quadratic probing, chaining.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. M. A. Weiss, ***Data Structures and Algorithm Analysis in C***, 2nd *Ed.*, Pearson Education, 2002.
T2. E. Horowitz, S. Sahni, S. A-Freed, ***Fundamentals of Data Structures in C***, 2nd *Ed.*, Univ. Press, 2008.

Reference Books:

R1. A. M. Tenenbaum, Y. Langsam, and M. J. Augenstein, ***Data Structures Using C***, 3rd *Ed.*, Pearson Education, 2007.
R2. J. P. Tremblay and P. G. Sorenson, ***An Introduction to Data Structures with Applications***, 2nd *Ed.*, McGraw Education, 2017.
R3. S. Lipschutz, ***Data Structures***, 1st *Revised Ed.*, McGraw Education, 2014.

Online Resources:

1. https://nptel.ac.in/courses/106/106/106106127/: By Prof. H. A. Murthy, Prof. S. Balachandran, and Dr. N. S. Narayanaswamy, IIT Madras
2. https://nptel.ac.in/courses/106/102/106102064/: By Prof. N. Garg, IIT Delhi
3. https://nptel.ac.in/courses/106/106/106106130/: By Dr. N. S. Narayanaswamy, IIT Madras
4. https://www.geeksforgeeks.org/data-structures/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Analyze performance of algorithms and implement operations on arrays and sparse matrices.
CO2	Apply the basic operations of stacks and queues to solve real world problems.
CO3	Implement different types of linked list operations and their applications.
CO4	Represent data using trees & graphs to use them in various real life applications.
CO5	Analyze various sorting algorithms and explore different hashing techniques.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	2	2	2	1					1	2	2	1
CO2	3	3	3	2	2	2					1	2	1	1
CO3	3	3	2	2	2	1					1	2	1	1
CO4	3	3	3	3	2	2					1	2	2	1
CO5	3	3	3	2	2	2					1	2	3	1

Category	Code	Basic Electronics Engineering Lab	L-T-P	Credits	Marks
UCR	EC1002		0-0-2	1	100

Objectives	The objective of this practical course if to learn the concepts and functionalities of the electronic devices, tools and instruments. Students will understand general specifications and deployability of the electronic devices and assemblies, and also develop confidence in handling and usage of electronic devices, tools and instruments in engineering applications.
Pre-Requisites	Knowledge on intrinsic and extrinsic Semiconductors, Physics and Chemistry of Higher Secondary Science level.
Teaching Scheme	Regular laboratory experiments to be conducted under the supervision of teachers and demonstrators with the help of ICT, as and when required along with pre-lab session and demonstration for each experiment.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Identification of electronic components and devices (Testing of semiconductor diodes and transistors using digital multi-meter).
2	Understand and use oscilloscope, signal generator to view waveforms and measure amplitude and frequency of a given waveform.
3	Generate V-I characteristics of semiconductor diode and determine its DC and AC resistances.
4	Implement clipper circuits (positive clipper and negative clippers) and observe its output waveforms and compare them with theoretically analyzed results.
5	Design half-wave and full-wave rectifier circuits without and with capacitor filter, record the waveforms and measure average & RMS values of the rectified output.
6	Generate and analyze the static characteristics of BJT in CE configuration.
7	Design the DC biasing (Fixed) circuit of transistor in CE configuration and determine its operating point.
8	Analyze the static characteristics of FET in CS configuration.
9	Apply Op-Amp in inverting, non-inverting, integrating and differentiating configurations & record their input-output waveforms.
10	Understand and verify truth tables of various logic gates.
11	Apply NAND and NOR as Universal logic gates.
12	Analyze and implement of R.C phase shift Oscillator using Op-AMP.
13	Design and simulate BJT and FET I/O characteristics using OrCAD PSpice/ Multisim.
14	Design and analysis of AM modulator and demodulator.

Text Books:

T1. R. L. Boylestad and L. Nashelsky, ***Electronic Devices and Circuit Theory***, 11th *Ed.*, Pearson Education.
T2. A. S. Sedra and K. C. Smith, ***Microelectronic Circuits***, 7th *Ed.*, Oxford University Press.

Reference Books:

R1. V. K. Mehta and R. Mehta, ***Principles of Electronics***, 3rd *Ed.*, S. Chand Publishing, 1980.

Online Resources:

1. http://vlab.co.in/ba_labs_all.php?id=1
2. http://iitg.vlab.co.in/?sub=59&brch=165

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Recognize electronic components, measuring instruments, semiconductor diodes and their use.
CO2	Determine the characteristics of transistors and use them in various electronic circuits.
CO3	Explore design and testing of Op-Amp and design circuits for various applications using them.
CO4	Design and test digital circuits using logic gates for different applications.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1									2	2	2
CO2	3	3	2	1								3	3	2
CO3	2	2	2	1							2	3	2	2
CO4	2	2	3								2	3	3	2

Category	Code	Basic Electrical Engineering Lab	L-T-P	Credits	Marks
UCR	EE1002		0-0-2	1	100

Objectives	The objective of this practical course is to expose the students to different electrical components and basic safety rules and regulations, give hands on practice about different measuring and protection equipment and their operations to understand and verify the concept of electrical & magnetic circuits and electric machines.
Pre-Requisites	Basic knowledge of different electrical components and different analysis techniques of electrical and magnetic circuits. Topics taught in Basic Electrical Engineering theory class are essential to conduct the experiments.
Teaching Scheme	Regular laboratory experiments conducted under supervision of the teacher. Demonstration will be given for each experiment.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Measurement of power consumption & power factor of a fluorescent lamp and its power factor improvement.
2	Measurement of winding resistances of a DC compound machine.
3	Power & power factor measurement of three-phase load by two-wattmeter method.
4	Connection and testing of a single-phase energy meter.
5	Determination of open circuit characteristics (OCC) of a DC shunt generator.
6	Calculation of power & power factor in series R-L-C circuit excited by single-phase supply.
7	Determination of no-load parameters through OC Test of single-phase transformer.
8	Study of capacitor start and run single-phase induction motor/fan motor.
9	Study and verification of Thevenin's Theorem and Norton's Theorem.
10	Draw the B-H curve of a magnetic Specimen.
11	Starting of three-phase induction motor.
12	Voltage Regulation & efficiency of single-phase transformer by direct loading.

Text Books:

T1. A. Husain, ***Fundamentals of Electrical Engineering***, 4th *Ed.*, Dhanpat Rai & Co., 2016.
T2. B. L. Thereja & A. K. Thereja, ***A Textbook of Electrical Technology***, 23rd *Ed.*, S. Chand & Co.

Reference Books:

R1. J. B. Gupta, ***A Textbook of Electrical Science***, S. K. Kataria & Sons, 2013.
R2. B. R. Gupta and V. Singhal, ***Electrical Science***, S. Chand & Co, 2005.

Online Resources:

1. https://nptel.ac.in/courses/108/105/108105053/: by Prof. G. D. Roy, Prof. N. K. De, and Prof. T. K. Bhattacharya, IIT Kharagpur
2. https://nptel.ac.in/courses/108/108/108108076/: By Prof. L. Umanand, IISc Bangalore
3. https://www.electrical4u.com/
4. www.electronics-tutorials.ws/dc-circuits

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Get an exposure to common electrical components and their ratings.
CO2	Develop electrical circuits and measure its characteristics using different measuring instruments and deploy different protective devices of appropriate ratings.
CO3	Understand the usage of common electrical measuring instruments.
CO4	Understand the basic characteristics of transformers and electrical machines.
CO5	Verify different network theorems and magnetic properties.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1			2		1		1	1	1	1	1	1	2
CO2	2			2		1		2	1	1	2	1	1	1
CO3	1			3		2		2	1	1	1	2	1	2
CO4	1			2		2		1	1	2	2	2	1	2
CO5	1			1		1		1	1	1	1	2	1	2

Category	Code	Computer Programming Lab	L-T-P	Credits	Marks
UCR	CS1002		0-0-4	2	100

Objectives	To enable the students to analyze problems, formulate and implement solutions using the C programming language. The students will write C programs using proper logic to solve a problem and execute them on a computer.
Pre-Requisites	Basic analytical and logical understanding including basic knowledge and usage of computers is required for this course.
Teaching Scheme	Regular laboratory classes conducted under supervision of the teacher. The experiments shall comprise of programming assignments.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Introduction to computers and Linux operating system.
2, 3	Get acquainted with the programming environment - Linux commands and VI-editor.
4	Editing, compiling, executing, and debugging of simple C programs.
5	Programs using operators and formatted input/output statements.
6	Decision making using `if`, `if-else`, `else-if` ladder, nested `if`.
7	Decision making using `switch-case` construct.
8, 9	Loop control structure (`while`, `do-while`, `for`) with jump statements.
10	Nested loops (printing various formats)
11, 12	1-D arrays including operation like searching, sorting, merging etc.
13	Handling 2-D arrays such as matrix operations.
14, 15	Programs on strings using various string handling functions (library functions)
16, 17	Designing user-defined functions.
18, 19	Programs on recursion.
20	Designing user defined functions for string manipulation.
21	Passing arrays (both 1D and 2D) to functions.
22, 23	Structure, array of structure, nested structure.
24	Dynamic memory management.
25	Self-referential structure (create and display operation of single linked list)
26, 27	File handling - reading from and writing to files.
28	Command-line argument, pre-processor directives.

Text Books:

T1. E. Balagurusamy, ***Programming in ANSI C***, 7th *Ed.*, McGraw-Hill Education, 2017.
T2. Y. Kanetker, ***Let Us C***, 16th *Ed.*, BPB Publications, 2018.

Reference Books:

R1. B. W. Kernighan and D. M. Ritchie, ***The C Programming Language***, 2nd *Ed.*, Pearson Education, 2015.
R2. H. Schildt, ***C: The Complete Reference***, 4th *Ed.*, McGraw-Hill, 2017.
R3. A. Kelley and I. Pohl, ***A Book on C***, 4th *Ed.*, Pearson Education, 2008.

R4. B. Gottfried, ***Schaum's Outline of Programming with C***, 3rd *Ed.*, McGraw-Hill, 2017.

Online Resources:

1. https://www.w3resource.com/c-programming-exercises/
2. https://www.includehelp.com/c-programming-examples-solved-c-programs.aspx
3. https://www.onlinegdb.com/online_c_compiler
4. https://www.tutorialspoint.com/compile_c_online.php

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Construct C programs for mathematical operations using control statements.
CO2	Develop C programs for Array and String manipulation.
CO3	Construct modular programs for better maintenance and reusability.
CO4	Manipulate heterogeneous data using structure and union.
CO5	Create and manipulate files using C programs.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	2							2	3	2	3
CO2	3	3	1	2							2	3	2	3
CO3	3	3	3	2							2	3	2	3
CO4	3	3	1	2							2	3	2	3
CO5	3	3	1	2							2	2	1	1

Category	Code	Communicative & Technical English	L-T-P	Credits	Marks
SEC	HS1001		0-0-4	2	100

Objectives	The objectives of this laboratory course are to provide practice sessions to enhance students' communication ability in the four language skills with focus on technical communication.
Pre-Requisites	Basic knowledge of general communication skills in english is required.
Teaching Scheme	Regular laboratory classes with various tasks designed to facilitate technical communication through pair and/or team activities with regular assessments, presentations, discussions, role-playing, audio-visual supplements, writing activities, business writing practices and vocabulary enhancement.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Introduction to the course and diagnostic test.
2	JAM: content development, structuring and delivery.
3	Group presentation.
4	Effective Verbal Communication exercises: plain English, bias-free language, formal and informal style, usage etc.
5	Activities on non-verbal communication.
6	Sounds of English: Vowels and consonants.
7	Sounds of English: Transcription.
8	Sounds of English: Syllable and stress.
9	Sounds of English: Rhythm.
10	Sounds of English: Intonation I.
11	Sounds of English: Intonation II.
12	Role play on simulated business contexts considering different channels of business communication.
13	Listening comprehension.
14	Practice on elements of business writing.
15	Composing effective paragraphs with unity, coherence, cohesion, progression.
16	Process writing.
17	Writing memos.
18	Emails and email etiquette.
19	Business letter I.
20	Business letter II.
21	Error correction: usage and grammar.
22	Reading Comprehension I: Essay – skimming, scanning, inferential comprehension, critical reading.
23	Reading Comprehension II: Short story – Analysing the tone of the author.

Cont'd. . .

Experiment-#	Assignment/Experiment
24	Reading Comprehension III: News editorial – Differentiating facts from opinion.
25	Reading Comprehension IV: Texts on Science and Technology – Identifying discourse markers.
26	Reading Comprehension V: Texts on Science and Technology – Intensive reading and note-taking.
27	Note-making and summary writing.
28	Verbal Advantage: vocabulary exercises.

Text Books:

T1. M. A. Rizvi, ***Effective Technical Communication***, 2nd *Ed.*, Tata McGraw Hill, 2017.
T2. M. Raman and S. Sharma, ***Technical Communication: Principles and Practices***, 3rd *Ed.*, Oxford University Press, 2015.
T3. B. K. Das, K. Samantray, R. Nayak, S. Pani, and S. Mohaty, ***An Introduction to Professional English & Soft Skills***, Cambridge Univ. Press, 2009.

Reference Books:

R1. J. Seeley, ***The Oxford Guide to Effective Writing and Speaking: How to Communicate Clearly***, 3rd *Ed.*, Oxford University Press, 2013.
R2. S. Kumar and P. Lata, ***Communication Skils***, Oxford University Press, 2011.
R3. T. Panigrahi, ***Communicative Competence***, 1st *Ed.*, Notion Press, 2024.

Online Resources:

1. https://nptel.ac.in/courses/109/106/109106094/: by Prof. A. Iqbal, IIT Madras
2. https://nptel.ac.in/courses/109/104/109104031/: by Dr. T. Ravichandran, IIT Kanpur
3. https://ocw.mit.edu/courses/comparative-media-studies-writing/21w-732-5-introduction-to-technical-communication-explorations-in-scientific-and-technical-writing-fall-2006/download-course-materials/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Communicate with clarity, fluency and impact.
CO2	Develop comprehensive understanding of communication concepts, its importance, types, barriers and principles.
CO3	Communicate effectively in business set-ups.
CO4	Compose coherent, clear and impactful business correspondences.
CO5	Practice sub-skills of reading and become adept readers.

Program Outcomes Relevant to the Course:

PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

Cont'd. . .

PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1						1	3	3	3	3	3	1	1	1
CO2						1	3	3	3	3	2	1	1	1
CO3						2	3	3	3	3	2	1	1	1
CO4						1	3	3	3	3	2	1	1	1
CO5						2	2	3	3	3	2	1	1	1

Category	Code	Workbench Practices	L-T-P	Credits	Marks
UCR	EE1003		0-0-2	1	100

Objectives	The objective of this practical course is to provide hands-on exposure on tools, fasteners, computers, electrical wiring, electronic components & instruments, soldering & desoldering, making of PCB, and using other advanced tools necessary for creating working models and prototypes for engineers of circuit branches.
Pre-Requisites	Familiarity with some hand tools used in home is desired.
Teaching Scheme	Regular experiments and jobs using tools and instruments under supervision of the teacher. Demonstration will be given for each experiment.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	General introduction & familiarity with tools (measuring, marking, holding, and cutting tools), Fitting (Limit, Fit, Tolerance)and Fastening (different types of screws, rivets, nuts & bolts).
2	Disassembling and assembling of Desktop Computer System and recognize its parts.
3	Study of cables, wires, switches, fuses, MCB, and fuse carriers in an electrical network.
4	Study of earthing and electrical safety, demonstration of the precautionary steps in case of electrical shocks.
5	Calculation of current and power for series and parallel connected lamp load.
6	Study and design of house wiring.
7	Study of digital measuring equipment and calculation of energy consumption in an electrical system.
8	Study of basic electronic & electrical components (such as Resistor, Capacitor, Inductor, Potentiometer, Diode, Transistor, Sensors, ICs, etc.) for circuit design.
9	Study of PCB assembling tools (such as Soldering iron, De-soldering pump, Pliers, Cutters, Wire strippers, Crimping tool, Micro-soldering, Hot air soldering and de-soldering station etc.)
10	Study of different measuring and testing tools such as Multimeter, Digital Storage Oscilloscope (DSO), Clamp meter, and Function generator etc.
11	Familiarization with EDA tools (such as Eagle or XCircuit) with general purpose components for designing PCB of simple circuits.
12	Fabrication & testing of single-sided and double-sided PCB for selected applications using general purpose instruments.

Text Books:

T1. B. H. Deshmukh, ***Electrical Materials and Wiring Practices***, Nirali Prakashan, 2018.
T2. G. Haldar, ***Electronics Course Book: Basic Components, IC boards, SMD, Logic Gates, Transistors, Resistors, Capacitors, Diodes, Audio Circuit and More***, GRPV Arts and Office Supplies, 2024.
T3. R. S. Khandpur, ***Printed Circuit Boards: Design, Fabrication, Assembly and Testing***, 1st *Ed.*, McGraw Hill,2006.

Reference Books:

R1. H. Joshi, ***Residential, Commercial and Industrial Electrical Systems: Protection, Testing and Commissioning, Vol-3***, McGraw-Hill Education, 2008.
R2. S. Monk, ***Make Your Own PCBs with EAGLE: From Schematic Designs to Finished Boards***, 1st *Ed.*. McGraw-Hill, 2014.
R3. J. Varterisian, ***Fabricating Printed Circuit Boards***, 1st *Ed.*, Newnes, 2002.
R4. A. Kemp, ***The Makerspace Workbench: Tools, Technologies and Techniques for Making***, O'Reilly Media, 2013.

Online Resources:

1. https://bharatskills.gov.in/pdf/E_Books/Electrcian_SEM1_TP.pdf
2. https://bharatskills.gov.in/pdf/E_Books/Electrician_SEM2_TP.pdf
3. https://bharatskills.gov.in/Home/StudyMaterial?var=WSdYV6aWadK8jUuNKxoBWg==
4. https://onlinecourses.swayam2.ac.in/nou20_cs08/preview
5. https://www.lanl.gov/safety/electrical/docs/arc_flash_safety.pdf
6. https://www.ee.iitb.ac.in/~pcpandey/courses/ee616/pcblayout_c_aug07.pdf
7. https://nptel.ac.in/courses/108/108/108108157/
8. https://nptel.ac.in/courses/122/106/122106025/
9. https://nptel.ac.in/courses/108/101/108101091/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Utilize appropriate tools for various workbench jobs within their limits, fits, and tolerance.
CO2	Disassemble and reassemble a computer System and replace its components.
CO3	Identify and utilize common electrical components with propery safety mechanisms.
CO4	Design house wiring and measure energy consumption using digital meters.
CO5	Identify and use basic electronic components, PCB assembling, measuring and testing tools.
CO6	Design and fabricate PCBs for different applications and assemble electronic components.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).

Cont'd. . .

PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	1	1	1	1			1	1	1	1	1	
CO2	1	1			3	1		2		1	2			
CO3	1	1	2	1	2	1	1	1	1	1	1			
CO4	2	2	3	1	1	1	1	2	2	2	1			
CO5	2	2	1		1			1		1	1	2		
CO6	1	2	3		3	1		2		1	1	1	2	

Category	Code	Engineering Graphics	L-T-P	Credits	Marks
UCR	ME1003		0-0-2	1	100

Objectives	The objective of this laboratory course is to learn engineering drawing standards, conventions & practices, develop drawing skills in 2D & 3D, and use computer-aided drawing software to create meaningful engineering drawings.
Pre-Requisites	Basic understanding of 2D and 3D geometry is required.
Teaching Scheme	Regular laboratory classes using drawing tools under supervision of the teacher. Demonstration will be given for each drawing assignment using both conventional and CAD software tools as per requirement.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Principles of Engineering Graphics and their significance (lettering & scale) and usage of Drawing instruments.
2	Orthographic projections, Principles of orthographic projections, Projections of points and lines.
3	Projections of different planes.
4	Projection of solids, 3D to 2D views, Machine component diagrams, Sectional views of simple and compound solid models.
5	Principles of Isometric projection, Isometric Scale & Views, Isometric views of planes and solids.
6	Development of surface and intersection of surfaces.
7	Engineering curves and conics.
8	Introduction to AutoCAD, its GUI, toolbars and commands, shortcut keys.
9	2D AutoCAD drawing using basic tools, Draw & Modify menu commands.
10	Orthographic projection drawings of various models using AutoCAD.
11	Isometric drawing & 3D modeling in AutoCAD, different solid editing options.
12	3D modeling of simple & compound models, and machine components using AutoCAD.

Text Books:

T1. N. D. Bhat, M. Panchal, ***Engineering Drawing***, Charotar Publishing House, 2008.
T2. M. B. Shah, B. C. Rana, ***Engineering Drawing and Computer Graphics***, Pearson Education, 2008.
T3. S. Tickoo, ***AutoCAD 2020 Work Book***, BPB Publications, 2020.

Reference Books:

R1. R. K. Dhawan, ***A Text Book of Engineering Drawing***, S. Chand Publications, 2007.
R2. K. Venugopal, ***Engineering Drawing and Graphics***, 3rd *Ed.*, New Age International, 1998.

Online Resources:

1. http://nptel.ac.in/courses/112103019
2. https://nptel.ac.in/courses/112/102/112102101/
3. https://freevideolectures.com/course/3420/engineering-drawing

4. https://www.autodesk.in/campaigns/autocad-tutorials
5. https://help.autodesk.com/view/ACD/2020/ENU/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand and apply the concepts of lettering and dimensioning for drafting of machine drawings and building drawings and different conics and curves.
CO2	Recognize and be familiar with the orthographic projections of points, lines, planes and solids.
CO3	Visualize the real product from isometric projections, solid and sectional views.
CO4	Draw 2D engineering drawings using various draw and modify tools of AutoCAD.
CO5	Design various machine components and building structure by using AutoCAD.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	2	1	2				2	1	1	1		1
CO2	2	2	2	1	2				2	1	1	1		1
CO3	2	2	3	1	2				2	1	1	1		1
CO4	2	2	3	1	2				2	1	1	2		1
CO5	2	2	3	1	2				2	1	1	2		2

Category	Code	Data Structures & Algorithms Lab	L-T-P	Credits	Marks
UCR	CS1004		0-0-4	2	100

Objectives	Develop skills to design and analyze simple linear and non linear data structures, strengthening the ability of students to identify and apply the suitable data structure for the given real world problem.
Pre-Requisites	Knowledge of programming in C, specifically on structures, pointers, functions, recursion etc., are required.
Teaching Scheme	Regular laboratory classes conducted under supervision of the teacher. The experiments shall comprise of programming assignments.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Operations on arrays – insert, delete, merge.
2	Selection Sort, Bubble sort.
3	Linear Search and Binary search.
4	Representation of sparse matrix.
5, 6	Addition and transpose of sparse matrix.
7	Implementation of stack using array.
8	Conversion of infix to postfix expression.
9	Evaluation of postfix expression.
10	Operations of queue using array.
11	Operations of circular queue.
12, 13	Single linked list operations.
14, 15	Double linked list operations.
16	Circular linked list operations.
17	Stack using linked list.
18	Queue using linked list.
19	Polynomial addition using linked-list.
20, 21	Binary Search Tree operations.
22, 23	Graph traversal (BFS, DFS).
24	Warshall's shortest path algorithm.
25, 26	Implementation Insertion Sort and Quick Sort.
27, 28	Implementation of Merge Sort and Heap Sort.

Text Books:

T1. E. Horowitz, S. Sahni, S. Anderson-Freed, ***Fundamentals of Data Structures in C***, 2nd *Ed.*, Universities Press, 2008.

T2. M. A. Weiss, ***Data Structures and Algorithm Analysis in C***, 2nd *Ed.*, Pearson Education, 2002.

Reference Books:

R1. A. K. Rath and A. K. Jagadev, ***Data Structures Using C***, 2nd *Ed.*, Scitech Publication, 2011.

R2. Y. Kanetkar, ***Data Structures Through C***, 2nd *Ed.*, BPB Publication, 2003.

Online Resources:

1. https://nptel.ac.in/courses/106/106/106106127/: By Prof. H. A. Murthy, Prof. S. Balachandran, and Dr. N. S. Narayanaswamy, IIT Madras
2. https://nptel.ac.in/courses/106/102/106102064/: By Prof. N. Garg, IIT Delhi
3. https://nptel.ac.in/courses/106/106/106106130/: By Dr. N. S. Narayanaswamy, IIT Madras

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Implement various operations on array and sparse matrix.
CO2	Design functions to implement basic operations on stack & queue and apply them to solve real world problems.
CO3	Implement single, double & circular linked list and apply them in various real life applications.
CO4	Construct binary search tree and perform traversal, insertion, deletion, and search operations on it.
CO5	Perform BFS and DFS traversal operations in a graph and implement various sorting and searching algorithms.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	3	2	1	1					1	2	2	1
CO2	2	2	3	2	1	1					1	2	1	1
CO3	2	2	3	2	1	1					1	2	1	1
CO4	2	2	2	3	1	1					1	2	2	1
CO5	2	2	3	3	1	1					1	2	3	1

Category	Code	Corporate Communication Skills	L-T-P	Credits	Marks
SEC	HS1002		0-0-4	2	100

Objectives	The objective of this laboratory course is to give students adequate practice in a simulated professional environment with focus on communication skills with professionalism in a typical corporate set up.
Pre-Requisites	Knowledge of communicative and technical english is required.
Teaching Scheme	Regular laboratory classes with various tasks designed to facilitate communication and soft skills through pair and/or team activities with regular assessments, presentations, discussions, role-playing, audio-visual supplements, writing activities, business writing practices and vocabulary enhancement.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Aspects of Inter-cultural communication and cultural conditioning.
2	Barriers to cross-cultural communication.
3	Personality test and personality development.
4	Team work and its stages.
5	Team work and leadership: Simulation.
6	Negotiation skills: Role-play.
7	Persuasive presentation I.
8	Persuasive presentation II.
9	Writing a blog.
10	Vlog making and presentation I.
11	Vlog making and presentation II.
12	Emotional Intelligence: its importance in the workplace.
13	Time management.
14	Social media etiquette.
15	Business etiquette.
16	Assertiveness at work: Role-play.
17	Power point presentation I.
18	Power point presentation II.
19	Power point presentation III.
20	Power point presentation IV.
21	Mind mapping.
22	Creative and critical thinking for problem solving.
23	Six thinking hats: Problem solving and decision making in meetings.
24	Verbal Ability I: synonyms and antonyms.
25	Verbal Ability II: One word substitution.

Cont'd. . .

Experiment-#	Assignment/Experiment
26	Verbal Ability III: Error correction.
27	Verbal Ability IV: Odd one out.
28	Verbal Ability V: Analogy.

Text Books:

T1. S. B. Bachu, ***Corporate Communication Skills for Professionals***, 1st *Ed.*, White Falcon Publishing, 2021.
T2. M. A. Rizvi, ***Effective Technical Communication***, 2nd *Ed.*, Tata McGraw-Hill, 2017.
T3. M. Raman and S. Sharma, ***Technical Communication: Principles and Practice***, 3rd *Ed.*, Oxford University Press, 2015.

Reference Books:

R1. P. A. Argenti and J. Forman, ***The Power of Corporate Communication: Crafting the Voice and Image of Your Business***, 1st *Ed.*, Tata McGraw-Hill, 2003.
R2. J. Seely, ***The Oxford Guide to Writing and Speaking***, 3rd *Ed.*, Oxford University Press, 2013.
R3. B. K. Mitra, ***Effective Technical Communication - A Guide for Scientists and Engineers***, 1st *Ed.*, Oxford University Press, 2006.

Online Resources:

1. https://archive.nptel.ac.in/courses/109/105/109105144/: by Prof. S. Singh, IIT Kharagpur
2. https://archive.nptel.ac.in/courses/109/106/109106129/: by Dr. Ay. I. Viswamohan, IIT Madras
3. https://archive.nptel.ac.in/courses/109/104/109104030/: by Dr. T. Ravichandran, IIT Kanpur
4. https://www.ef.com/wwen/english-resources/
5. https://owl.purdue.edu/owl/purdue_owl.html
6. https://www.usingenglish.com/
7. http://www.english-test.net

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand aspects of communication at the workplace and check the barriers.
CO2	Hone persuasive communication skills.
CO3	Enhance interpersonal communication at the corporate workplace.
CO4	Make impactful group/solo presentations and communicate with clarity.
CO5	Enhance verbal ability for better communication.

Program Outcomes Relevant to the Course:

PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.

Cont'd. . .

PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1						1	3	3	3	3	3	2	2	2
CO2						1	3	3	3	3	3	2	2	2
CO3						2	3	3	3	3	3	2	2	3
CO4						1	3	3	3	3	3	2	2	3
CO5						2	3	3	3	3	3	2	2	3

Category	Code	Vector Calculus & Fourier Analysis	L-T-P	Credits	Marks
PCR	MT2003		3-0-0	3	100

Objectives	The objective of this course is to provide the knowledge of vector calculus, partial differential equations & Fourier Transforms which are essential for study of various electrical systems.
Pre-Requisites	Knowledge of calculus of single variable, coordinate geometry of two and three dimensions and ordinary differential equations is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Periodic function and Fourier series, Euler formula, Even and odd functions, Half range expansions.	**7 Hours**
Module-2	Fourier integrals, Fourier cosine transform, Fourier sine transform, Fourier transform.	**7 Hours**
Module-3	Vector line integrals, Line integrals independent of path, Double integrals, Green's theorem in plane surfaces, Surface integrals, Triple integrals, Gauss divergence theorem, Stoke's theorem.	**10 Hours**
Module-4	Partial Derivatives, Chain Rule, Maxima & Minima in several variables; Vector and scalar functions and fields, Derivatives, Directional derivative & gradient of a scalar field, Divergence & Curl of a vector field.	**8 Hours**
Module-5	Basic Concepts of PDEs, One Dimensional Wave Equation and its solutions, One Dimensional Heat Equation and its solutions, Two dimensional heat equation, Laplace Equation, Solution of Laplace equation in cylindrical and spherical coordinates.	**10 Hours**
	Total	**42 Hours**

Text Books:

T1. E. Kreyszig, ***Advanced Engineering Mathematics***, 8th *Ed.*, Wiley India, 2015.

Reference Books:

R1. S. Pal and S. C. Bhunia, ***Engineering Mathematics***, 1st *Ed.*, Oxford University Press, 2015.
R2. B. V. Ramana, ***Higher Engineering Mathematics***, 1st *Ed.*, McGraw-Hill, 2017.

Online Resources:

1. https://nptel.ac.in/courses/122104017: by Prof. S. K. Ray, IIT Kanpur
2. https://nptel.ac.in/courses/111107063: by Dr. S. Gakkhar, IIT Roorkee
3. https://nptel.ac.in/courses/111105093: by Prof S. De, IIT Kharagpur
4. https://nptel.ac.in/courses/111107111: by Prof. Agrawal and Pandey, IIT Roorkee
5. https://nptel.ac.in/courses/111104519: by Prof. Prof. P. Mohanty, IIT Kanpur

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Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Determine the Fourier series of functions.
CO2	Obtain the Fourier integral and Fourier transform of functions.
CO3	Explain the concepts vector integral calculus and their applications.
CO4	Describe the concepts vector differential calculus and their applications.
CO5	Solve partial differential equations and interpret the solution

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	2	2						1	2	1	1
CO2	3	3	2	2	3						2	3	1	1
CO3	3	3	2	2	3						1	3	1	1
CO4	3	3	2	3	3						2	2	1	1
CO5	2	2	2	3	3						2	3	1	1

Category	Code	OOP Using Java	L-T-P	Credits	Marks
UCR	CS2001		3-0-0	3	100

Objectives	The objective of this course is to introduce the key concepts of object-oriented programming (OOP) using Java as the programming language.
Pre-Requisites	Basic analytical and logical understanding including basic knowledge and usage of computers is required for this course. Prior experience with a programming language will be beneficial.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Object oriented concepts: Object oriented systems development life cycle; Java Overview: Java Virtual Machine, Java buzzwords, Data types, Operators, Control statements, Class fundamentals, Objects, Methods, Constructors, Overloading, Access modifiers.	**8 Hours**
Module-2	Inheritance: Basics of Inheritance, Using super & final keyword, Method overriding, Abstract classes, Defining & importing packages, Access protection, Interfaces.	**8 Hours**
Module-3	Exception handling: Exception fundamentals, Types, Understanding different keywords (try, catch, finally, throw, throws), User defined exception handling; Threads: Thread model, Use of Thread class and Runnable interface, Thread synchronization, Multithreading, Inter-thread communication.	**9 Hours**
Module-4	Input/Output: Files, Stream classes, Reading console input; String manipulation: Basics of String handling, String class, StringBuilder, StringBuffer, String Tokenizer; Collection overview, Collection interfaces, Collection classes – ArrayList, LinkedList, Set, Tree; Accessing a collection using iterator & for-each statement.	**8 Hours**
Module-5	Basic GUI Programming: Working with windows, Frames, Graphics, Color and font; Swing fundamentals; Event handling: Delegation event model, Event classes, Sources, Listeners; Introduction to JDBC: Architecture of JDBC, JDBC Drivers, Interfaces of JDBC API, Create a simple JDBC application.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. J. Keogh, ***J2EE: The Complete Reference***, 11th *Ed.*, McGraw Hill, 2017.
T2. Y. D. Liang, ***Introduction to Java Programming***, 9th *Ed.*, Pearson Education, 2012.

Reference Books:

R1. B. Bates, K. Sierra, ***Head First Java***, 2nd *Ed.*, O'Reilly Media, 2005.
R2. E. Balaguruswamy, ***Programming with Java - A Primer***, 4th *Ed.*, McGraw-Hill, 2009.
R3. T. Budd, ***An Introduction to Object-Oriented Programming***, 3rd *Ed.*, Pearson Education, 2009.
R4. I. Horton, ***Beginning Java***, 7th *Ed.*, Wrox Publications, 2011.

Online Resources:

1. https://nptel.ac.in/courses/106105191/: by D. Samanta, IIT Kharagpur
2. https://docs.oracle.com/javase/tutorial/
3. http://www.javatpoint.com/java-tutorial
4. http://www.w3schools.in/java/
5. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-00-introduction-to-computer-science-and-programming-fall-2008/video-lectures/lecture-14/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Apply object oriented principles to develop Java programs for real life applications.
CO2	Employ inheritance techniques for developing reusable software.
CO3	Develop robust & concurrent programs using exception handling and multi-threading.
CO4	Design programs using I/O operations, string classes, and collection framework.
CO5	Design GUI applications using Swing and Database connectivity.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2		2					2	3		3
CO2	3	3	3	2		3					2	3		3
CO3	3	3	3	2		3					2	3		3
CO4	3	2	2	2		2					2	3		3
CO5	3	3	2	2		3					2	3		3

Category	Code	Management & Economics for Engineers	L-T-P	Credits	Marks
UCR	MG2001		3-0-0	3	100

Objectives	The objective of this course is to familiarize the students with elementary principles of management and economics, provide the tools needed for analyzing time value of money in engineering decision making, profit/revenue data, and make economic analysis for projects and alternatives.
Pre-Requisites	Basic knowledge on interest formula and derivatives is required.
Teaching Scheme	Regular classroom lectures with use of ICT as needed. Each session is planned to be interactive with focus on real-world problem solving.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction, Engineering Economics, It's meaning & importance, Basic problems of an economy, The concept of time value of money, Concept of Interest, Time value of equivalence, Compound interest factors, Cash flow diagrams, Calculation of time value of equivalence, Present worth comparison, Future worth comparison, Pay-back period comparison.	**9 Hours**
Module-2	Equivalent annual worth comparison method, Rate of return, Internal rate of return, Incremental IRR analysis, Depreciation Analysis - Methods of depreciation, Straight line method, Declining balance method, SOYD Method & MACRS method; Analysis of public project, Cost-benefit analysis.	**9 Hours**
Module-3	Theory of demand, Elasticity of demand, Price elasticity of demand, Measurement of elasticity of demand, Income elasticity & cross elasticity of demand, Law of supply, Elasticity of supply, Determination of price, Cost & Revenue concepts, Break-even analysis.	**8 Hours**
Module-4	Concept of Management, Management - Art or Science, Managerial skills, Levels and types of management, Managerial environment, Functions of Management: Planning and its features & process, Types of plan, Effective planning, Organizing and its process, Formal & informal organization, Directing and its elements, Staffing and functions, Controlling & its features and process, tools of controlling.	**8 Hours**
Module-5	Marketing Function: Modern concept of marketing, Marketing vs. Selling, Marketing Mix: Product and types of product, Product life cycle, Price, Factors affecting pricing, Pricing strategies, Distribution channel - Role & functions, Selection of a distribution channel, Promotion & types of promotion, Promotional strategies; HRM Function: Human resource management, Manpower planning, Recruitment, Selection, Induction, Training & development, Placement, Wage & Salary administration.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. L. Riggs, D. D. Bedworth, and S. U. Randhawa, ***Engineering Economics***, 4th *Ed.*, McGraw-Hill, 2004.
T2. H. L. Ahuja, ***Principles of Micro Economics***, 16th *Ed.*, S. Chand & Co, 2008.
T3. S. A. Sherlekar, ***Modern Business Organisation and Management***, Himalaya Publishing House, 2016.

Reference Books:

R1. C. S. Park, ***Contemporary Engineering Economics***, 6th *Ed.*, Pearson Education, 2015.
R2. A. Koutsoyiannis, ***Modern Micro Economics***, 2nd *Ed.*, Palgrave Macmillan UK, 2003.
R3. P. C. Tulsian and V. Pandey, ***Business Organization & Management***, 1st *Ed.*, Pearson Education, 2002.
R4. K. Keller and K. Jha, ***Marketing Management***, 13th *Ed.*, Pearson Education, 2018.

Online Resources:

1. https://nptel.ac.in/courses/112107209: by Dr. P. K. Jha, IIT Roorkee
2. https://nptel.ac.in/courses/110107150: by Prof. U. Lenka, IIT Roorkee
3. https://nptel.ac.in/courses/110104068: by Prof. J. Chatterjee and Dr. S. S. Mishra, IIT Kanpur
4. https://nptel.ac.in/courses/122105020: by Prof. K. Chakravarti, IIT Kharagpur
5. https://nptel.ac.in/courses/110105069: by Prof. A. Malik, IIT Kharagpur

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand the concepts of engineering economics and its applications.
CO2	Solve problems related to engineering economics and analyze decision alternatives.
CO3	Evaluate how changes in demand and supply affect market and production.
CO4	Apply the concepts of management to become a good manager and a team player.
CO5	Adopt appropriate marketing policies and manage human resources in an efficient manner.

Program Outcomes Relevant to the Course:

PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1						2	1	1		3	2		1	2
CO2						3	1	1		3	2		1	3
CO3						2	1	1		3	2		1	2
CO4						2	3	3		3	2		1	3
CO5						2	3	3		3	2		2	2

Category	Code	Biology for Engineers	L-T-P	Credits	Marks
UCR	BL2001		3-0-0	3	100

Objectives	The objective of this course is to integrate the knowledge of engineering and modern biology to solve problems encountered in living systems, analyze a problem from engineering and biological perspective, anticipate specific issues in working with living systems, and evaluate possible solutions.
Pre-Requisites	Basic knowledge of biology, chemistry, and physics is adequate.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on applications of biology in engineering.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Bioinspired Materials and Mechanisms**: Photosynthesis (photovoltaic cells, bionic leaf), Bird flying (GPS and aircrafts), Lotus leaf effect (Super hydrophobic and self-cleaning surfaces), Plant burrs (Velcro), Shark skin (Friction reducing swimsuits), Kingfisher beak (Bullet train), Human Blood substitutes - Haemoglobin-based oxygen carriers (HBOCs).	**10 Hours**
Module-2	**Biomolecules-based Technology**: Carbohydrates (transformation of carbohydrates into renewable energy, biodegradable plastics and organic chemicals), Nucleic acids (biochips and biosensors), Forensics - Automated DNA sequencing, Proteins (cellular agriculture to produce tissue mimicking meat), Lipids (biodiesel), Enzymes (AI mediated enzyme engineering).	**9 Hours**
Module-3	**Human Organ Systems and Bio Designs (I)**: Eye as a camera system (architecture of rod and cone cells, optical corrections, cataract, lens materials, bionic eye), Brain as a CPU system (architecture, signal transmission, brain-machine interactions), Heart as a pump system (reasons for blockages of blood vessels, Nanobots to remove artery blockage, vein detection patches).	**8 Hours**
Module-4	**Human Organ Systems and Bio Designs (II)**: Lungs as purification system (architecture, gas exchange mechanisms, spirometry, abnormal lung physiology - COPD, Ventilators, Heart-lung machine); Kidney as a filtration system (architecture, mechanism of filtration, CKD, dialysis systems), Muscular and skeletal systems as scaffolds (architecture, mechanisms, bioengineering solutions for muscular dystrophy and osteoporosis).	**8 Hours**
Module-5	**Genetics and Bioinformatics**: Mendelian and non-mendelian genetics, Mutation, Central dogma of molecular biology, Genetic disorders, Genetic code; Nucleotide and protein databases - EMBL, DDBJ, GenBank, UniProt, PDB, Tools used in bioinformatics - BLAST, FASTA, Machine learning applications in bioinformatics: Gene sequence analysis, Protein structure analysis, Establish phylogenetic relationship.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. Y. Bar-Cohen, ***Biomimetics: Nature-Based Innovation***, 1st *Ed.*, CRC Press, 2012.
T2. S. Fox and K. Rompolski, ***Human Physiology***, 16th *Ed.*, McGraw-Hill eBook, 2022.

T3. L. Cromwell, F. J. Weibel, and E. A. Pfeiffer, ***Biomedical Instrumentation & Measurements***, 2nd *Ed.*, Pearson Education, 2015.
T4. Any other book(s) and/or study material(s) as advised by the teacher.

Reference Books:

R1. S. Singh and T. Allen, ***Biology for Engineers***, 1st *Ed.*, Vayu Education, 2020.
R2. V. Sharma, A. Munjal, and A. Shanker, ***A Textbook of Bioinformatics***, 2nd *Ed.*, Rastogi Publications, 2018.

Online Resources:

1. https://nptel.ac.in/courses/102106065: by Prof. M. M. Gromiha, IIT Madras
2. https://nptel.ac.in/courses/121106008: Dr. M. Dixit and Prof. G. K. Suraishkumar, IIT Madras
3. https://ocw.mit.edu/courses/20-020-introduction-to-biological-engineering-design-spring-2009

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Correlate the concepts of biology in engineering for innovative materials and products.
CO2	Leverage biomolecules in food, pharma, energy, and other engineering domains.
CO3	Critically analyze organ systems and improve design of bio-medical equipment.
CO4	Design solutions for health challenges like prosthetics, organ regeneration, and medical devices.
CO5	Determine the connection between genetic alterations, diseases, and inheritance pattern.

Program Outcomes Relevant to the Course:

PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1		2	3		2	3					2	1	2	2
CO2		1	2		2	3					2	1	1	2
CO3		1	2		2	2					2	1	2	2
CO4		1	2		2	2					2	1	2	2
CO5		3	1		3	3					2	3	2	2

Category	Code	Analog Electronics	L-T-P	Credits	Marks
PCR	EC2016		3-0-0	3	100

Objectives	The objective of this course is to be familiar with Transistor (BJT, JFET and MOSFET) amplifiers, differential amplifiers and their implementations along with studying their characteristics & applications.
Pre-Requisites	Basic knowledge of semiconductor diodes and transistors is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Bipolar Junction Transistor (BJT) and its AC Analysis**: Introduction to BJT DC Biasing Circuits, Design of different Biasing Circuits, Bias Stability, Introduction to BJT small signal model, r_e and h-models of different configurations (CB, CE, and CC), r_e and h-models of different biasing circuits, Effect of R_S and R_L, Standard ICs.	**9 Hours**
Module-2	**Field Effect Transistor (FET) and its AC Analysis**: JFET DC Biasing Circuits (Fixed, Self and Voltage divider), MOSFET DC Biasing Circuits, Introduction to JFET and MOSFET small signal model, Small signal model of different configurations (CG, CD, and CS), Small signal model of different biasing circuits of MOSFET, Effect of R_S and R_L, Standard ICs.	**9 Hours**
Module-3	**Compound Configurations**: Darlington pair, Current Mirror, Cascade configuration, CMOS circuit realization. **Frequency Response Analysis**: Frequency Response of BJT, Miller's Effect, Multistage Frequency Effects, Gain-Bandwidth Relation.	**8 Hours**
Module-4	**Operational Amplifiers**: Introduction to OP-AMP, Applications of OP-AMP: Summing, Buffer, Log Differentiator, Schmitt Trigger and Integrator, Introduction to Differential Amplifier, DC and AC Analysis of Differential Amplifier, Instrumentation Amplifier, Active Filters, Standard ICs.	**8 Hours**
Module-5	**Feedback Amplifiers**: Introduction to Feedback Amplifiers, Feedback Topologies, Derivation of different parameters (Z_i, Z_o, A_v, A_i), Standard ICs. **Oscillators**: Crystal Oscillators, Standard ICs. **Power Amplifiers**: Introduction to Power Amplifiers, Classification of Power Amplifiers: Class A, Class B, Class C, Push-Pull Amplifiers.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. A. S. Sedra and K. C. Smith, ***Microelectronic Circuits: Theory and Applications (International Version)***, 7th *Ed.*, Oxford University Press, 2017.

T2. R. L. Boylestad and L. Nashelsky, ***Electronic Devices and Circuit Theory***, 11th *Ed.*, Pearson Education, 2013.

T3. J. Millman and A. Grabel, ***Microelectronics***, 2nd *Ed.*, McGraw-Hill Education, 2017.

Reference Books:

R1. J. Millman and C. C. Halkias, ***Integrated Electronics: Analog and Digital Circuits and Systems***, 2nd *Ed.*, TMH Publications, 2017.

R2. A. Malvino and D. J. Bates, ***Electronic Principles***, 7th *Ed.*, McGraw-Hill, 2017.
R3. P. Horowitz and W. Hill, ***The Art of Electronics***, 2nd *Ed.*, Cambridge University Press, 1989.
R4. P. R. Gray, P. J. Hurst, R. G. Meyer, and S. H. Lewis, ***Analysis and Design of Analog Integrated Circuits***, 5th *Ed.*, John Wiley & Sons, 2009.

Online Resources:

1. https://nptel.ac.in/courses/117101106: by Prof A. N. Chandorkar, IIT Bombay
2. https://nptel.ac.in/courses/108102095: by Prof S. C. Dutta Roy, IIT Delhi
3. http://www.allaboutcircuits.com
4. https://www.electronics-tutorials.ws/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain biasing methods and small signal models of BJT and their performance estimation.
CO2	Analyze the behavior, characteristics and biasing configurations of JFET and MOSFET.
CO3	Analyze the structural configuration of multi-stage amplifier and its frequency response.
CO4	Study the construction and characteristics of an Op-Amp and design circuits using Op-Amp.
CO5	Design oscillators & negative feedback amplifiers and validate their experimental results.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	3	3						1	3	1	1
CO2	3	3	3	3	2						2	3	2	2
CO3	3	3	2	3	2						2	3	2	3
CO4	3	3	3	2	3						1	3	1	2
CO5	3	3	3	3	3						1	3	3	3

Category	Code	Circuits & Signals	L-T-P	Credits	Marks
PCR	EE2001		3-1-0	4	100

Objectives	The objective of this course is to study circuit configuration & analysis with given specifications or network functions, test and improve the design as required. It also includes study of various signals & systems in time & frequency domains, and investigate the systems' stability & causality.
Pre-Requisites	Knowledge of circuit analysis, Laplace transform, Fourier transform. differential equations, complex numbers, and elementary calculus are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Network graph and incidence matrix; Network Theorems: Thevenin's theorem, Norton's theorem, Superposition theorem, Reciprocity theorem, Maximum power transfer theorem, Millman's theorem; Coupled Circuits: Introduction, Dot convention, Coefficient of coupling, Electrical equivalent of magnetically coupled coils, Series & parallel connection of coupled coils; Resonance: Introduction, Series Resonance, Parallel Resonance, Quality factor, Bandwidth & Selectivity for series & parallel resonant circuits.	**12 Hours**
Module-2	Signals & Systems: Introduction, Classification of Signals, Operation on Continuous-time signals, Classification of Systems, LTI System and its response; Laplace Transform: Definition, Properties, Initial and final value theorem, Inverse Laplace Transform; Application of Laplace Transform to Transient Analysis: Fundamentals of Switching behavior, Response of RL, RC & RLC network with step input, Transient Numericals.	**12 Hours**
Module-3	Two-Port Network Parameters: Introduction to Z, Y, ABCD, and h-parameters, Reciprocity and Symmetry conditions, Interrelation between parameters, Interconnection of networks, parameter calculation; Network Functions: Transfer functions and driving point functions, Concept of poles and zeros, Significance of Poles and Zeros, Hurwitz polynomial and its properties, Positive real functions and their properties.	**12 Hours**
Module-4	Fourier Series: Introduction, Fourier Analysis, Symmetry in Fourier Series, Frequency Spectrum; Fourier Transform: Definition, properties, Circuit analysis with Fourier Series and Fourier Transform, Network Filters: Introduction, Classification, Ideal & Practical Filters, Frequency response curve, Design of Filters.	**10 Hours**
Module-5	Convolution & Correlation of continuous-time and discrete-time signals, Discrete-Time Fourier Transform: Z-Transform and its properties, Inverse Z-transform, Region of Convergence (ROC) and its properties, Z-transform of Standard functions and ROC.	**10 Hours**
	Total	**56 Hours**

P.T.O

Text Books:

T1. M. E. Van Valkenburg, ***Network Analysis***, 3rd *Ed.*, Pearson Education, 2015.
T2. C. K. Alexander and M. N. O. Sadiku, ***Fundamentals of Electric Circuits***, 5th *Ed.*, Tata McGraw-Hill, 2013.
T3. A. V. Oppenheim, A. S. Willsky, and S. H. Nawab, ***Signals and Systems***, 2nd *Ed.*, Prentice Hall India, 1992.

Reference Books:

R1. A. Chakrabarti, ***Circuit Theory: Analysis and Synthesis***, 7th *Ed.*, Dhanpat Rai & Co., 2013.
R2. S. Ghosh, ***Network Theory: Analysis And Synthesis***, 1st *Ed.*, Prentice Hall of India, 2009.
R3. P. K. Satpathy, P. Kabisatapathy, S. P. Ghosh, and A. K. Chakraborty, ***Network Theory***, 1st *Ed.*, Tata McGraw-Hill, 2009.
R4. J. G. Proakis and D. G. Manolakis, ***Digital Signal Processing: Principles, Algorithms and Applications***, 4th *Ed.*, Prentice Hall India, 2007.
R5. B. P. Lathi, ***Principles of Signal Processing and Linear Systems***, 2nd *Ed.*, Oxford Univ. Press, 2009.
R6. A. N. Kani, ***Signals and Systems***, 2nd *Ed.*, McGraw-Hill Education, 2010.

Online Resources:

1. https://nptel.ac.in/courses/108102042/: by Prof. S. C. Dutta Roy, IIT Delhi
2. https://nptel.ac.in/courses/108106075/: by Prof. V. G. K. Murti, IIT Madras
3. https://nptel.ac.in/courses/117104074/: by Prof. K. S. Venkatesh, IIT Kanpur
4. https://nptel.ac.in/courses/108105065/: by Prof. T. K. Basu, IIT Kharagpur
5. https://nptel.ac.in/courses/108104100/: by Prof. A. K. Jagannatham, IIT Kanpur
6. https://nptel.ac.in/courses/117101055/: by Prof. V. M. Gadre, IIT Bombay
7. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/lecture-notes/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain the concepts of network theorems, coupled circuits, and resonant circuits and apply them to solve complex network problems.
CO2	Analyze and classify signals and systems and solve the transient analysis of RLC circuits using Laplace transform.
CO3	Evaluate two-port network parameters and network functions, understanding their applications in electrical network interconnections and stability analysis.
CO4	Analyze sinusoidal & non-sinusoidal signals using the Fourier series & transform and apply them to electric circuit analysis.
CO5	Perform convolution, correlation, and Z-transform analysis of continuous and discrete-time signals to address real-world engineering challenges.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).

Cont'd. . .

PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3			2						2	2	2
CO2	2	2		3	2						2	3	3	2
CO3	2	1	2	2							1	2	3	2
CO4	2	2	3		3						2	3	2	1
CO5	2	2			3				2		2	2	2	1

Category	Code	Electromagnetic Theory	L-T-P	Credits	Marks
PCR	EE2002		3-0-0	3	100

Objectives	The objective of this course is to study, analyze, synthesize & interpret the application of electric & magnetic fields as functions of time & space using different coordinate systems, and propagation of electromagnetic waves.
Pre-Requisites	Knowledge of physics, mathematics, and fundamentals of engineering sciences is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Vector Analysis: Scalars, Vectors, Unit vector, Scalar & Vector fields, Co-ordinate systems and transformation, Cartesian co-ordinates, Cylindrical co-ordinates, Spherical co-ordinates and Application; Vector Calculus: Line, Surface and volume integrals, Del operator, Gradient of a scalar, Divergence of a vector and Divergence theorem, Curl of a vector and Stoke's theorem, Laplacian and Applications.	**8 Hours**
Module-2	Electrostatic Fields: Coulomb's Law, Electric field intensity, Electric fields due to point, line, surface and volume charge, Electric flux density, Gauss's Law - Maxwell's equation, Application of Gauss's Law, Electric potential, Potential due to a line, Surface and volume charge; Conservative field, Relationship between E & V - Maxwell's equations, An Electric Dipole, Dipole moment, Expression of E due to an electric Dipole, Energy density in the Electrostatic fields; Conductors: Current and Current density, Continuity equation, Point form of Ohm's law, Resistance of a conductor, Relaxation time; Dielectrics: Polarization, Dielectric strength, Capacitance, Boundary conditions, Poisson's and Laplace's equation, Uniqueness Theorem, General procedures for solving Laplace's equation.	**12 Hours**
Module-3	Magnetostatic Fields: Magnetic field Intensity, Biot-Savart's law & its application, Ampere's Circuital Law & its application, Magnetic scalar & vector potentials, Magnetic Boundary conditions, Application; Force in Magnetic Fields: Force on a moving Point charge, Force between two straight, Long and parallel conductors carrying currents.	**8 Hours**
Module-4	Faraday's Law and Lenz's Law: Statically inducted EMF, Dynamically induced EMF, Displacement current density and displacement current, Physical significance of displacement current; Maxwell's Equations for Static fields, Maxwell's equations for Time varying fields: Maxwell's Equation for Harmonic varying fields; Maxwell's Equation for Good conductors, Maxwell's Equation for Free space; Retarded Potential, Average power density, Poynting vector and Poynting Theorem(Integral & Point forms),Applications.	**8 Hours**

Cont'd. . .

Module-#	Topics	Hours
Module-5	Wave Propagation: Electromagnetic wave, Electromagnetic wave equation in phasor form, Intrinsic impedance, The loss tangent, Uniform plane waves, Uniform plane wave in lossy dielectric, Perfect dielectric, Free space and in Good conductors, Skin depth, Transmission lines, Transmission line equations, Characteristic impedance, Wave form distortion, Distortionless line.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. S. C. Mahapatra and S. Mahapatra, ***Principles of Electromagnetics***, 2nd *Ed.*, McGraw Hill Education, 2015.
T2. M. N. O. Sadiku and S. V. Kulkarni, ***Principles of Electromagnetic***, 6th *Ed.*, Oxford University Press, 2009.

Reference Books:

R1. E. C. Jordan and K. G. Balmin, ***Electromagnetic Waves and Radiating Systems***, 2nd *Ed.*, Pearson Education, 2009.
R2. B. N. Basu, ***Engineering Electromagnetic Essential***, 1st *Ed.*, Orient Blackswan, 2015.

Online Resources:

1. https://nptel.ac.in/courses/108104087: by Prof. P. Kumar, IIT Kanpur
2. https://nptel.ac.in/courses/108102119: by Prof. S. Aditya, IIT Delhi
3. https://nptel.ac.in/courses/115104088: by Prof. M. K. Harbola, IIT Kanpur
4. https://nptel.ac.in/courses/108106073: by Prof. H. Ramachandran, IIT Madras

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain various co-ordinate systems and solve problems involving vector calculus.
CO2	Describe electrostatic fields, their characteristics and associated parameters.
CO3	Visualize magneto-static fields, their characteristics and associated parameters.
CO4	Analyze and apply Maxwell's equations to various electromagnetic fields.
CO5	Interpret the propagation of EM waves through different mediums.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).

Cont'd. . .

PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	2	1	2						2	2	2
CO2	3	3	2	3	3	2					2	3	3	2
CO3	2	2	1	2	3	2					1	2	3	2
CO4	3	2	2	2	3	1					2	3	2	1
CO5	3	3	3	1	2	1					2	2	2	1

Category	Code	OOP Using Java Lab	L-T-P	Credits	Marks
UCR	CS2004		0-0-2	1	100

Objectives	The objective of the course is to apply object oriented programming principles and implement object oriented programming using JAVA language.
Pre-Requisites	Basic analytical and logical understanding including basic knowledge and usage of computers is required for this course. Prior experience with any other object oriented programming language will be beneficial.
Teaching Scheme	Regular laboratory classes with the use of ICT whenever required, demonstration through practical simulation of code using IDE.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Understanding Java platform, compilation, and execution of a java program.
2	Overview of Eclipse IDE.
3	Use of class, use of control statements, data types, operators.
4	Implement class, object, constructor, methods, and other OOP features.
5	Inheritance Basics, more uses of constructor, method overriding, use of final.
6	Object class, practical use of abstract class.
7	Using Interface for achieving multiple inheritance, implementation of package.
8	Exception handling fundamentals, java built-in exceptions, use of Scanner class for console input, use of own Exception subclass.
9	Java thread life cycle model and implementation approach, thread priority, implementation of synchronization.
10	I/O Basics, byte stream and character streams, reading and writing files, text processing using Java pre-defined StringBuilder and StringBuffer classes.
11	Basics of Java collection framework, implementation of collections in Java with different programs.
12	GUI basics and Window fundamentals, working with different Component, Container and Layout Managers.
13	Event handling for interactive GUI application, working with JDBC.
14	Mini Project.

Text Books:

T1. J. Keogh, ***J2EE: The Complete Reference***, 11th *Ed.*, McGraw Hill, 2017.
T2. Y. D. Liang, ***Introduction to Java Programming***, 9th *Ed.*, Pearson Education, 2012.

Reference Books:

R1. B. Bates, K. Sierra, ***Head First Java***, 2nd *Ed.*, O'Reilly Media, 2005.
R2. T. Budd, ***An Introduction to Object-Oriented Programming***, 3rd *Ed.*, Pearson Education, 2009.
R3. I. Horton, ***Beginning Java***, 7th *Ed.*, Wrox Publications, 2011.

Online Resources:

1. https://nptel.ac.in/courses/106105191/: by D. Samanta, IIT Kharagpur
2. https://docs.oracle.com/javase/tutorial/
3. http://www.javatpoint.com/java-tutorial
4. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-00-introduction-to-computer-science-and-programming-fall-2008/video-lectures/lecture-14/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Apply object oriented programming to develop Java programs for real-life applications.
CO2	Employ inheritance techniques for developing reusable software.
CO3	Develop robus and concurrent programs using exception handling and multi-threading.
CO4	Design programs using I/O operations, String classes and collection framework.
CO5	Design GUI applications using Swing and database connectivity.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2		3					3	1		2
CO2	3	3	3	2		3					2	2		2
CO3	3	3	3	2		3					2	2		2
CO4	3	3	2	3		3					3	2		2
CO5	3	3	3	3		3					3	2		2

Category	Code	Analog Electronics Lab	L-T-P	Credits	Marks
PCR	EC2017		0-0-2	1	100

Objectives	The objective of the course is to design, implement and test transistor biasing, amplifying action and frequency response. Also study the linear and nonlinear applications of amplifiers.
Pre-Requisites	Knowledge of basic electronics and analytical reasoning is required.
Teaching Scheme	Regular laboratory experiments to be conducted under supervision of the teacher with focus on implementation using hardware and software tools.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Design and simulate BJT bias circuit and compare the results.
2	Design and simulate JFET/MOSFET bias circuit and compare the results.
3	Design and simulate BJT common-emitter circuit and compare DC and AC performance.
4	Design and simulate JFET/MOSFET common-source circuit and compare DC and AC performance.
5	Determining the frequency response of a common-emitter amplifier: low frequency, high frequency and mid frequency response and compare with simulated results.
6	Differential amplifier circuits: DC bias & AC operation with & without current source.
7	Study of Darlington connection and current mirror circuits.
8	OP-Amp Frequency Response and Compensation.
9	Application of Op-Amp as differentiator, integrator, square wave generator.
10	Obtain the band width of FET/BJT using Square wave testing of an amplifier.
11	RC phase shift oscillator/Wien-Bridge Oscillator using Op-Amp/Crystal Oscillator.
12	Class A and Class B Power Amplifiers.

Text Books:

T1. R. L. Boylestad and L. Nashelsky, ***Electronic Devices and Circuit Theory***, 10th *Ed.*, Pearson Education, 2009.

Reference Books:

R1. L. K. Maheshwari and M. M. S. Anand, ***Laboratory Experiments and PSPICE Simulations in Analog Electronics***, PHI Learning, 2006.
R2. L. K. Maheshwari and M. M. S. Anand, ***Laboratory Manual for Introductory Electronics Experiments***, John Wiley & Sons, 1980.
R3. K. A. Navas, ***Electronics Lab Manual, Vol-2***, 6th *Ed.*, PHI Learning, 2018.

Online Resources:

1. http://www2.ece.ohio-state.edu/ee327/

P.T.O

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Design, assemble and test BJT biasing circuits.
CO2	Analyze the DC and AC performance of BJT and FET.
CO3	Understand the frequency response of single & multi-stage BJT and compare the results.
CO4	Study operational amplifier and its various applications.
CO5	Analyze and design various wave shaping circuits.
CO6	Implement different oscillator circuits and analyze power amplifier characteristics.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	3	2						2	3	1	1
CO2	3	3	2	3	2						2	3	1	1
CO3	3	3	2	3	3						1	3	2	2
CO4	3	3	3	3	3						1	3	1	2
CO5	3	2	3	3	3						1	3	3	2

Category	Code	Circuits & Signals Lab	L-T-P	Credits	Marks
PCR	EE2003		0-0-4	2	100

Objectives	The objective of this laboratory course is to provide practical knowledge of network theory and recording the experimental data effectively. It also includes studying various signals & systems in time & frequency domains using software tools.
Pre-Requisites	Knowledge of circuit analysis, Laplace transform, Fourier transform, differential equations, complex numbers and elementary calculus are required.
Teaching Scheme	Regular laboratory experiments to be conducted using hardware and software tools under the supervision of the teacher. Demonstration along with required safety measures will be explained for each experiment.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1, 2	Verification of network Theorems in DC & AC networks.
3, 4	Study of resonance in R-L-C series and parallel circuit excited by single-phase AC circuit.
5, 6	Determination of different parameters of a two-port network.
7, 8	Frequency response of 1st order active filters
9	Determination of self-inductance, mutual inductance, and coupling coefficient of a magnetic coupled circuit.
10	Transient analysis in the DC network for RL, RC, and RLC circuits.
11	Introduction to MATLAB Programming and Simulink.
12, 13	Generation of standard signals (impulse, step, ramp, and sinusoidal signal) in continuous and discrete domains using MATLAB.
14	Operations on signals (shifting, scaling, reversal) both in time and amplitude for continuous and discrete signals using MATLAB.
15	Linear convolution of signals (with and without using the inbuilt conv function in MATLAB).
16	Computation of autocorrelation of a signal, and cross-correlation of two signals using MATLAB.
17	Spectral analysis of a non-sinusoidal waveform.
18, 19	Modeling and analysis of DC and AC transients for R-L, R-C, and R-L-C circuits (with damping conditions) using MATLAB simulations.
20	Evaluate the Z-transform of standard functions using MATLAB.

Text Books:

T1. M. E. Van Valkenburg, ***Network Analysis***, 3rd *Ed.*, Pearson Education, 2015.
T2. C. K. Alexander and M. N. O. Sadiku, ***Fundamentals of Electric Circuits***, 5th *Ed.*, Tata McGraw-Hill, 2013.
T3. A. Chakrabarti, ***Circuit Theory: Analysis and Synthesis***, 7th *Ed.*, Dhanpat Rai & Co., 2013.

Reference Books:

R1. S. Ghosh, ***Network Theory: Analysis And Synthesis***, 1st *Ed.*, Prentice Hall of India, 2009.
R2. P. K. Satpathy, P. Kabisatapathy, S. P. Ghosh, and A. K. Chakraborty, ***Network Theory***, 1st *Ed.*, Tata McGraw-Hill, 2009.
R3. J. G. Proakis and D. G. Manolakis, ***Digital Signal Processing: Principles, Algorithms and Applications***, 4th *Ed.*, Prentice Hall India, 2007.
R4. B. P. Lathi, ***Principles of Signal Processing and Linear Systems***, 2nd *Ed.*, Oxford Univ. Press, 2009.

Online Resources:

1. https://nptel.ac.in/courses/108102042/: by Prof. S. C. Dutta Roy, IIT Delhi
2. https://nptel.ac.in/courses/108106075/: by Prof. V. G. K. Murti, IIT Madras
3. https://nptel.ac.in/courses/108104100/: by Prof. A. K. Jagannatham, IIT Kanpur
4. https://nptel.ac.in/courses/117101055/: by Prof. V. M. Gadre, IIT Bombay
5. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/lecture-notes/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Verify fundamental network theorems and analyze resonance in AC and DC circuits.
CO2	Analyze two-port network parameters and demonstrate electrical network characteristics.
CO3	Evaluate the frequency response of active filters for signal conditioning applications.
CO4	Generate and analyze standard signals and perform various operations using software tools.
CO5	Model and simulate DC & AC transients for R-L, R-C, and R-L-C circuits using software tools.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2		2					2	1	1	2
CO2	2	3	2	2	2	3					3	1	1	1
CO3	2	2	3	2		2					1	2	1	2
CO4	3	2		3	3	2					1	2	1	2
CO5	2	2	2	3	3	1					1	2	1	2

Category	Code	Complex Analysis & Numerical Methods	L-T-P	Credits	Marks
PCR	MT2004		3-0-0	3	100

Objectives	The objective of this course is to provide the knowledge of analytic functions, poles & zeros, residue calculus, and numerical methods, along with the applications of these methods in engineering.
Pre-Requisites	Knowledge of calculus of single variables, coordinate geometry of two and three dimensions, matrix algebra and ordinary differential equations is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Basics of Complex Numbers, Derivatives, Analytic Functions, C-R Equations, Basic elementary Complex functions.	**8 Hours**
Module-2	Complex Line Integration, Integral Theorems, Complex Power Series and Taylor Series.	**8 Hours**
Module-3	Laurent Series, Residue Integration and its application for evaluation of real integrals.	**8 Hours**
Module-4	Error Analysis, Solution of Nonlinear Equations, Bisection Method, Fixed-Point Iteration Method, Secant Method, Newton Method, Interpolation by Polynomials: Lagrange Interpolation, Newton Divided Differences, Newton's forward & backward Interpolation.	**9 Hours**
Module-5	Numerical Differentiation and Integration, Trapezoidal, Simpson's Rules, Composite Rules, Error Formulae, Gaussian Quadrature Rules, Solution of Differential Equations by Euler Method, Modified Euler Method, and Runge-Kutta Methods.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. E. Kreyszig, ***Advanced Engineering Mathematics***, 8th *Ed.*, Wiley India, 2015.

Reference Books:

R1. S. Pal and S. C. Bhunia, ***Engineering Mathematics***, 1st *Ed.*, Oxford University Press, 2015.
R2. B. V. Ramana, ***Higher Engineering Mathematics***, 1st *Ed.*, McGraw-Hill, 2017.

Online Resources:

1. https://nptel.ac.in/courses/111105035: by Prof. P. D. Srivastava, IIT Kharagpur.
2. https://nptel.ac.in/courses/122104017: by Prof. S. K. Ray, IIT Kanpur.
3. https://nptel.ac.in/courses/122102009: by Prof. S. R. K. Iyengar, IIT Delhi.
4. https://nptel.ac.in/courses/111107063: by Dr. S. Gakkhar, IIT Roorkee.
5. https://nptel.ac.in/courses/112102316: by Prof. A. Gupta, IIT Delhi.
6. https://nptel.ac.in/courses/111101165: by Prof. S. Baskar, IIT Bombay.
7. https://nptel.ac.in/courses/111107107: by Prof. A. K. Nayak, IIT Roorkee.

P.T.O

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain the fundamental concepts of Analytic function.
CO2	Evaluate complex line integral and find the Taylor's series expansion of analytic functions.
CO3	Expand functions in Laurent's Series and evaluate integrations using residues.
CO4	Find the root of nonlinear and transcendental equations using numerical methods and interpolate data.
CO5	Perform numerical integration and solve ODE using various numerical methods.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	3						1	2	1	1
CO2	2	2	2	2	2						1	2	1	1
CO3	3	3	2	3	3						1	2	1	1
CO4	3	3	3	3	3						2	3	1	1
CO5	3	3	3	3	3						2	2	1	1

Category	Code	Programming in Python	L-T-P	Credits	Marks
UCR	CS2007		3-0-0	3	100

Objectives	The objective of this course is to develop programming skills in Python which is rich in tools & libraries and is popularly used for solving real-life computing problems in many engineering domains.
Pre-Requisites	Basics of programming, algorithms and problem solving skills are required. Prior experience with a programming language will be beneficial.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with programming & problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction to Python**: Introduction, Features of Python, Data types, Variables, Literals, Input/output statements, Keywords, Identifiers, Operators, Precedence and associativity, Expressions, Control statements.	**8 Hours**
Module-2	**Data Structures**: Lists - Operations, Slicing, Built-in list functions, List comprehension, Tuples - Accessing elements, Operations using built-in tuple functions, Dictionaries - Accessing values in dictionaries, Built-in dictionary functions, Sets, Functions, Recursion, Anonymous functions; Modules: Creating modules, Import statement, Packages.	**9 Hours**
Module-3	**Object Oriented Programming**: Creating class and object, Using a class and its methods, Constructor; Inheritance: Types of inheritance, Overriding methods, Encapsulation and information hiding, Polymorphism, Operator overloading, Method overloading and overriding, Abstract method and class.	**8 Hours**
Module-4	**File Handling**: Types of files, Opening & closing, Reading & writing, Binary files; Command line arguments; Exception Handling: Errors, Types of exception, try, except, and finally, assertion; Database Connectivity: Connect with a SQL database, Executing queries, Transactions, SQLDB database connection parameters, Insert, Update, Delete operations.	**7 Hours**
Module-5	**Data Handling, Visualization, and GUI Programming**: Regular Expressions - Match & Search functions, Quantifiers, Pattern; NumPy: Introduction, Creating of arrays and matrices; Panda: Creating a DataFrame, DataFrame operations, Data manipulation and aggregation, Reshaping DataFrame objects; Matplotlib: Introduction, creating basic plots (line plot, scatter plot, bar chart, histogram), Customizing plots; Graphical User Interface: GUI toolkits, Creating GUI widgets with Tkinter, Creating layouts, Radio buttons, Checkboxes, Dialog boxes.	**10 Hours**
	Total	**42 Hours**

Text Books:

T1. R. N. Rao, ***Core Python Programming***, 2nd *Ed.*, DreamTech Press, 2019.

T2. V. Guttag, ***Introduction to Computation and Programming Using Python with Application to Understanding Data***, 2nd *Ed.*, PHI Learning, 2016.

T3. W. McKinney, ***Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Jupyter***, 3rd *Ed.*, O'Reilly Media, 2022.

Reference Books:

R1. P. Barry, ***Head First Python***, 2nd *Ed.*, O'Reilly Media, 2010.
R2. A. Downey, ***Think Python***, 2nd *Ed.*, Green Tea Press, 2015.
R3. E. Matthes, ***Python Crash Course: A Hands-On, Project-Based Introduction to Programming***, 3rd *Ed.*, No Starch Press, 2023.
R4. J. Zelle, ***Python Programming: An Introduction to Computer Science***, 3rd *Ed.*, Franklin, Beedle & Associates, 2016.

Online Resources:

1. https://nptel.ac.in/courses/106106182: By Prof. S. Iyengar, IIT Ropar
2. https://nptel.ac.in/courses/106106145: By Prof. M. Mukund, IIT Madras
3. https://nptel.ac.in/courses/106106212: By Prof. R. Rengasamy, IIT Madras
4. https://nptel.ac.in/courses/106107220: By Prof. A. Ramesh, IIT Roorkee

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Compile and debug basic python programs, and solve problems using control structures.
CO2	Apply the data structure for real life problems and design modular python programs.
CO3	Develop applications using object oriented programming concepts using python.
CO4	Apply the concept of file handling and database connectivity in real life problems.
CO5	Utilize advanced tools & libraries for data analysis and develop GUI based applications.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1		1					2	2	3	1
CO2	3	3	3	2	1	2					3	2	3	2
CO3	3	3	2	2	1	2					2	2	3	1
CO4	2	2	3	2	2	1					2	2	3	1
CO5	3	3	2	1	3	2					3	2	3	2

Category	Code	Digital Electronics	L-T-P	Credits	Marks
PCR	EC2001		3-0-0	3	100

Objectives	The objective of this course is to introduce the concepts & techniques associated with digital electronic systems and their design & simulation using HDL.
Pre-Requisites	Knowledge of Basic Electronics and fundamentals of Number Systems is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Number System: Number System (binary, octal, decimal, hexadecimal) and their Conversion, Arithmetic Operation using 1's and 2's complements; Codes: Binary codes and Their application - BCD Code, Excess-3 Code, 2-4-2-1 Code, 8-4-(-2)-(-1) code and Gray code; Logic Gates: Basic Logic Gates, Universal Logic Gates, Function Realization using basic and universal logic gates, Examples of Logic Gate ICs.	**8 Hours**
Module-2	Combinational Logic Design: Boolean Algebra and Identities, Algebraic Reduction; Sum of Product and Product of Sum forms, Canonical SOP and POS forms, K-Map (Up to 4-variable); Combinational Logic Design: Code Converter, MSI devices like Half and Full Adders, Subtractors, Comparators, Multiplexers, De-Multiplexors, Encoder, Decoder.	**9 Hours**
Module-3	Sequential Logic Design: Flip flops - S-R, D, JK & T Flip Flops. Master-Slave JK FF, Edge triggered FF, Flip Flop Conversion; Synchronous Counters: (Up counter, Down Counter, Up-Down Counter, Mod-N Counters & Random Sequence Counter); Asynchronous Counter: (Up & Down using positive and negative edge trigger Flip Flop) Mod-N Asynchronous counter.	**9 Hours**
Module-4	Shift registers: SISO, SIPO, PIPO & PISO, Bi-directional shift register, Ring Counter, Johnson Ring Counter; Finite State Machines: Mealy and Moore models - State Diagram, State Table, FSM Design using Melay based model, FSM Design using Moore based model, Sequence detector (Melay based), Sequence detector (Moore based).	**8 Hours**
Module-5	Verilog HDL: Introduction to Verilog HDL, different modeling styles in Verilog - Data flow, Behavioral, Gate level and Structural modeling, Data types, Synthesis and simulation, Verilog design codes for combinational and sequential circuits, Verilog test bench for design simulation.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. M. M. Mano and M. D. Ciletti, ***Digital Design: With an Introduction to Verilog HDL***, 5th *Ed.*, Pearson Education, 2013.

T2. L. K. John and C. H. Roth Jr., ***Digital System Design using VHDL***, 2nd *Ed.*, Cengage Learning, 2012.

P.T.O

Reference Books:

R1. D. V. Hall, ***Digital Circuits and Systems***, International Student Edition, McGraw-Hill Education, 1989.
R2. A. A. Kumar, ***Fundamentals of Digital Circuits***, 3rd *Ed.*, PHI Learning, 2014.
R3. R. P. Jain, ***Modern Digital Electronics***, 4th *Ed.*, McGraw-Hill Education, 2009.

Online Resources:

1. https://nptel.ac.in/courses/117106086/: by Prof. S. Srinivasan, IIT Madras
2. https://nptel.ac.in/courses/117103064/: by Prof. Mahanta and Prof. Palanthinkal, IIT Guwahati
3. https://nptel.ac.in/courses/108105113: by Prof. S. Chattopadhyay, IIT Kharagpur
4. https://nptel.ac.in/courses/108105132: by Prof. G. Saha, IIT Kharagpur

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain various number systems, codes and Logic gates.
CO2	Design and analyze combinational logic circuits.
CO3	Design and analyze various sequential logic circuits and explain counter design.
CO4	Implement memory array using sequential logic and explain FSM for digital circuit design.
CO5	Simulate and synthesize digital circuits using Verilog HDL and explore open source tools.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	2	2						2	2	2	2
CO2	3	3	3	2	3						2	3	3	2
CO3	3	3	3	3	3						3	2	3	2
CO4	2	2	2	2	3						2	3	2	1
CO5	3	3	2	2	3						2	2	2	1

Category	Code	Electrical Machines	L-T-P	Credits	Marks
PCR	EE2004		3-1-0	4	100

Objectives	The objective of this course is to study constructional features, working principles, operation, performance and various other aspects of DC & AC electrical machines, transformers, synchronous and induction machines etc.
Pre-Requisites	Knowledge of Basic Electrical Engineering, Physics and knowledge of Basic Mathematics such as Calculus, Ordinary Differential Equations is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**DC Machines**: Constructional features, Armature windings, Armature reaction, Commutation; DC Generator – Expression for EMF induced, Voltage build-up process, OCC, Critical resistance and critical speed, Load characteristics; DC Motor – Back Emf, Torque developed, Characteristic curves; Starting and speed Control of DC Shunt and Series motors, Losses, Efficiency and Power Flow diagram of a DC Machine.	**12 Hours**
Module-2	**Synchronous Machines**: Synchronous Generator – Constructional details, Types of rotors, Winding factors, Emf equation, Synchronous reactance, Armature reaction, Phasor diagrams of non-salient pole synchronous generator connected to infinite bus, Synchronizing and parallel operation, Synchronizing torque, Change of excitation and mechanical input, Voltage regulation (EMF & MMF method), Steady state power-angle characteristics, Two reaction theory, Phasor diagram for salient pole machines, Reluctance power and power angle characteristics, Slip test; Synchronous Motor – Principle of operation, Torque equation, V and Inverted V curves, Power input and power developed equations, starting methods, Hunting.	**12 Hours**
Module-3	**Transformers**: Single-Phase Transformers – Emf equation, Phasor Diagrams at No-Load and Load Conditions of an Ideal transformer and Practical transformer, Equivalent Circuit, Per Unit Calculation and its importance, Voltage regulation, Losses, Efficiency and All-Day efficiency, Open Circuit and Short Circuit Test, Polarity Test, Parallel operation of transformers; Auto Transformer – Constructional and Operational features, Conversion of a two-winding transformer into auto-transformer; Three Phase Transformers – Connections, Vector Groups, Open Delta (V-Connection), Scott Connection (T-Connection).	**12 Hours**

Cont'd. . .

Module-#	Topics	Hours
Module-4	**Induction Motor**: Three-Phase Induction Motor – Principle of operation, Slip, Equivalent circuit, Torque-Slip characteristics, Condition for maximum torque, Losses and efficiency, No-load and blocked rotor tests, Cogging and crawling, Induction generators; Starting method and Speed Control of Three Phase Induction Motor – Types of Starters, DOL, Rotor resistance, Autotransformer and Star-delta starters; Speed Control methods - Voltage control, Frequency control and pole changing, Cascaded connection.	**11 Hours**
Module-5	**Single-Phase Induction Motors**: Constructional details, Double field revolving theory and operation, Equivalent circuit, No-load and blocked rotor test, starting methods of single-phase induction motors, Capacitor Start & Capacitor run Induction motor. **Special Machines**: Shaded pole induction motor, AC series motor, Stepper motors, BLDC motor. **Practical Transformers**: Components of a practical transformer, Power and distribution transformer, Cooling methods of transformers, Buchholtz's relay, Tap changing transformers and its application.	**9 Hours**
	Total	**56 Hours**

Text Books:

T1. A. E. Fitzgerald, C. Kingsley Jr., and S. D. Umans, ***Electric Machinery***, 6th *Ed.*, McGraw-Hill, 2017.
T2. S. J. Chapman, ***Electric Machinery and Fundamentals***, 4th *Ed.*, McGraw-Hill, 2017.

Reference Books:

R1. P. S. Bimbhra, ***Electrical Machinery***, 7th *Ed.*, Khanna Publishers, 2011.
R2. D. P. Kothari and I. J. Nagrath, ***Electric Machines***, 5th *Ed.*, McGraw-Hill Education, 2017.
R3. P. K. Mukherjee and S. Chakravorti, ***Electrical Machines***, Dhanpat Rai Publications, 2011.
R4. B. S. Guru and H. R. Hiziroglu, ***Electric Machinery and Transformers***, 3rd *Ed.*, Oxford Univ. Press, 2012.
R5. B. L. Theraja and A. K. Theraja, ***A Textbook of Electrical Technology (Vol.2) - AC and DC Machines***, 23rd *Revised Ed.*, S Chand & Co, 2005.

Online Resources:

1. https://nptel.ac.in/courses/108105017: by Prof. D. Kastha, IIT Kharagpur
2. https://nptel.ac.in/courses/108105131: by Prof. T. K. Bhattacharya, IIT Kharagpur
3. https://nptel.ac.in/courses/108106072: by Prof. Vasudevan, Rao, and Rao, IIT Madras
4. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-685-electric-machines-fall-2013/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Analyze the construction and operation of DC machines and evaluate their performance through key operating characteristics.
CO2	Explain the construction and performance of different types of synchronous generators and motors and plot their characteristic curves.
CO3	Explain the principles of various transformers and analyze their circuit parameters & operating performances.
CO4	Explain the construction, operation, starting methods, speed control techniques, and performance evaluation of 3-phase induction machines.
CO5	Explore single-phase induction motors, special types of machines and the practical transformer.

P.T.O

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	2	1					1	3	1	
CO2	3	2	1	1	2	1					2	3	2	
CO3	3	2	1	1	2	1					2	3	2	
CO4	3	2	1	1	2	1					2	3	1	
CO5	2	2	1	1	1	1					1	2	2	

Category	Code	Advanced Electronic Circuits	L-T-P	Credits	Marks
PEL	EC2018		3-0-0	3	100

Objectives	The objective of this course is to learn the advanced electronic circuits such as filters, multivibrators, timers, etc., and their applications in the real world.
Pre-Requisites	Fundamental knowledge of basic electronics and analog electronics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Active Filters**: Active filters and their frequency response, First- and second-order low-pass and high-pass Butterworth filters, Filter design, Frequency scaling, Band-pass and band-reject filters (wide and narrow), All-pass filters; **Oscillators**: principles, types, Quadrature and voltage-controlled oscillator, Sawtooth wave generator; **Comparators**: Basic comparator, Zero-crossing detector, Schmitt trigger, Comparator characteristics, Limitations of op-amp as comparators.	**9 Hours**
Module-2	**Multivibrator**: Bi-stable (fixed bias and self-bias) multivibrator, Loading, Commutating capacitors, Triggering the binary (symmetrical and asymmetrical through unilateral device), Schmitt trigger circuit (emitter-coupled bi-stable MV), Mono-stable multivibrator (collector- and emitter-coupled), Gate width and waveforms, Triggering of the monostable MV, Astable multivibrator (collector- and emitter-coupled).	**9 Hours**
Module-3	**Wide-band Amplifiers**: The Hybrid-π, High-frequency, small-signal common-emitter model, RC-coupled amplifier, Frequency response of a transistor stage, Short-circuit current gain, Current gain with resistive load, Transistor amplifier response taking source impedance into account, Transient response of a transistor stage; **Negative Resistance Switching Devices**: Voltage-controllable negative resistance devices, Tunnel diode operation and characteristics, Monostable, astable, bi-stable operations using tunnel diode, Voltage-controlled negative resistance switching circuits.	**8 Hours**
Module-4	**Voltage & Current Time Base Generators**: Time-base generators, General features of a time-base signal, Methods of generating a voltage time-base waveform, Exponential sweep circuit, Miller and bootstrap time-base generators - basic principles, Transistor Miller and transistor bootstrap time-base generators, Current time-base generators, A simple current sweep, Linearity correction through adjustment of driving waveform, Transistor current time-base generator.	**8 Hours**
Module-5	**Specialized IC Applications**: IC 555 timer as monostable and astable multivibrator, Applications, Phase locked loop – Operating principle of PLL, Phase detectors, Exclusive-OR and monolithic phase detectors, Instrumentation amplifier and its applications.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. Millman and H. Toub, ***Pulse, Digital and Switching Waveforms***, 3rd *Ed.*, McGraw Hill, 2017.
T2. R. A. Gayakwad, ***Op-Amps and Linear Integrated Circuits***, 4th *Ed.*, Pearson Education, 2015.

Reference Books:

R1. A. A. Kumar, ***Pulse and Digital Circuits***, 2nd *Ed.*, PHI Learning, 2008.
R2. K. V. Rao, K. R. Sudha, and G. M. Rao, ***Pulse and Digital Circuits***, 1st *Ed.*, Pearson Education, 2011.

Online Resources:

1. https://nptel.ac.in/courses/108102095: by Prof. S.C. Dutta Roy, IIT Delhi
2. https://nptel.ac.in/courses/117107094: by Dr. P. Agarwal, IIT Roorkee
3. https://nptel.ac.in/courses/117108038: by Prof. M. K. Gunasekaran, IISc Bangalore
4. https://www.elprocus.com/types-active-filters-and-applications/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain the concepts of active filters, oscillators, comparators, and signal generators with uses.
CO2	Differentiate and analyze astable, monostable and bistable multivibrator circuits.
CO3	Design multivibrator and microwave circuits using wideband amplifiers and NDR devices.
CO4	Design and implement voltage and current time-base generators for engineering applications.
CO5	Implement specialized ICs like timers, PLLs, and instrumentation amplifiers for applications.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	1	1						1	2	1	1
CO2	3	2	3	1	2						1	2	1	1
CO3	2	2	3	1	2						1	2		
CO4	3	2	2	1	2						1	2	1	
CO5	2	1	1	2	1						1	1	1	

Category	Code	Soft Computing Techniques	L-T-P	Credits	Marks
PEL	EE2007		3-0-0	3	100

Objectives	The objective of this course is to introduce the concepts of various soft computing techniques like fuzzy logic, neural networks, Genetic algorithm etc., along with optimization techniques/evolutionary computation, and their applications in different fields of engineering.
Pre-Requisites	Knowledge of engineering mathematics and the basics of programming is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Basic Tools of Soft Computing**: Evolution of Computing - Soft Computing constituents, Difference between soft computing and hard computing, Characteristics of Soft computing and its applications, Fuzzy logic, Basics of fuzzy logic theory, Crisp and fuzzy sets, Operations on Fuzzy Sets, Membership Functions, Fuzzy relations.	**8 Hours**
Module-2	**Fuzzy Logic Systems**: Fuzzy rules, Propositions, Implications and inferences, Zadeh's compositional rule of inference, Methods of Defuzzification; Fuzzy Logic Controller: Fuzzy Inference System, Mamdani, Takagi and Sugeno architectures, Examples and applications of fuzzy logic controllers.	**10 Hours**
Module-3	**Artificial Neural Networks**: Biological background of Neural Networks and its architecture, Single layer feed forward network, Multi-layer feed forward network, Recurrent networks, Early neural network architectures - Rosenblatt's Perceptron, ADALINE network, MADALINE network, Examples and applications of neural networks.	**8 Hours**
Module-4	**Training of ANN**: Back propagation algorithm, Effect of tuning parameters of the back propagation algorithm, Radial Basis Function networks & Least Square training algorithm, Kohenen self–organizing map and learning vector quantization networks, Recurrent neural networks, Simulated annealing neural networks, Adaptive Neuro-fuzzy inference systems (ANFIS).	**10 Hours**
Module-5	**Evolutionary Computing**: Basics of Genetic Algorithm and its architectures, GA operators - Encoding, Crossover, Selection, Mutation; Introduction to other optimization techniques and hybrid evolutionary algorithms.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. J. S. R. Jang, C. T. Sun, and E. Mizutani, ***Neuro-Fuzzy & Soft Computing - A Computational Approach to Learning and Machine Intelligence***, 1st *Ed.*, PHI Learning, 2015.

T2. S. Rajasekaran and G. A. V. Pai, ***Neural Networks, Fuzzy Systems and Evolutionary Algorithms : Synthesis and Applications***, 2nd *Revised Ed.*, PHI Learning, 2017.

Reference Books:

R1. F. O. Karry and C. De Silva, ***Soft Computing and Intelligent Systems Design - Theory, Tools and Applications***, 1st *Ed.*, Pearson Education, 2009.

R2. S. Haykin, ***Neural Networks : A Comprehensive Foundation***, 2nd *Ed.*, Pearson Education,1997.
R3. T. J. Ross, ***Fuzzy Logic with Engineering Applications***, 3rd *Ed.*, Wiley, 2011.

Online Resources:

1. https://nptel.ac.in/courses/127105006: by Prof. D. K. Pratihar, IIT Kharagpur
2. https://nptel.ac.in/courses/106105173: Prof. D. Samanta, IIT Kharagpur
3. https://nptel.ac.in/courses/117105084: Prof. S. Sengupta, IIT Kharagpur

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain the fundamentals of fuzzy logic and apply its concepts to solve various problems.
CO2	Apply fuzzy principles & inference and implement them for designing fuzzy systems.
CO3	Apply different types of neural networks in electrical & electronics engineering problems.
CO4	Analyze effectiveness of neural networks for solving complex engineering problems.
CO5	Explore evolutionary computation techniques & its application to genetic algorithm.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	2	1	1					1	1	1	
CO2	3	3	2	2	2	2					2	2	2	2
CO3	3	3	1	1	3	2					2	2	2	2
CO4	3	3	1	1	3	2					1	2	2	2
CO5	3	3	1	1	2	1					1	1	2	2

Category	Code	Renewable Energy Systems	L-T-P	Credits	Marks
PEL	EE2008		3-0-0	3	100

Objectives	The objective of this course is to study various renewable energy sources, their generation technologies, storage methods, and efficient utilization, along with their environmental impacts.
Pre-Requisites	Basic knowledge of semiconductor physics, fluid dynamics, and electrical engineering concepts is required. Familiarity with energy systems, power generation, and environmental science is recommended.
Teaching Scheme	Regular classroom lectures with use of ICT as needed, sessions are planned to be interactive with focus on real world examples and case-studies.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction: Conventional & non-conventional energy sources, their impact, availability, variability, Indian and world scenario; Basic concept: Solar, Wind, Biomass, Wave, Tidal, Geothermal energy systems and Hydroelectric Energy; Solar Energy: Solar processes, Composition of solar radiation; Extra-terrestrial & terrestrial radiation, Angles - Azimuth, Zenith, Hour; Irradiance, Solar constant; Solar Thermal Systems & Applications: Solar collectors, Types & performance characteristics, Water heating systems (active & passive), Space heating & cooling systems, Solar Cooker, Solar thermal power plant.	**8 Hours**
Module-2	Solar Photovoltaic System: Operating principle, Photovoltaic cell concepts, Cell, Module, Array, Losses in solar cell, Effects of partial & complete shadowing, Series and parallel connections, Cell mismatching, PV voltage-current characteristics, Equivalent circuit, Maximum power point tracking; Applications: battery charging, Pumping, Lighting.	**9 Hours**
Module-3	Biomass Power: Principles of biomass conversion, Combustion and fermentation, Anaerobic digestion, Types of biogas digester, Wood gasifier, Pyrolysis, Applications: Biogas, Wood stoves, Biodiesel, Combustion engine, Urban waste to energy conversion, Biomass-based power generation.	**9 Hours**
Module-4	Wind Energy: Wind energy, Variability, Conversion principle; Wind power density, Efficiency limit, Types of converters, Aerodynamics of rotors, Power∼Speed and Torque∼Speed characteristics, Wind turbine control systems; Conversion to Electrical Power: Induction and synchronous generators, Grid connected & self-excited induction generator operation, Constant voltage & constant frequency generation with power electronic control, Single & double output systems, Reactive power compensation, Characteristics of wind power plant, Concepts of DFIG.	**9 Hours**

Cont'd. . .

Module-#	Topics	Hours
Module-5	Energy Storage Systems: Batteries, Ultracapacitors, SMES; Fuel Cell: Fuel Cell Basics, History of fuel cell technology, Open circuit voltage, Nernst equation analysis, Causes for voltage loss, Types of fuel cell and their efficiency, Electric Vehicles (EVs) and Backup Power & Uninterruptible Power Supply (UPS); Introduction to Hybrid Energy Systems: PV-Wind, PV-Fuel Cell, PV-Diesel, Introduction to Green Hydrogen Technology.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. B. H. Khan, ***Non-Conventional Energy Resources***, 3rd *Ed.*, McGraw Hill Education, 2017.
T2. S. N. Bhadr, D. Kastha, and S. Banerjee, ***Wind Electrical Systems***, 7th *Ed.*, Oxford University Press, 2005.
T3. G. Boyel, ***Renewable Energy - Power for a Sustainable Future***, 3rd *Ed.*, Oxford University Press, 2012.

Reference Books:

R1. S. A. Abbasi and N. Abbasi, ***Renewable Energy Sources and Their Environmental Impact***, 1st *Ed.*, PHI Learning, 2004.
R2. S. H. Saeed and D. K. Sharma, ***Non-Conventional Energy Resources***, 4th *Ed.*, S. K. Kataria & Sons, 2019.
R3. S. Peake, ***Renewable Energy : Power for a Sustainable Future***, 4th *Ed.*, Oxford University Press, 2018.
R4. C. S. Solanki, ***Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers and Engineers***, 1st *Ed.*, PHI Learning, 2013.

Online Resources:

1. https://nptel.ac.in/courses/103107157: by Prof. B. Mondal, IIT Roorkee
2. https://nptel.ac.in/courses/108105058: by Prof. S. Banerjee, IIT Kharagpur
3. https://nptel.ac.in/courses/121106014: by Dr. P. Haridoss, IIT Madras

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Generalize solar thermal systems and identify alternate energy sources & their characteristics.
CO2	Analyse and design a solar photovoltaic system for specified applications.
CO3	Evaluate the effectiveness of biomass energy conversion in waste management.
CO4	Design wind energy systems and analyze their operational characteristics.
CO5	Investigate the operation of fuel cells and the working of different energy storage systems.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).

Cont'd. . .

PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	1	1	1	2					1	3	1	1
CO2	2	1	2	2	2	2					2	2	3	2
CO3	1	1	2	1	1	3					2	2	1	1
CO4	2	1	2	2	2	3					2	3	2	2
CO5	1	1	2	2	1	2					2	2	1	1

Category	Code	Design of Electrical Apparatus	L-T-P	Credits	Marks
HNS	EE2009		3-0-0	3	100

Objectives	The objective of this course is to study advanced topics in various electrical machines and transformers, and applications of computers to design them.
Pre-Requisites	Knowledge of DC and AC machines is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Design of Field System and Armature: Major considerations in Electrical Machine Design, Materials for Electrical apparatus, Design of Magnetic circuits, Magnetising current, Flux leakage, Leakage in Armature, Design of lap winding and wave winding.	**8 Hours**
Module-2	Design of DC Machines: Construction, Output Equations, Main Dimensions – Choice of specific loadings, Selection of number of poles, Design of Armature, Design of commutator and brushes, design of field, Computer program: Design of Armature main dimensions.	**8 Hours**
Module-3	Design of Transformers: Construction, KVA output for single and three phase transformers, Overall dimensions, design of yoke, core and winding for core and shell type transformers, Estimation of No-load current, Temperature rise in Transformers, Design of Tank and cooling tubes of Transformers. Computer program: Complete Design of single-phase core transformers.	**8 Hours**
Module-4	Design of Induction Motors: Construction, Output equation of Induction motor, Main dimensions, choice of specific loadings, Design of squirrel cage rotor and wound rotor, Magnetic leakage calculations, Operating characteristics: Magnetizing current, Short circuit current, Circle diagram, Computer program: Design of slip-ring rotor.	**10 Hours**
Module-5	Design of Synchronous Machines: Output equations, choice of specific loadings, Design of salient pole machines, Short circuit ratio, Armature design, Estimation of air gap length, Design of rotor, Design of damper winding, Determination of full load field MMF, Design of field winding, Design of turbo alternators, Computer program: Design of Stator main dimensions, Brushless DC Machines.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. A. K. Sawhney, ***A Course in Electrical Machine Design***, 5th *Ed.*, Dhanpat Rai & Sons, 1984.

T2. M. V. Deshpande, ***Design and Testing of Electrical Machines***, 3rd *Ed.*, PHI learning, 2011.

T3. S. K. Sen, ***Principles of Electrical Machine Designs with Computer Programs***, 2nd *Ed.*, Oxford & IBH, 2009.

Reference Books:

R1. A. Shanmugasundaram, G. Gangadharan, and R. Palani, ***Electrical Machine Design Data Book***, 1st *Ed.*, New Age International, 2007.

R2. B. Singh, ***Electrical Machine Design***, 1st *Ed.*, Vikas Publishing House, 1981.
R3. V. Rajini and V. S. Nagarajan, ***Electrical Machine Design***, 1st *Ed.*, Pearson Education, 2018.
R4. K. M. Vishnumurthy, ***Computer Aided Design of Electrical Machines***, 1st *Ed.*, BSP Books, 2015.

Online Resources:

1. https://nptel.ac.in/courses/108105017: by Prof. S. Maiti, IIT Kharagpur
2. https://nptel.ac.in/courses/108105131: by Prof. T. K. Bhattacharya, IIT Kharagpur
3. https://nptel.ac.in/courses/108102372: by Prof. B. Singh, IIT Delhi

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Design and construct the armature & field system of rotating machines.
CO2	Design and analyze the performance of DC machines.
CO3	Explore the design principles of transformers and their analysis.
CO4	Design and analyze of various types of induction machines.
CO5	Model synchronous machines and evaluate their performance characteristics.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	1	1	1					1	2	2	1
CO2	3	3	2	1	1	1					1	2	2	1
CO3	3	3	2	1	2	1					1	2	2	1
CO4	3	3	2	1	2	1					1	2	2	1
CO5	3	3	2	1	2	1					1	2	2	1

Category	Code	Operating Systems	L-T-P	Credits	Marks
MNR	CS2003		3-0-0	3	100

Objectives	The objective of this course is to understand the fundamental concepts, techniques & algorithms, and internal working principles of a computer operating system to become a system designer or an efficient application developer.
Pre-Requisites	Knowledge of computer programming and data structures is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Overview, Evolution of operating system, Types of systems - Batch Processing, Multiprogramming, Time Sharing systems; Personal Computers, Parallel, Distributed, and Real-time Systems; Operating System Services, System components, System calls.	**7 Hours**
Module-2	**Process Management**: Process concepts, states, PCB, Process scheduling queues, queuing diagram, Types of schedulers, Operations on process; Interprocess communication - shared memory, message passing, Concept of buffering, Thread overview, Benefits of multi-threaded program, User and kernel threads, Multi-threading models, Issues with multi-threading - thread cancellation, thread pools, thread specific data; CPU Scheduling: Dispatcher, Scheduling - Criteria, Algorithms - FCFS, SJF, SRTF, RR, Priority, Multi-level Queue (MLQ), MLQ with Feedback.	**9 Hours**
Module-3	**Process Synchronization**: Background, Bounded-buffer – Shared-memory solution to Producer-consumer problem, Race condition, Critical section problem - Peterson's solution, Synchronization hardware: TestAndSet(), swap() instructions, Semaphores - Counting and binary semaphore, spinlocks, Classical problems of synchronization - Bounded-buffer problem, Readers-writers problem, Dining-philosophers problem, Monitors; Deadlock: System model, characterization, Resource-allocation graph, Methods for handling deadlocks, Deadlock prevention & avoidance, Banker's algorithm, Deadlock detection & recovery.	**9 Hours**
Module-4	**Memory Management**: Background, Logical & physical address space, Dynamic loading & dynamic linking, Swapping, Contiguous memory allocation, Dynamic storage allocation problem, Overlays, Paging, Segmentation; Virtual Memory: Background, Demand paging, Page fault, Basic page replacement policy, Page replacement algorithms - FIFO, OPT, LRU, LRU Approximation, LFU, MFU, Thrashing, Working-set model.	**9 Hours**

Cont'd. . .

Module-#	Topics	Hours
Module-5	**Secondary Storage Structure**: Overview of mass storage structure, Disk structure, Disk scheduling - FCFS, SSTF, SCAN, C-SCAN, LOOK, CLOOK, Swap-space management, RAID structure; File System: Concept, Access methods, Directory structure, Directory implementation, Allocation methods, Free space management, Access control list; I/O System: Polling, Interrupts, DMA; Case Studies: The LINUX System visual representations of your data, Avoiding common pitfalls.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. A. Silberschatz, P. B. Galvin, and G. Gagne, ***Operating System Concepts***, 8th *Ed.*, Wiley, 2009.
T2. M. Milenković, ***Operating Systems: Concepts and Design***, 2nd *Ed.*, Tata McGraw-Hill, 2001.

Reference Books:

R1. A. S. Tanenbaum, ***Modern Operating Systems***, 3rd *Ed.*, PHI, 2009.
R2. P. B. Prasad, ***Operating Systems and System Programming***, 2nd *Ed.*, Scitech Publications, 2015.

Online Resources:

1. https://nptel.ac.in/courses/106102132/: by Prof. S. Bansal, IIT Delhi
2. https://nptel.ac.in/courses/106108101/: by Prof. P. C. P. Bhatt, IISc Bangalore
3. https://nptel.ac.in/courses/106106144/: by Prof. C. Rebeiro, IIT Madras
4. https://nptel.ac.in/courses/106105214/: by Prof. S. Chattopadhyay, IIT Kharagpur
5. https://www.cse.iitb.ac.in/~mythili/os/: Notes & slides by Prof. M. Vutukuru, IIT Bombay
6. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-828-operating-system-engineering-fall-2012/lecture-notes-and-readings/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explore principles behind various types of operating systems, system components, system calls, protection mechanisms and services.
CO2	Explain different schedulers, scheduling policies, and design new scheduling algorithms for real life problems.
CO3	Describe the significance of process synchronization through classical synchronization problems and deadlock handling mechanisms.
CO4	Describe the working principle of main memory, cache memory and virtual memory organization and solve memory related problems.
CO5	Articulate secondary storage management, and analyze the performance of various disk scheduling algorithms.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).

Cont'd. . .

PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1		2					2	2	2	
CO2	3	3	3	1		2					2	3	3	1
CO3	3	3	3	1	1	2					2	3	3	1
CO4	3	3	3	1	1	2					1	3	3	1
CO5	2	2	2	1	1	2					1	3	3	1

Category	Code	Data Mining & Data Warehousing	L-T-P	Credits	Marks
MNR	CS3013		3-0-0	3	100

Objectives	The objective of this course is to analyze large, complex, information-rich data in various domains, study the concepts and applications of data warehouses and discover useful patterns by applying data mining techniques.
Pre-Requisites	Knowledge of database management systems, probability, statistics and programming language are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Data Warehousing**: Concepts and applications, Difference between operational database and data warehouses, OLTP and OLAP systems, 3-tier architecture, ETL Process, Data Marts, Data staging area, Metadata.	**8 Hours**
Module-2	**Data Mining**: Concepts and applications, KDD process, Data Objects and attributes types, Basic Statistical Descriptions of Data – Central tendency - variation, spread, standard deviation and Boxplot, Data similarity; Data Pre-processing – Data cleaning, binning, integration, reduction and transformation; Correlation Analysis – Pearson's coefficient, Chi-Square and Covariance.	**10 Hours**
Module-3	**Mining Frequent Patterns**: Introduction, Market Basket Analysis, Association rule mining, Support, Confidence, Lift, Frequent Item-sets, Closed Item-sets, Maximal Item-set and generation, Apriori and FP-Growth algorithms, Evaluation of association patterns, Association and Correlation analysis.	**8 Hours**
Module-4	**Classification**: Concepts and applications, Decision Tree Induction, Information Gain, Bayes Theorem, Naïve Bayesian Classifier, K Nearest Neighbor; Classification evaluation techniques (Confusion matrix – Precision, Recall & F-Measure), Handling the class imbalance problem (Oversampling, Undersampling, Threshold moving and Ensemble techniques).	**8 Hours**
Module-5	**Clustering**: Concepts and applications, Partition-based Clustering – K-Means and K-Medoid algorithms, Hierarchical clustering – Agglomerative and Divisive methods, Density-based Clustering – DBSCAN, Graph-based clustering, Clustering evaluation techniques (Silhouette Coefficient and Dunn's Index).	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. Han, M. Kamber, and J. Pei, ***Data Mining: Concepts and Techniques***, 3rd *Ed.*, Morgan Kaufmann, 2011.

T2. R. Thareja, ***Data Warehousing***, 1st *Ed.*, Oxford University Press, 2009.

P.T.O

Reference Books:

R1. A. Berson and S. J. Smith, ***Data Warehousing, Data Mining & OLAP***, 1st *Ed.*, McGraw Hill Education, 2017.
R2. P. N. Tan, M. Steinbach, A. Karpatne, and V. Kumar, ***Introduction to Data Mining***, 2nd *Ed.*, Pearson Education, 2019.

Online Resources:

1. https://nptel.ac.in/courses/106105174/: by Prof. P. Mitra, IIT Kharagpur
2. https://nptel.ac.in/courses/110107092: by Prof. G. Dixit, IIT Roorkee
3. http://infolab.stanford.edu/~ullman/mining/2003.html: notes by Stanford University
4. https://www.cse.iitb.ac.in/~krithi/courses/631/anand.ppt: by Prof. A. Deshpande, IIT Bombay

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe the concepts and applications of Data Warehouse and its components.
CO2	Explain the concepts of Data Mining and its applications.
CO3	Construct frequent patterns and association rules by discovering correlations among data.
CO4	Compare key classification algorithms and apply them to real life problems in multiple domains.
CO5	Apply different clustering algorithms for solving real life problems in various domains.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	3	3							2	3	1	1
CO2	2	2	2	2							2	3	2	2
CO3	3	2	2	2							3	3	2	2
CO4	3	3	2	3							3	3	2	2
CO5	2	3	2	3							3	3	2	2

Category	Code	Semiconductor Devices	L-T-P	Credits	Marks
MNR	EC2013		3-0-0	3	100

Objectives	The objective of this course is to study the characteristics of different semiconductor devices used in modern electronic equipment and explore the nano scale CMOS structures and materials for applications in advanced technology nodes.
Pre-Requisites	Knowledge of physics and semiconductor devices is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	MOSFET: ITRS roadmap for semiconductors, Different groups of MOSFETs, Gate length scaling, Short channel effects, Scattering mechanisms, Hot carrier effect, Buried channel device, Gate oxide scaling and Gate leakage currents in MOSFETs.	**9 Hours**
Module-2	Advanced Materials for MOSFETs: High-K materials, Gate stack & Channel stack technology, Reverse short channel effect and HALO doping, FDSOI technology.	**9 Hours**
Module-3	Hetero structure FETs: Hetero junction MOSFETs, Strain engineering for higher mobility (Strained-Si/Strained-SiGe), Staggered hetero junction MOSFETs, Tunnel FETs.	**8 Hours**
Module-4	Nanoscale Devices: Multiple Gate MOS Structures – Double Gate MOSFET, FinFET, Surrounding Gate MOSFET, HEMTs – AlGaN/GaN HEMT structure and operation.	**8 Hours**
Module-5	Applications of MOSFETs: RF performance and linearity analysis of MOSFETs for high frequency applications, MOSFET application as bio-sensor, optoelectronic devices (LEDs, LASERs, Photo diodes, Solar cells).	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. D. A. Neamen, ***Semiconductor Physics and Devices***, 4th *Ed.*, McGraw-Hill, 2012.
T2. S. M. Sze and K. N. Kwok, ***Physics of Semiconductor Devices***, 3rd *Ed.*, Wiley & Sons, 2006.

Reference Books:

R1. G. Streetman and S. K. Banerjee, ***Solid State Electronic Devices***, 7th *Ed.*, Pearson, 2014.
R2. C. C. Hu, ***Modern Semiconductor Devices for Integrated Circuits***, 1st *Ed.*, Pearson, 2010.
R3. R. S. Muller, T. I. Kamins and M. Chan, ***Device Electronics for Integrated Circuits***, 3rd *Ed.*, Wiley & Sons, 2003.
R4. C. K. Maiti, S. Chattopadhyay and L. K. Bera, ***Strained-Si Heterostructure Field Effect Devices***, 1st *Ed.*, CRC Press, 2007.

Online Resources:

1. https://nptel.ac.in/courses/108108122: by Prof. D. N. Nath, IISc Bangalore
2. https://nptel.ac.in/courses/117108047: by Dr. N. Bhat, et al., IISc Bangalore
3. https://nptel.ac.in/courses/108107129: by Prof. S. Dasgupta, IIT Roorkee
4. https://nptel.ac.in/courses/117107149: by Prof. V. S. Poonia, IIT Roorkee

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Illustrate the limit at ions of down scaling the size of MOS transistor.
CO2	Explore the use of advanced materials in the MOS structure and their benefits.
CO3	Analyze the advantages of Hetero Junction MOSFET structures.
CO4	Summarize the advantages of nano scale MOS structures and HEMTs.
CO5	Explain the applications of MOSFETs in different domains.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	2	2	2	1	2		1			1	2		2
CO2	3	3	2	2	2	2		2			2	2	1	2
CO3	3	1	3	1	1	1		2			1	1	1	1
CO4	3	3	3	2	2	2		2			2	2	2	2
CO5	3	3	3	2	2	2		2			2	3	2	2

Category	Code	Embedded C Programming	L-T-P	Credits	Marks
MNR	EC2011		3-0-0	3	100

Objectives	The objective of this course is to learn the in-depth concepts of embedded C programming techniques, GPIO, peripheral operations, and serial communication standards by leveraging industry standard MCUs.
Pre-Requisites	Knowledge of computer programming and basic electronics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on design & programming activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**C Programming**: Names, Types, and Type declarations, Storage classes, Linkage and Scope, Character constants, Arrays, Other types, Operators and Expressions, Increment and Decrement operators, Precedence and Associativity, Program Flow and Control, Functions, Recursion, Demonstration and practice.	**8 Hours**
Module-2	**Advanced Topics in C**: Pointers, Multidimensional arrays, Structures, Input and Output, Memory Management, Miscellaneous functions, Demonstration and practice.	**9 Hours**
Module-3	**Introduction to STM MCU**: Principal MCU components, Bit Serial Ports, S/W for MCU programming, STM project development, Memory-Mapped peripherals, Core memory addresses, Peripheral memory addresses; HAL_GPIO module – GPIO pin hardware, LED Test demonstration, Enabling multiple outputs, Push-Button test; Clock speed – Setting the PIN clock speed, Demonstration and practice.	**9 Hours**
Module-4	**Interrupts, Timer and UART**: NVIC specifications; Interrupt Process – External Interrupts; STM timer peripherals, Timer configurations, LED test programs; UART & USARTs – Transmit and Receive programming, Demonstration and practice.	**8 Hours**
Module-5	**ADC and PWM**: ADC Functions – ADC module with HAL, Conversion modes, Channels, Groups, and Ranks, Demonstrations; General purpose timer PWM signal generation, Timer H/W architecture, PWM signals with HAL; Introduction to I2C, SPI, Demonstration and practice.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. P.S. Deshpande and O. G. Kakde, ***C and Data Structures***, 1st *Ed.*, Dreamtech Press, 2003.
T2. E. Balagurusamy, ***Programming in ANSI C***, 7th *Ed.*, McGraw-Hill Education, 2017.
T3. C. Noviello, ***Mastering STM32***, 2nd *Ed.*, Leanpub, 2022.
T4. M. A. Mazidi, S. Chen, and E. Ghaemi, ***STM32 Arm Programming for Embedded Systems (Using C Language with STM32 Nucleo)***, 1st *Ed.*, Microdigitaled, 2018.

Reference Books:

R1. K. R. Venugopal and S. R. Prasad, ***Mastering C***, 3rd *Ed.*, McGraw-Hill Education, 2017.
R2. T. V. Sickle, ***Programming Microcontrollers in C***, 2nd *Ed.*, LLH Publishing, 2001.

Online Resources:

1. https://nptel.ac.in/courses/106104128: By Prof. S. Nandakumar, IIT Kanpur
2. https://nptel.ac.in/courses/106105171: By Prof. A. Basu, IIT Kharagpur
3. https://nptel.ac.in/courses/106105193: By Prof. I. Sengupta and Prof. K. Datta, IIT Kharagpur
4. https://nptel.ac.in/courses/108105102: By Prof. S. Chattopadhyay, IIT Kharagpur

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain the concepts of C programming required to program any MCU.
CO2	Develop advanced C programming skills for embedded system applications.
CO3	Program an Industry standard MCU using embedded C programming.
CO4	Describe interrupts, timers, and UART operations for real-time applications.
CO5	Analyze the ADC and PWM operations using embedded C programming techniques.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	1	1	1						1	2	2	2
CO2	2	2	2	1	2						1	2	2	2
CO3	3	3	3	3	2						2	3	3	3
CO4	3	3	3	3	2						2	3	3	3
CO5	3	3	3	3	1						2	3	3	3

Category	Code	Digital Marketing & SMO	L-T-P	Credits	Marks
MNR	MG2002		3-0-0	3	100

Objectives	The objective of this course is to provide students with foundational knowledge and practical skills in digital marketing tools, platforms and analytics, enabling them to design, execute and evaluate effective data-driven marketing campaigns across digital channels.
Pre-Requisites	Basic understanding of marketing, computer fundamentals and familiarity with the internet, websites and social media platforms is required.
Teaching Scheme	Regular classroom lectures with the use of ICT tools as and when required; sessions are planned to be interactive with emphasis on real-world case studies, demonstrations and exposure to digital marketing tools.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Digital Marketing**: Fundamentals of Marketing Concepts and Principles, Key Marketing Terminology, Role of Marketing in the Digital Age, Digital Marketing Channels and Platforms, Role of Data in Digital Marketing; Introduction to Google Ads, Setting Up Google Ads Campaigns, Keyword Research and Selection, Ad Copywriting Best Practices, Ad Formats and Extensions, Bid Management and Budgeting, Quality Score Optimization, Performance Measurement and Reporting.	**8 Hours**
Module-2	**Content Creation & Email Marketing**: Content Creation Tools and Platforms, Visual Content Creation (Graphics, Images, Videos), Content Marketing Strategy Development, Content Distribution and Promotion, Content Calendar Planning, Measuring Content Marketing Effectiveness; Email Marketing - Introduction, Email Marketing Platforms, Designing Effective Email Campaigns, Automation Workflows and Drip Campaigns, Email Marketing Analytics and Tracking.	**7 Hours**
Module-3	**Marketing on Social Media**: Advertising on Facebook and Instagram, Ad Campaign Objectives, Ad Creatives and Visuals, Ad Placements and Audience Targeting, Facebook Pixel and Conversion Tracking; Video Advertising on YouTube, Video Ad Creation and Optimization, Targeting Options and Metrics; Advertising Formats on Twitter, Campaign Measurement and Reporting.	**8 Hours**
Module-4	**SEO & SMO Management**: SEO Fundamentals and Principles, Keyword Research and Analysis, On-Page SEO Optimization, Off-Page SEO Including Link Building and Backlinks, Technical SEO and Site Audit, SEO Tools and Platforms such as SEMrush and Ahrefs; Setting Up Organizational Pages on Social Platforms, Content Calendar Creation, Use of Social Media Management Tools such as Buffer and Hootsuite, Social Media Analysis and Management.	**8 Hours**

Cont'd. . .

Module-#	Topics	Hours
Module-5	**B2B & Marketing Analytics**: B2B Digital Marketing on LinkedIn, LinkedIn Advertising Formats, Targeting Options, Sponsored Content and InMail, Lead Generation Campaigns, Campaign Optimization; Influencer Marketing Strategy, Influencer Identification and Collaboration, Measuring Influencer Marketing ROI, Influencer Marketing Platforms and Tools; Web Analytics Fundamentals, Analytics Setup and Usage, Conversion Rate Optimization Principles, Website Traffic and User Behavior Analysis.	**11 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Gupta, ***Digital Marketing***, 3rd *Ed.*, McGraw-Hill, 2022.
T2. D. Chaffey and F. Ellis-Chadwick, ***Digital Marketing: Strategies, Implementation and Practice***, 6th *Ed.*, Pearson Education, 2015.
T3. T. L. Tuten and M. R. Solomon, ***Social Media Marketing***, 3rd *Ed.*, Sage Publications, 2017.

Reference Books:

R1. D. Chaffey and P. R. Smith, ***Digital Marketing Excellence: Planning, Optimizing and Integrating Online Marketing***, 5th *Ed.*, Routledge Publication, 2017.
R2. E. Enge, S. Spencer, J. C. Stricchiola, and R. Fishkin, ***The Art of SEO: Mastering Search Engine Optimization***, 3rd *Ed.*, O'Reilly Media, 2015.
R3. S. S. Chauhan, P. Bhatia, and V. Prakash, ***Digital and Social Media Marketing***, 1st *Ed.*, Mahe Publications, 2023.
R4. M. O. Opresnik, S. Hollensen, and P. Kotler, ***Social Media Marketing: A Practitioner Approach***, Indian Edition, Vikas Publishing, 2022.

Online Resources:

1. https://nptel.ac.in/courses/110105091: by S. Das, IIT Kharagpur
2. https://nptel.ac.in/courses/110107081: by IIT Roorkee
3. https://nptel.ac.in/courses/110105085: by IIT Kharagpur
4. https://nptel.ac.in/courses/110106120: by IIT Madras
5. https://nptel.ac.in/courses/110106144: by IIT Bombay
6. https://academy.hubspot.com/courses
7. https://skillshop.withgoogle.com/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain digital marketing fundamentals and design basic Google Ads with performance analysis.
CO2	Create content and email marketing campaigns using tools, automation and analytics.
CO3	Design and analyze social and video advertising campaigns across major digital platforms.
CO4	Apply SEO techniques and manage social media using industry tools and performance metrics.
CO5	Implement B2B, influencer and analytics strategies to optimize digital marketing outcomes.

Program Outcomes Relevant to the Course:

PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).

Cont'd. . .

PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1		1	1	1	1	1	1	1	2	1	2	1	1	2
CO2		2	2	2	3	1	1	2	3	2	3	1	2	3
CO3		2	2	3	3	2	1	2	3	2	3	1	3	3
CO4		2	1	3	2	1	1	2	3	2	3	1	3	3
CO5		2	2	2	3	2	1	2	3	2	3	1	2	3

Category	Code	Fundamentals of Business Analytics	L-T-P	Credits	Marks
MNR	MG2005		3-0-0	3	100

Objectives	The objective of this course is to introduce the fundamental concepts of business analytics with preliminary tools & techniques used for discovering important knowledge and use them for achieving business goals.
Pre-Requisites	Basic knowledge of mathematics, probability & statistics, and intermediate level of competence in spreadsheet applications is required.
Teaching Scheme	Regular classroom lectures, power point presentations with use of ICT as required, with examples, real-life case studies, assignments and projects.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Business Intelligence and Business Analytics, Its importance & need for businesses, Business process flow, Business challenges, Decision making under uncertainty, Data driven decision making; Types of analytics: Descriptive, Diagnostic, Predictive, Prescriptive.	**6 Hours**
Module-2	**Business Statistics**: Data types, Descriptive and Inferential statistics, Sampling techniques, Measure of central tendencies, Measure of dispersion, Hypothesis Testing, Chi Square test, Regression and Correlation.	**8 Hours**
Module-3	**Basic Analysis**: Tools and functionalities of spread- sheets, Data recording rules, Formatting, Conditional formatting, Data protection, Working with multiple sheets & files, Hyperlinking, Cell reference, Sort, Filter, Find and replace, Data cleaning, Applying spreadsheet functions.	**8 Hours**
Module-4	**Advanced Analysis**: Data calculation and manipulation functions (Text, Unique, Sort, Transpose, Filter etc.), Data extraction Functions (Nested Ifs, If And, If Or, Xlookup, Vlookup, Index etc.), Pivot table and charts; Automation using Macros, Basics of power query, Business reporting and visual analytics, Slicers, Advanced functions on cloud-based spreadsheets (Importhtml, Importdata, Importrange, Query, Finance).	**8 Hours**
Module-5	**Business Analytics using AI**: AI tools for data insight, Business verticals, Sales and Marketing analytics, Finance analytics, Human resources analytics, Supply chain analytics.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. V. Chavda, ***Fundamentals of Business Analytics***, 1st *Ed.*, Himalaya Publishing House, 2024.
T2. U. D. Kumar, ***Business Analytics: The Science of Data-Driven Decision Making***, 2nd *Ed.*, Wiley Publication, 2017.

Reference Books:

R1. J. R. Evans, ***Business Analytics***, 3rd *Ed.*, Pearson Education, 2011.
R2. S. Gupta and A. Jathar, ***Marketing Analytics***, 1st *Ed.*, Wiley Publication, 2021.
R3. R. Bhattacharya and A. M. Bhattacharyya, ***Supply Chain Analytics***, 1st *Ed.*, Sage Publications, 2022.

Online Resources:

1. https://nptel.ac.in/courses/110105089: by Prof. R. P. Pradhan, IIT Kharagpur
2. https://nptel.ac.in/courses/110106050: by Dr. S. Vaidhyasubramaniam, IIT Madras

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Appreciate business processes, concepts of business intelligence and analytics.
CO2	Apply statistical methods for descriptive, inferential, predictive and diagnostic analytics.
CO3	Leverage spreadsheet tools for data entry, cleaning, analysis & visualization through dashboards.
CO4	Apply advanced tools for data extraction, pivoting, automation and visual analytics.
CO5	Employ AI-driven analytics across commercial functions to guide key managerial decisions.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	1	1						2	1	1	1
CO2	2	1	1	2	2						2	1	2	2
CO3	2	2	1	3	2						3	2	1	2
CO4	2	2	1	3	2						3	2	1	2
CO5	2	2	1	3	2						3	2	1	2

Category	Code	Programming in Python Lab	L-T-P	Credits	Marks
UCR	CS2010		0-0-2	1	100

Objectives	The objective of this laboratory course is to develop problem solving skills using python programming language and prepare the students use python tools & libraries for solving advanced engineering problems.
Pre-Requisites	Knowledge of programming and basic problem solving skills are required.
Teaching Scheme	Regular laboratory classes conducted under supervision of the teacher. The experiments shall comprise programming assignments.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Write, compile, test, and debug simple Python programs.
2	Write programs using control structures (if, if-elif-else).
3	Write programs using loop control structure (while & for loops).
4	Write programs based on the concept of lists and tuples
5	Write programs based on the concept of set and dictionaries.
6	Develop the Python programs step-wise by defining functions and calling them, function with variable number of parameters.
7	Write programs for creating class, object, methods and constructor.
8	Write programs for demonstrating inheritance, and method overriding.
9	Write programs on operator overloading, method overloading, and abstract classes.
10	Write programs on file handling, exception handling, and database connectivity.
11	Write programs using regular expressions, Numpy arrays and matrices.
12	Panda module, data frame from CSV file, reshaping & data aggregation.
13	Programs for creating different types of plots using Matplotlib libraries.
14	Creating widgets using Tkinter and designing layouts with radio buttons, checkboxes, and dialogue boxes.

Text Books:

T1. R. N. Rao, ***Core Python Programming***, 2nd *Ed.*, DreamTech Press, 2019.

T2. V. Guttag, ***Introduction to Computation and Programming Using Python with Application to Understanding Data***, 2nd *Ed.*, PHI Learning, 2016.

T3. W. McKinney, ***Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Jupyter***, 3rd *Ed.*, O'Reilly Media, 2022.

Reference Books:

R1. P. Barry, ***Head First Python***, 2nd *Ed.*, O'Reilly Media, 2010.

R2. A. Downey, ***Think Python***, 2nd *Ed.*, Green Tea Press, 2015.

R3. E. Matthes, ***Python Crash Course: A Hands-On, Project-Based Introduction to Programming***, 3rd *Ed.*, No Starch Press, 2023.

R4. J. Zelle, ***Python Programming: An Introduction to Computer Science***, 3rd *Ed.*, Franklin, Beedle & Associates, 2016.

Online Resources:

1. https://nptel.ac.in/courses/106106182: By Prof. S. Iyengar, IIT Ropar
2. https://nptel.ac.in/courses/106106145: By Prof. M. Mukund, IIT Madras
3. https://nptel.ac.in/courses/106106212: By Prof. R. Rengasamy, IIT Madras
4. https://nptel.ac.in/courses/106107220: By Prof. A. Ramesh, IIT Roorkee

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Develop programs using various features of the Python programming language.
CO2	Develop programs using built-in as well as user-defined functions in Python.
CO3	Apply object-oriented concepts, perform file processing & exception handling.
CO4	Explore regular expressions, NumPy and Panda modules of Python for solving real-life problems.
CO5	Visualize data using matplotlib libraries and design GUI based applications.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2		2	3		2	1		2	2	3	1
CO2	3	3	3		2	3		2	1		3	2	3	2
CO3	3	3	3		3	3		2	2		2	2	3	1
CO4	2	3	3		3	3		3	2		2	2	3	1
CO5	3	3	3		3	3		3	2		3	2	3	2

Category	Code	Electrical Machines Lab	L-T-P	Credits	Marks
PCR	EE2005		0-0-4	2	100

Objectives	The objective of this laboratory course is to provide practical exposure to different electrical machines and help understand & verify the concepts of electrical machines, calculate different parameters like speed regulation, voltage regulation, efficiency & losses and their effect on performance. The laboratory experiments shall go hand-in-hand with the topics taught in the theory class.
Pre-Requisites	Knowledge of Basic Electrical Engineering, Physics and knowledge of Basic Mathematics such as Calculus, ordinary differential equations is required.
Teaching Scheme	Regular laboratory experiments to be conducted under supervision of the faculty with demonstration and simulation-based verification of the experiments.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Speed control of DC Shunt motor by armature voltage & flux control method and its realization through software.
2	Determination of critical resistance and critical speed from No-load test of DC Separately Excited generator.
3	Determination of efficiency of a DC Shunt Motor by brake test and Swinburne's test.
4	Plotting of External & Internal characteristics of DC shunt generator from load test.
5	Determination of efficiency and voltage regulation by Open Circuit and Short Circuit test on 1-ϕ Transformer.
6	Study of Scott connection of two 1-ϕ Transformers.
7	Back to Back test on two 1-ϕ Transformers.
8	Study of various vector groups of 3-ϕ Transformer.
9	Study of 3-ϕ induction generator.
10	Speed control of 3-ϕ induction motor using variable frequency (V/F) control method.
11	Determination of efficiency, plotting of torque-slip characteristics of 3-ϕ slip ring induction motor by electrical loading.
12	Determination of parameters of a 3-ϕ squirrel cage induction motor from No-load & Blocked rotor test.
13	Determination of the parameters of a 1-ϕ capacitor start induction run motor from No-load & Blocked rotor test.
14	Determination of the voltage regulation of an alternator by synchronous impedance and MMF method.
15	Determination of the voltage regulation of an alternator by ZPF Method.
16	Measurement of direct and quadrature axis reactance of salient pole synchronous machine and calculation of voltage regulation.
17	Study of parallel operation of two alternators.
18	Determine the power angle characteristics of an alternator & simulation by software.

Cont'd. . .

Experiment-#	Assignment/Experiment
19	Performance analysis of a universal motor by direct loading.
20	Study the characteristics of a synchronous motor.

Text Books:

T1. A. E. Fitzgerald, C. Kingsley Jr., and S. D. Umans, ***Electric Machinery***, 6th *Ed.*, McGraw-Hill Education, 2017.
T2. S. J. Chapman, ***Electric Machinery and Fundamentals***, 4th *Ed.*, McGraw-Hill, 2017.

Reference Books:

R1. P. S. Bimbhra, ***Electrical Machinery***, 7th *Ed.*, Khanna Publishers, 2011.
R2. D. P. Kothari and I. J. Nagrath, ***Electric Machines***, 5th *Ed.*, McGraw-Hill Education, 2017.
R3. P. K. Mukherjee and S. Chakravorti, ***Electrical Machines***, Dhanpat Rai Publications, 2011.
R4. B. S. Guru and H. R. Hiziroglu, ***Electric Machinery and Transformers***, 3rd *Ed.*, Oxford University Press,, 2012.
R5. B. L. Theraja and A. K. Theraja, ***A Textbook of Electrical Technology (Vol.2) - AC and DC Machines***, 23rd *Revised Ed.*, S Chand & Co, 2005.

Online Resources:

1. https://nptel.ac.in/courses/108105017: by Prof. D. Kastha, IIT Kharagpur
2. https://nptel.ac.in/courses/108105131: by Prof. T. K. Bhattacharya, IIT Kharagpur
3. https://nptel.ac.in/courses/108106072: by Prof. Vasudevan, Rao, and Rao, IIT Madras
4. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-685-electric-machines-fall-2013/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Perform various tests conducted on DC machines.
CO2	Evaluate the performance parameters of transformers.
CO3	Assess the performance of 1-ϕ and 3-ϕ induction motors in specific applications.
CO4	Determine voltage regulation of synchronous generators and compare the results.
CO5	Simulate the performance characteristics of electrical machines and interpret the results.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).

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PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	2		2	2				2	1	1	2
CO2	2	2	1	3		2	3				3	1	1	1
CO3	2	2	1	2		3	3				1	2	1	2
CO4	2	1	1	2		2	2				1	2	1	2
CO5	1	2	2	2		2	1				1	2	1	2

Category	Code	Digital Electronics Lab	L-T-P	Credits	Marks
PCR	EC2002		0-0-2	1	100

Objectives	The objective of the course is to provide hands-on exposure on logic gates, its implementation using Boolean algebra, designing digital circuits like counters, registers and simulating the digital systems using HDL.
Pre-Requisites	Knowledge of Basic Electronics is required.
Teaching Scheme	Regular laboratory experiments to be conducted under supervision of the faculty with use of ICT as and when required, with focus on implementation using hardware & software tools.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Digital Logic Gates: Investigate logic behavior of AND, OR, NAND, NOR, EX-OR, EX-NOR, Invert and Buffer gates, use of Universal (NAND & NOR) Gates.
2	Gate-level minimization: Two level and multi level implementation of Boolean functions.
3	Design, implement and test a given design example with: (a) NAND Gates only, (b) NOR Gates only, and (c) Using minimum number of Gates.
4	Combinational Circuits: Design, assemble and test: adders and subtractors, Code Converters, gray code to binary and 7-segment display.
5	Study of Multiplexer, Demultiplexer. Implement a function using a multiplexer.
6	Flip-Flop: assemble, test and investigate operation of SR, D, J-K & T flip-flops.
7	Shift Registers: Design and investigate the operation of all types of shift registers.
8	Counters: Design, assemble and test various ripple and synchronous counters.
9	Verilog/VHDL simulation and implementation of logic gates.
10	Verilog/VHDL simulation and implementation of different combinational circuits in dataflow and behavioral modeling.
11	Memory Unit: Investigate behaviour of RAM and its storage capacity – 16 $\times$ 4 RAM: testing, simulating and memory expansion.
12	Clock-pulse generator: design, implement and test.
13	Binary Multiplier: design and implement a circuit that multiplies 4-bit unsigned numbers to produce a 8-bit product.

Text Books:

T1. M. M. Mano and M. D. Ciletti, ***Digital Design: With an Introduction to Verilog HDL***, 5th *Ed.*, Pearson Education, 2013.

Reference Books:

R1. A. M. Michelén, ***Digital Electronics Laboratory Manual***, Prentice Hall, 2000.
R2. J. W. Stewart, C. -Y. Wang, ***Digital Electronics Laboratory Experiments*** (Using the Xilinx XC95108 CPLD with Xilinx Foundation: Design and Simulation Software), Prentice Hall, 2001.

Online Resources:

1. https://www2.mvcc.edu/users/faculty/jfiore/Resources/DigitalElectronics1LaboratoryManual.pdf
2. https://www.elprocus.com/top-digital-electronic-projects-for-electronics-engineering-students/
3. https://de-iitr.vlabs.ac.in/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Analyze the function of logic gates and implementation of Boolean functions.
CO2	Design and analyze different combinational circuits.
CO3	Design various asynchronous and synchronous sequential circuits.
CO4	Acquire knowledge about internal circuitry and logic behind digital systems.
CO5	Simulate various digital circuits using Verilog/VHDL & industry standard tools.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	2	2	2						1	2	2	
CO2	2	3	3	2	3						1	3	3	
CO3	2	3	2	3	3						2	3	2	1
CO4	2	2	2	3	2						1	2	3	1
CO5	2	3	2	3	3						2	2	2	1

Category	Code	Electrical & Electronics Design Lab	L-T-P	Credits	Marks
PCR	EE2006		0-0-2	1	100

Objectives	The objective of this course is to expose the students to different electrical and electronic components and give hands-on practice about the fundamental design procedure and their operations to make the students understand and verify the concept of various electrical & electronic devices.
Pre-Requisites	Knowledge of basic electrical, basic electronics, and circuit theory is required.
Teaching Scheme	Regular laboratory experiments using modeling and simulation platforms and hardware devices will be conducted under the supervision of the teacher. Demonstration will be given for each experiment.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Design and development of a 5V regulated power supply.
2	Design of AC-DC converter using transistors and diodes.
3	Design of latching and interlocking configuration control circuit using contactors.
4	Design of zero-crossing detector using op-amp circuits.
5	Design of Digital to Analog Converter(DAC) using R-2R ladder arrangement.
6	Design of microcontroller Interface circuit for temperature, distance, and voltage.
7	Design of speed control system for universal motor using TRIAC circuit.
8	Modeling & simulation of 1-ϕ induction motors and study of the torque-speed characteristics.
9	Modelling a stand-alone photovoltaic energy system and study of the IV and PV characteristics.
10	Evaluation & study of two-port network parameters.
11	V- curve & inverted V-curve of synchronous motor.
12	Study of torque-speed characteristic of a 3-ϕ induction motor with variable rotor resistance method.

Text Books:

T1. A. Pressman, K. Billings, and T. Morey, ***Switching Power Supply Design***, 3rd *Ed.*, McGraw-Hill Professional, 2009.

T2. S. B. Katariya, ***Industrial Automation Solutions for PLC, SCADA, Drive and Field Instruments***, 1st *Ed.*, Notion Press, 2020.

T3. M. Bhattacharyya, ***Electrical Machines: Modelling and Analysis***, 1st *Ed.*, PHI Learning, 2016.

T4. S. Kumar, M. R. Das, R. Kushalkar, N. Venkat, C. G. Kannan, and M. Moudgalya, ***Microcontroller Programming with Arduino and Python***, 1st *Ed.*, SPD Publishers, 2024.

Reference Books:

R1. A. S. Sedra and K. C. Smith, ***Microelectronic Circuits: Theory and Applications (International Version)***, 6th *Ed.*, Oxford University Press, 2013.

R2. A. Malvino and D. J. Bates, ***Electronic Principles***, 7th Edition, McGraw-Hill, 2017.

R3. D. V. Hall, ***Digital Circuits and Systems***, International Student Edition, McGraw-Hill Education, 1989.
R4. D. Gajski, ***Embedded System Design: Modeling, Synthesis and Verification***, Springer, 2009.

Online Resources:

1. https://nptel.ac.in/courses/106105159: by Prof. A. Basu, IIT Kharagpur
2. http://www.allaboutcircuits.com
3. https://www.electronics-tutorials.ws

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain and design common electrical and electronic control circuits.
CO2	Design and fabricate zero crossing detector and DAC.
CO3	Design and fabricate different interfacing circuits.
CO4	Understand the basic characteristics of photovoltaic modules and filter circuits.
CO5	Model different electrical machines and observe the characteristics.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

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Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	1	2	1	2	2	1			2	1	2	1
CO2	2	2	3	2	1	2	1	2	1		1	2	2	2
CO3	2	2	3	2	2	2	3	2	1		2	2	2	2
CO4	2	2	1	2	3	3	3	1			2	2	3	3
CO5	1	1	2	3	3	2	2	1			2	2	2	3

Category	Code	Control Systems Engineering	L-T-P	Credits	Marks
PCR	EE3001		3-0-0	3	100

Objectives	The objective of the course is to create an understanding of how modern-day control systems operate along with a thorough knowledge of mathematical modeling and stability analysis. This course also covers fundamentals of state-space methods.
Pre-Requisites	Mathematical background of differential equation, Laplace transforms, Basic electrical engineering, Dynamic equations of physical systems are required.
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Concept of control system, Definition, Open Loop/Closed-loop, Feedback, Effect of feedback, Review of complex variables, Laplace Transform, Transfer function, Block diagram, Signal flow graphs, Mason's Gain formula, Mathematical modeling of dynamical systems using transfer function; Control System Components: Potentiometer, Synchros, AC/DC Servo motors.	**10 Hours**
Module-2	**Time Response Analysis**: Standard Test Signals, Time response of first order systems, Time Response of Second order systems, Type and order of a system, Steady State Errors and Static & Dynamic Error Constants, Effect of adding pole and zero to a system, Time-domain Design specification of second order system, Performance indices; Introduction to Controllers: P, PI, PD, PID Controllers, Tuning Rules for PID controllers (Z-N Tuning).	**8 Hours**
Module-3	**Concepts of Stability**: Necessary conditions for stability, Hurwitz Stability Criterion, Routh Stability Criterion, Relative Stability Analysis; The Root Locus Technique: Introduction, Root locus concepts, Construction of Root locus, Root Contours, Systems with transportation lag.	**8 Hours**
Module-4	**Stability in Frequency Domain**: Mathematical Preliminaries, Frequency Response Analysis: Correlation between Time and Frequency Response, Polar plots; Nyquist Stability Criterion, Assessment of Relative stability using Nyquist Criterion, Closed loop Frequency Response, Bode plots, All Pass and Minimum-Phase Systems.	**9 Hours**
Module-5	**State Variable Analysis**: Concept of state, State variable and state space model of dynamic system using physical variable, Phase Variables and Canonical Variables, Derivation of Transfer Function, Solution of State Equation, State Transition Matrix, Controllability and Observability, Pole placement by state feedback.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. I. J. Nagrath and M.Gopal, ***Control Systems Engineering***, 5th *Ed.*, New Age Intl., 2010.
T2. K. Ogata, ***Modern Control Engineering***, 5th *Ed.*, PHI Learning, 2010.

Reference Books:

R1. B. C. Kuo, ***Automatic Control Systems***, 7th *Ed.*, Prentice Hall India, 2010.
R2. R. C. Dorf and R. H. Bishop, ***Modern Control Systems***, 8th *Ed.*, Addison Wesley, 2003.
R3. U. A. Bakshi and V. U. Bakshi, ***Control System Engineering***, 1st *Ed.*, Technical Publications, 2010.

Online Resources:

1. https://nptel.ac.in/courses/108102043: by Prof M. Gopal, IIT Delhi
2. https://nptel.ac.in/courses/108106098: by Prof. R. Pasumarthy, IIT Madras

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain control system concepts, transfer functions, and basic components of feedback systems.
CO2	Analyze time response characteristics and design PID controllers for desired performance.
CO3	Determine system stability using Hurwitz, Routh, and root locus techniques and criteria.
CO4	Evaluate system stability and performance using Nyquist and Bode frequency response methods.
CO5	Develop state-space models and analyze controllability, observability, and pole placement.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1						1	3	2	2
CO2	3	2	2	2	2						2	3	1	2
CO3	3	3	1	1	2						2	3		1
CO4	3	3	1	2	2						2	3	1	2
CO5	3	2	1	1	2						2	3		1

Category	Code	Electrical Power Transmission & Distribution	L-T-P	Credits	Marks
PCR	EE3002		3-0-0	3	100

Objectives	The objective of the course is to learn the concept of the power system, its components and parameters, characteristics of power lines for different voltage levels and the equipment used in power transmission & distribution.
Pre-Requisites	Knowledge of AC and DC circuits, characteristics & response of the electrical parameters (R, L, and C), and elementary idea on electrical power system and components is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Transmission Line Parameters**: Types of conductors, Resistance, Inductance of a conductor due to internal flux, Flux linkages between two points, Inductance Calculation - Composite-conductor, Single-phase line, Three-phase line with equilateral & unsymmetrical spacing, Bundled conductors; Skin effect, Proximity effect; Electric field of long & straight conductor, Potential difference between two points due to a charge, Capacitance Calculation- Two-wire, 3-phase line with equilateral & unsymmetrical spacing, Effect of earth on capacitance, Capacitance of Bundled conductors.	**10 Hours**
Module-2	**Transmission Line Performance**: Short & medium transmission lines - representation as π & T model, ABCD parameter, Performance analysis; Long Transmission Lines: Hyperbolic form of equations & its interpretation, ABCD parameters, Equivalent π and T network; Power flow through transmission line, Voltage compensation techniques.	**8 Hours**
Module-3	**Overhead Line Insulators**: Insulator materials, Types of insulators, Voltage distribution over insulator string, Improvement of string efficiency, Insulation failure; Mechanical Design of OHT Lines - General considerations, Span, Conductor configuration, Spacing & clearances, Sag & tension, Factors affecting sag; Catenary, Conductor vibration, Corona phenomenon.	**8 Hours**
Module-4	**Distribution Systems**: Types, AC 3-phase 4-wire distribution system, Primary & secondary distribution system, Voltage drop in DC & AC distributors, Design of distribution substation, Design of secondary network, Kelvin's economy law & limitations, Causes of low power factor and its effect, Power factor improvement & its economics, Power factor correction by static capacitor.	**8 Hours**
Module-5	**Underground Cables**: Cable insulation, Sheath, Armor & covering, Classification of cables, Pressurized cables, Effective resistance, Inductive reactance & capacitance of single-core & 3-phase belted cables, Breakdown of cables, Cable installation, System operating problems with underground & HVDC cables; **Power System Earthing**: Types and methods, Earth resistance, Design of earthing grid, Tower footing resistance, Neutral grounding.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. J. Grainger and W. D. Stevenson Jr., ***Power System Analysis***, 1st *Ed.*, McGraw Hill, 2017.
T2. B. R. Gupta, ***Power System Analysis and Design***, 3rd *Ed.* (Reprint), S. Chand Publications, 2003.

Reference Books:

R1. M. S. Naidu and V. Kamaraju, ***High Voltage Engineering***, 5th *Ed.*, McGraw Hill, 2013.
R2. D. P. Kothari and I. J. Nagrath, ***Power System Analysis***, 4th *Ed.*, McGraw Hill, 2011.

Online Resources:

1. https://nptel.ac.in/courses/108102047/: by Prof. D. P. Kothari, IIT Delhi
2. https://nptel.ac.in/courses/117101056/: by Prof. R. K. Shevgaonkar, IIT Bombay

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Analyze transmission line parameters including resistance, inductance, and capacitance effects.
CO2	Evaluate performance of short, medium, and long transmission lines using network models.
CO3	Analyze insulators, mechanical design parameters, sag–tension relations, and corona effects.
CO4	Design AC/DC distribution systems, substations, voltage drop and power factor correction.
CO5	Explain underground cable design, parameters, faults and earthing in power systems.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2			2	3					1	3	1	
CO2	3	3	2		2	2					1	2	2	1
CO3	3	3			2	2					2	2	2	1
CO4	3	3	2		3	2					2	3	1	
CO5	3	3			2	2					1	3		1

Category	Code	Electrical & Electronics Measurement	L-T-P	Credits	Marks
PCR	EE3003		3-0-0	3	100

Objectives	The objective of this course is to learn basic operations of electrical & electronic measuring instruments and their uses in branches of engineering, applications of transducers, storage, display and data acquisition systems.
Pre-Requisites	Basic knowledge of intermediate physics, mathematics, basic electrical and electronics engineering is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Measurement Systems - Types of Measurement Systems, Accuracy & Precision, Types of Errors, Standards and Calibration, Classification of Measuring Instruments; Electromechanical Indicating type Instruments - Types of Torque, General Constructional Details; Ammeter & Voltmeter - Derivation for Deflecting Torque of PMMC & MI type; Measurement of Power and Energy - Construction, Theory and Principle of Operation of Electro-Dynamometer, Induction Type Wattmeter and Single Phase Induction Type Watt-hour meter.	**12 Hours**
Module-2	Measurement of Resistance - Measurement of Resistance of Insulating Materials, Measurement of Earth Resistance using Fall of Potential Method; Measurement of Inductance - Maxwell's Inductance and Anderson Bridges; Measurement of Capacitance - Schering Bridge & Wein's Bridge, Wagnor's Earthing Device.	**7 Hours**
Module-3	Potentiometer - DC (Crompton) & AC (Drysdale) Potentiometers; Instrument Transformers - Construction, Theory, Equivalent Circuit, Phasor Diagram and Characteristics of CTs & PTs.	**8 Hours**
Module-4	Electronic Instruments - AC Voltmeters using Rectifiers, Digital voltmeters, Digital Multimeters, Digital RLC Meter and Digital Frequency Meter; Storage and Display Devices - Magnetic Disk, CRT display, DSO, LED.	**7 Hours**
Module-5	Transducers and Data Acquisition Systems - Classification and Selection of Transducers, Resistive, Capacitive & Inductive Transducers, Piezoelectric, Hall Effect, Optical & Digital Transducers, Elements of Data Acquisition System, A/D & D/A Converters, Introduction to PLC, SCADA and LabVIEW environment.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. E. W. Golding and F. C. Widdis, ***Electrical Measurements and Measuring Instruments***, 5th *Ed.*, Reem Publication, 2015.

T2. A. K. Sawhney, ***A Course in Electrical and Electronics Measurement and Instrumentation***, 19th *Ed.*, Dhanpat Rai & Co., 2011.

T3. R. K. Rajput, ***Electrical and Electronic Measurement and Instrumentation***, S. Chand & Co, 2016.

Reference Books:

R1. R. S. Sedha, ***Electronic Measurements and Instrumentation***, 1st *Ed.*, S. Chand & Co., 2013.
R2. D. A. Bell, ***Electronic Instrumentation and Measurements***, 3rd *Ed.*, Oxford University Press, 2013.
R3. A. D. Helfrick and W. D. Cooper, ***Modern Electronic Instrumentation and Measurement Techniques***, 1st *Ed.*, Pearson Education, 2015.
R4. J. B. Gupta, ***A Course in Electrical and Electronic Measurements & Instrumentation***, S. K. Kataria & Sons, 2013..
R5. R. Mehera and V. Vij, ***PLCs and SCADA***, 1st *Ed.*, University Science Press, 2011.

Online Resources:

1. nptel.ac.in/courses/108102191: by Prof. Ankur Gupta, IIT Delhi

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Identify suitable instruments for accurate measurement with their construction and operation.
CO2	Estimate resistance, inductance, and capacitance accurately using suitable bridge methods.
CO3	Explain construction, theory and applications of potentiometers and instrument transformers.
CO4	Illustrate the working principle of various electronic instruments, storage and display devices.
CO5	Explain the working of various transducers and data acquisition systems with applications.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2			1						3	3		
CO2	2	2		2	1						3	2	1	1
CO3	2	2			1						3	3	1	
CO4	2	2			1						3	2		
CO5	1	1	2		1						3	2		1

Category	Code	Power Electronics	L-T-P	Credits	Marks
PCR	EE3004		3-1-0	4	100

Objectives	The objective of this course is to provide an overview of different types of power semiconductor devices and their switching characteristics along with the operation and characteristics of various types of power electronic converters.
Pre-Requisites	Knowledge of physics, basic mathematics, calculus, ordinary differential equations and basic electronics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Power semiconductor devices - Switching and V-I characteristic of devices: Transistor family - BJT, IGBT, and MOSFET, Thyristor family, SCR, TRIAC, Series & parallel grouping of SCR, SCR triggering methods, SCR: Over voltage, Over Current, dV/dt, di/dt, Gate Protection, Snubber circuit; Commutation - Natural & Forced Commutations, Commutation by resonant load, LC load, complementary & Auxiliary commutation.	**13 Hours**
Module-2	AC to DC Phase Controlled converter - Principle of phase controlled converter operation, Single phase full converter with R, R-L & R-L-E load, 3-Phase full converter with R, R-L & R-L-E load, Single phase semi converter with R, R-L & R-L-E load.	**10 Hours**
Module-3	AC to AC converter - Single phase bi-directional controllers with R & R-L load, Single phase Cycloconverters – Step up & Step down, Applications.	**7 Hours**
Module-4	DC to DC converter - First quadrant, Second quadrant, First & Second quadrant, Third & Fourth quadrant converter; Switching mode regulators - Design of Buck & Boost regulators, Basic operation of Buck-Boost & SEPIC Converter, Understand the concept of how to find the transfer function of the DC-DC converter; Isolated Converters - Fly-back & Forward Converter, Applications.	**13 Hours**
Module-5	DC to AC converter - Voltage Source Inverter (VSI), Single phase bridge Inverters, 3-Phase Inverters-180° mode conduction, 1200 mode conduction, Voltage control of 3-Phase Inverters by Sinusoidal PWM (PWM VSI), Current Source Inverter (CSI); Resonant Converters - ZCS, ZVS, Comparison and Applications; Power Electronics Applications - UPS, SMPS, Induction Heating, AC/DC drives speed control.	**13 Hours**
	Total	**56 Hours**

Text Books:

T1. M. H. Rashid, ***Power Electronics: Devices, Circuits, and Applications***, 4th *Ed.*, Pearson Education, 2017.

T2. P. S. Bhimbra, ***Power Electronics***, 6th *Ed.*, Khanna Publishers, 2014.

P.T.O

Reference Books:

R1. M. D. Singh and K. B. Khanchandani, ***Power Electronics***, 2nd *Ed.*, McGraw-Hill, 2017.
R2. P. C. Sen, ***Power Electronics***, 1st *Ed.*, McGraw Hill India, 2001.

Online Resources:

1. https://nptel.ac.in/courses/108102145: by Prof. G. Bhuvaneshwari, IIT Delhi
2. https://nptel.ac.in/courses/108101126: by Dr. L Umanand, IISc Bangalore
3. https://nptel.ac.in/courses/108105066: by Dr. D. Kastha and others, IIT Kharagpur
4. https://nptel.ac.in/courses/108101038: by Prof. B. G. Fernandes and Prof. K. Chatterjee, IIT Bombay

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Analyze switching, protection, and commutation techniques of power semiconductor devices.
CO2	Describe the operation of AC - DC converters and its application in the practical field.
CO3	Interpret the operation of AC -AC converters and perform the performance analysis.
CO4	Illustrate the operation of DC - DC converters , classification and use in DC drives.
CO5	Analyze DC–AC converters, SPWM techniques, resonant converters and their applications.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	2	2	1					1	3	2	
CO2	3	2	2	3	3	1					1	3	3	2
CO3	3	2	2	2	3	2					1	3	2	2
CO4	3	2	2	2	3	2					1	3	2	1
CO5	3	2	3	3	2	2					2	2	2	1

Category	Code	IoT & Applications	L-T-P	Credits	Marks
PEL	EC3014		3-0-0	3	100

Objectives	The objective of this course is to learn design, deployment, protocols, networking and security aspects of the IoT including IoT system implementation using Arduino & Raspberry Pi, data analytics and case studies.
Pre-Requisites	Basic knowledge of computer networks, internet technology, basic analog & digital electronics and computer programming is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions shall focus on design, programming and applications of IoT.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction to IoT**: Physical & Logical Design, Enabling Technologies, Levels & Deployments, M2M, Difference between IoT and M2M, IoT Design Methodology, Network Function Virtualization, Need for IoT Systems Management, Simple Network Management Protocol (SNMP) and Its Limitations, Network Operator Requirements, NETCONF, YANG, Energy Harvesting Techniques.	**9 Hours**
Module-2	**Domain-Specific IoTs**: Overview, Home Automation, Smart Cities, Environment, Retail, Logistics, Agriculture, Industry, Health & Lifestyle IoT in Energy Sectors, Virtual Sensors, Generic Web-Based Protocols (SOAP, REST, HTTP, RESTful and WebSockets), IoT Application Layer Protocols (CoAP, MQTT, AMQP, REST and XMPP).	**7 Hours**
Module-3	**Sensing Technology**: Temperature Sensor (RTD, Thermistor, Thermocouple, IC type), Humidity Sensor - Capacitive, Displacement sensor - LVDT, Acceleration Sensor (Potentio-metric, LVDT, Piezoelectric, Variable Reluctance Type), Pressure Sensor (Diaphragm type), ADC concept; S/C Applications – Deflection Bridge, Amplifier, Integrator & Differentiator.	**9 Hours**
Module-4	**IoT Device Interfacing**: Interoperability in IoT, Arduino Programming, Integration of Sensors & Actuators, Microcontrollers, Embedded C Programming, Analog Interfacing, Serial, SPI, I2C, Ethernet-based Data Communication, DHCP, Web Client, Telnet, MQTT; IoT using Raspberry Pi - Introduction, Linux on Raspberry Pi, Implementation of IoT with Raspberry Pi; Raspberry Pi Interfaces - Serial, SPI, I2C.	**10 Hours**
Module-5	**Data Analytics for IoT**: Introduction, Apache Hadoop – Map Reduce Programming Model, Map Reduce Job Execution, job execution workflow, Hadoop Cluster Setup, YARN, Apache Oozie: Setting of Oozie, Oozie Workflow for IoT Data Analysis, Apache Spark, Apache Storm.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. A. Bahga and V. Madisetti, ***Internet of Things: A Hands-On Approach***, 1st *Ed.*, Orient Blackswan, 2015.

T2. M. Schwartz, ***Internet of Things with Arduino Cookbook***, Packt Publishing, 2016.

T3. C. D. Johnson, ***Process Control Instrumentation Technology***, 8th *Ed.*, Pearson Education, 2014.

Reference Books:

R1. A. K. Ghosh, ***Introduction to Measurement and Instrumentation***, 3rd *Ed.*, PHI, 2009.
R2. R. Kamal, ***Internet of Things: Architecture and Design Principles***, 1st *Ed.*, McGraw-Hill, 2017.
R3. J. P. Bentley, ***Principles of Measurement Systems***, 4th *Ed.*, Pearson Education, 2005.

Online Resources:

1. https://nptel.ac.in/courses/106105195/: by Prof. S. Misra, IIT Kharagpur.
2. https://nptel.ac.in/courses/108108098/: by Prof. T. V. Prabhakar, IISc Bangalore
3. https://nptel.ac.in/courses/106105166/: by Prof. S. Misra, IIT Kharagpur
4. https://nptel.ac.in/courses/108105064/: by Prof. A. Barua, IIT Kharagpur
5. https://nptel.ac.in/courses/106106182/: by Prof. S. Iyengar, IIT Madras
6. https://nptel.ac.in/courses/115104095/: by Prof. M. Verma, IIT Kanpur
7. https://nptel.ac.in/courses/106104189/: by Dr. R. Misra, IIT Patna

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain IoT technologies basics, design methodologies and network management protocols.
CO2	Evaluate the domain-specific IoT and communication protocols.
CO3	Describe the concepts of sensors, signal conditioning circuits, and their application to IoT.
CO4	Develop programs for IoT Applications using Arduino and Raspberry Pi.
CO5	Apply the concepts of data analytics in various IoT applications.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	3	2	2				2	3	2	2
CO2	3	3	2	2	3	2	2				2	3	3	2
CO3	3	3	3	2	2	2	2				2	2	3	2
CO4	2	2	3	3	3	3	2				3	3	2	3
CO5	2	2	2	3	2	2	3				3	2	2	3

Category	Code	HVDC Transmission	L-T-P	Credits	Marks
PEL	EE3010		3-0-0	3	100

Objectives	The objective of this course is to learn various aspects of high voltage DC power transmission including control, conversion, harmonics, faults and other engineering design considerations.
Pre-Requisites	Knowledge of circuit topology, analysis of switching circuits, magnetics, power semiconductor devices and basic simulation skill is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**High Voltage Transmission System**: Introduction, AC & DC System and Comparison, Reliability and application of DC transmission, Types of DC links, Typical layout of a HVDC converter station. HVDC converters, Pulse number, Converter bridge characteristics, Equivalent circuits of rectifier and inverter configurations of twelve pulse converters.	**8 Hours**
Module-2	**Converters in HVDC Transmission**: 6-Pulse Converter Operation and Analysis – Configuration, Output voltage, Analysis with overlap angle, Equivalent circuit of rectifier & inverter, 12-pulse Converter Operation and Analysis, Power flow in HVDC link, VSC Converter Operation and analysis.	**10 Hours**
Module-3	**Control of HVDC Converter & Systems**: Mechanism of AC power transmission, Principle of control, Necessity of control in case of a DC link, Rectifier control, Compounding of rectifiers, Power reversal in a DC link, Voltage dependent current order limit (VDCOL), Characteristics of the converter, System control hierarchy and Basic philosophy, Inverter extinction angle control (EAG), Pulse phase control, Starting and stopping of a DC link, Constant power control, Control systems for HVDC converters, Inverter operation problems, Control of VSC converters.	**8 Hours**
Module-4	**Harmonics in HVDC Systems**: Importance of harmonic study, Generation of harmonics by converters, Characteristic harmonics on the DC Side, Characteristic current harmonics, Characteristic variations of harmonic currents with variation of α & μ, Effect of control modes on harmonics, non-characteristic harmonics, Harmonics in VSC converters; Valve configuration, Converter theory, Types of DC links, Converter station, Principle of DC link control and characteristics.	**8 Hours**

Cont'd. . .

Module-#	Topics	Hours
Module-5	**Harmonic Suppression & Protection**: Harmonic model and equivalent circuit, Use of filters, Filter configurations, Design of Band-Pass & High-Pass filters, Protection of filters, DC filters; Faults and Protection Schemes - Nature and types of faults, Faults on AC side of converter stations, Converter faults, Faults on DC side of the system, Protection against over currents/voltages, Protection of filter units; **Multi-terminal HVDC Systems**: Types, Parallel operation aspects, Paralleling (Disconnecting) of units or converter, Control of power, VSC multi-level DC systems; Types of converter faults, Converter station protection against faults, Harmonics and filters, Starting, Stopping and power flow reversal.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. K. R. Padiyar, ***HVDC Power Transmissions Systems : Technology & Systems Interaction***, 3rd *Ed.*, New Age Publication, 2017.

Reference Books:

R1. S. Kamakshaiah and V. Kamaraju, ***HVDC Transmission***, TMH Education, 2011.
R2. M. H. Rashid, ***Power Electronics***, 3rd *Ed.*, PHI Learning, 2008.

Online Resources:

1. https://nptel.ac.in/courses/108104013: by Dr. S. N. Singh,IIT Kanpur
2. https://nptel.ac.in/courses/108106160: by Prof. S. Krishna, IIT Madras

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain HVDC transmission systems, types of DC links, and converter circuit configurations.
CO2	Analyze 6-pulse, 12-pulse, and VSC converter circuits in HVDC transmission.
CO3	Design and analyze control strategies for HVDC converters and power flow management.
CO4	Evaluate harmonics in HVDC systems and analyze their generation, control, and effects.
CO5	Develop harmonic suppression and protection strategies for HVDC transmission systems.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).

Cont'd. . .

PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3			2						1	1		
CO2	3	3			3						1	1		
CO3	3	3	2	2	3						2	1	2	2
CO4	2	3	2	3	3						2	1	2	2
CO5	2	2	3	2	3						2	1	2	2

Category	Code	Microwave Engineering	L-T-P	Credits	Marks
PEL	EC3010		3-0-0	3	100

Objectives	The objective of this course is to study microwaves their frequency bands, behaviour of electromagnetic waves at microwave frequencies along with principles of radar and its scanning and tracking techniques.
Pre-Requisites	Basic knowledge of circuit theory, electromagnetic theory and solid state physics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Microwave Tubes**: Introduction, Frequency bands, Applications, Limitations of conventional tubes, Reflex Klystron - Construction, Operation, Velocity Modulation, Power output, Efficiency, Electronic admittance, Magnetron - Construction, Operation, Cyclotron - Angular frequency, Resonant modes, Hull's cut-off magnetic flux density and cut-off voltage.	**8 Hours**
Module-2	**Microwave Amplifiers**: Klystron Amplifier - Construction, Operation, Re-entrant cavities, Velocity modulation, Output power, Beam loading, Efficiency, Mutual conductance, Travelling Wave Tube (TWT) - Slow wave structures, Construction, Amplification process.	**8 Hours**
Module-3	**Microwave Components**: Analysis using S-parameters, Junctions (E-Plane, H-Plane, Magic Tee), Directional coupler; Bends and corners, Microwave posts, Slide Screw tuners, Attenuators, Phase shifter, Ferrite devices (Isolator, Circulator, Gyrator), Cavity resonator.	**9 Hours**
Module-4	**Radar Systems**: Principles and operations, Range equation, Pulse repetition frequency (PRF) & range ambiguities, Doppler Radars – Determination of velocity, Continuous wave (CW) radar and its limitations, Frequency modulated continuous wave (FMCW) radar, Moving target indicator (MTI) radar, Delay line cancellers, Blind speeds & staggered PRFs, Scanning & tracking - horizontal, vertical, spiral, palmer, raster, nodding, Angle tracking systems - Lobe switching, Conical scan, Mono pulse.	**8 Hours**
Module-5	**Microwave Solid State Devices**: Limitations of conventional solid state devices at microwaves, Transistors, Diodes (Tunnel, Varactor, PIN), Transferred electron devices (Gunn diode); Avalanche transit time effect (IMPATT, TRAPATT, SBD), Microwave amplification by stimulated emission of radiation (MASER).	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. D. M. Pozar, ***Microwave Engineering***, 4th *Ed.*, Wiley Publications, 2011.
T2. S. Liao, ***Microwave Devices and Circuits***, 3rd *Ed.*, Pearson Education, 2006.
T3. M. I. Skolnik, ***Introduction to Radar Systems***, 3rd *Ed.*, McGraw-Hill Education, 2001.

Reference Books:

R1. G. S. Rao, ***Microwave and Radar Engineering***, 1st *Ed.*, Pearson Education, 2014.
R2. R. E. Collin, ***Foundation of Microwave Engineering***, 2nd *Ed.*, John Wiley & Sons, 2007.
R3. M. Kulkarni, ***Microwave Devices and Radar Engineering***, 5th *Ed.*, Umesh Publications, 2014.

Online Resources:

1. https://nptel.ac.in/courses/108101112: by Prof. G. Kumar, IIT Bombay
2. https://nptel.ac.in/courses/108103141: by Prof. R. Bhattacharjee, IIT Guwahati
3. https://nptel.ac.in/courses/117105138: by Prof. A. Bhattacharya, IIT Kharagpur
4. https://nptel.ac.in/courses/117105130: by Prof. A. Bhattacharya, IIT Kharagpur
5. https://nptel.ac.in/courses/117105122: by Prof. A. Bhattacharya, IIT Kharagpur
6. https://nptel.ac.in/courses/117101119: by Prof. J. Mukherjee, IIT Bombay

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain different microwave frequency bands and their sources with applications.
CO2	Describe the construction, operation and principles of various microwave amplifiers.
CO3	Analyze microwave components using S-parameters and characterize various passive devices.
CO4	Explain radar principles, range and Doppler measurement, and various target tracking methods.
CO5	Articulate operation & characteristics of microwave solid-state and transferred electron devices.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	3	1						1	3	1	1
CO2	3	3	1	3	1						1	3	1	1
CO3	2	2	1	3	1						1	2	1	1
CO4	2	3	1	3	1						1	2	1	1
CO5	2	2	1	3	3						1	2	1	1

Category	Code	Smart Grid	L-T-P	Credits	Marks
PEL	EE3011		3-0-0	3	100

Objectives	The objective of the course is to learn fundamental knowledge of Smart Grid concepts, architecture, communication technologies and their integration with distributed energy resources and microgrids.
Pre-Requisites	Basic understanding of Power Systems, Electrical Machines and Fundamental knowledge of Power Electronics & Control Systems is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on current trends of smart grid.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Evolution & Basic concepts of grid, Needs for Smart grid, Standard concepts and definitions of Smart grid, Functions, Opportunities, Challenges and benefits, Comparison between conventional and Smart grid; **Smart Grid Components**: Smart infrastructure, Communication, Management & protection, Initiatives in Smart grid.	**8 Hours**
Module-2	**Architecture and Standards**: Types of domains in architecture, Standards in Distributed energy resources (DERs), Wide area situation awareness, Protection and automation, Time synchronization, Cyber security; **Elements & Technologies**: Smart metering and Advanced metering infrastructure (AMI), Distribution automation (DA), SCADA system, Outage management system (OMS), Plug-in Hybrid Electric Vehicle (PHEV), Vehicle-to-Grid (V2G); **Communication Infrastructure & Protocols**: WAN, NAN & HAN, Types of communication technologies - Ethernet, Wireless LANs, Bluetooth, ZigBee, WiMax and Broadband over power line (BPL).	**10 Hours**
Module-3	**Distributed Energy Resources (DERs)**: Types, Working, Advantages & disadvantages of solar PV system, Solar thermal, Biomass, Wind, Fuel cell, Micro turbine; **Energy Storage Technologies**: Mechanical, Electrical, Electromagnetic, Electrochemical (Battery energy storage system (BESS)), Thermal.	**8 Hours**
Module-4	**Wide Area Measurement System (WAMs)**: Phasor estimation, Phasor Measurement Units (PMU) - Synchro phasor, PMU device, Operation; **Smart Sensors**: Intelligent electronic devices (IEDs), Geographic information systems (GIS), Basics of Demand side management (DSM).	**8 Hours**
Module-5	**Microgrid**: Introduction, Definitions, Types of microgrids, Modes of operation, Introduction to microgrid control and protection, Structure of AC and DC microgrid, Challenges in microgrid, Value addition of microgrid.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. Ekanayake, N. Jenkins, K. Liyanage, J. Wu, and A. Yokoyama, ***Smart Grid: Technology and Applications***, Student Edition, Wiley, 2012.

T2. C. W. Gellings, ***The Smart Grid: Enabling Energy Efficiency and Demand Response***, 1st *Ed.*, CRC Press, 2009.

Reference Books:

R1. S. Borlase, ***Smart Grid: Infrastructure, Technology and Solutions***, 1st *Ed.*, CRC Press, 2012.
R2. J. A. Momoh, ***Smart Grid: Fundamentals of Design and Analysis***, 1st *Ed.*, Wiley-IEEE Press, 2012.
R3. S. K. Salman, ***Introduction to the Smart Grid: Concepts, Technologies and Evolution***, IET, 2017.

Online Resources:

1. https://nptel.ac.in/courses/108107113: by Prof. N.P. Padhy, and Prof. P. Jena, IIT Roorkee
2. https://www.smartgrid.gov/
3. http://www.nsgm.gov.in/
4. https://smartgrid.ieee.org/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe smart grid evolution, components, benefits, and compare with conventional systems.
CO2	Explain the architecture, standards, technologies and communication protocols in smart grids.
CO3	Analyze distributed energy resources and energy storage technologies in smart grid systems.
CO4	Illustrate wide area measurement systems and smart sensors for enhanced grid performance.
CO5	Explain the concepts, classifications, control and protection mechanisms of microgrids.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2				2						3		
CO2	2		2		2	1						2	2	
CO3	2	2			2							2		2
CO4	1			3							2		2	2
CO5	2		2		2	1						2		3

Category	Code	Electrical Drives	L-T-P	Credits	Marks
PEL	EE3012		3-0-0	3	100

Objectives	The objective of this course is to study different power electronics converters used for drives and their industrial applications.
Pre-Requisites	Knowledge of power electronics, electrical machines, and basic simulation skill is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on power electronics and machine drives.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Study of Motor Drives**: Fundamentals of drives and its block diagram, Selection of drives, Classification, Nature and components of load torques, Fundamental torque equations, Determination of equivalent drive parameters, Time and energy calculation in transient operations, Speed-torque conventions and Multi-quadrant operation, Steady-state stability, Load equalizations, Thermal model of motor, Classes of motor duty, Rating based on thermal consideration; **Control of Electrical Drives**: Current limit control, Closed-loop torque control, Closed-loop speed control and closed-loop position control.	**12 Hours**
Module-2	**Performance of DC Drives**: DC motors and their performances, Starting, Braking, Speed control: Methods of armature voltage control, Controlled rectifier based DC drives, Chopper controlled DC drive.	**7 Hours**
Module-3	**Performance of AC Drives**: Induction motor drives - Static speed control: Stator voltage control, V/f control, Constant torque and constant power operation, VSI controlled drive, CSI controlled drive, Current regulated VSI control, Static rotor resistance control, Static slip power recovery scheme; Synchronous motor drive - True and self-synchronous mode.	**10 Hours**
Module-4	**Electric Traction**: Traction system mechanics: Speed-time and distance-time curves, Tractive effort, Effective weight, Train resistance, Adhesive weight, Specific energy output and consumption, Traction motor.	**7 Hours**
Module-5	**Industrial Applications**: Steel rolling mills, Textile mills, Cement mills, Paper mills, etc.; Microprocessor applications in drive systems.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. G. K. Dubey, ***Fundamentals of Electrical Drives***, 3rd *Ed.*, Norasa Publishing, 2010.
T2. S. K. Pillai, ***First Course on Electrical Drives***, 3rd *Ed.*, New Age International, 2012.
T3. V. Subrahmanyam, ***Electric Drives***, 2nd *Ed.*, McGraw Hill Education, 2017.

Reference Books:

R1. M. H. Rashid, ***Power Electronics***, 3rd *Ed.*, PHI Learning, 2008.
R2. B. K. Bose, ***Modern Power Electronics and AC Drives***, 1st *Ed.*, Pearson Education, 2005.

Online Resources:

1. https://nptel.ac.in/courses/108104140: by Prof. S. P. Das, IIT Kanpur

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain drive basics, selection, torque, stability, thermal aspects and closed-loop control.
CO2	Design and analyze performance of DC drives under steady-state and transient conditions.
CO3	Design and analyze performance of AC drives under steady-state and transient conditions.
CO4	Analyze electric traction mechanics, tractive effort, energy use and motor performance.
CO5	Select suitable industrial drives and apply microprocessor-based control in drive systems.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	2	2	1					1	3	2	
CO2	3	3	3	3	3	1					1	3	3	2
CO3	3	3	3	2	3	2					1	3	2	2
CO4	3	3	2	2	3	2					1	3	2	1
CO5	3	2	3	3	2	2					2	2	2	1

Category	Code	Communication Systems Engineering	L-T-P	Credits	Marks
PEL	EC3045		3-0-0	3	100

Objectives	The objective of this course is to learn electronic communication systems, modulation techniques, digital transmission of analog signals, random variables & sources, and filtering of noise.
Pre-Requisites	Knowledge of signals & systems and probability theory is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Signals & Spectra**: An Overview of Electronic Communication Systems, Types of Signal, Fourier Series, Fourier Transform, Properties of Fourier Transform, Orthogonal Signal.	**7 Hours**
Module-2	**Amplitude Modulation Systems**: Need For Frequency Translation, Double Side band with Carrier(DSB-C),Double Side band with Suppressed Carrier (DSB-SC), Modulators - Square-Law, Switching, Balanced, Detectors - Square-Law, Envelope, Synchronous, Single Side Band with Suppressed Carrier (SSB-SC), Frequency and Phase Discrimination Methods, Coherent Detection, Modulation & Demodulation Of Vestigial Side Band Modulation (VSB), Frequency Division Multiplexing, Radio Transmitter & Receiver (Super Heterodyne Receiver).	**10 Hours**
Module-3	**Angle Modulation**: Angle Modulation, Narrow band FM, Wide band FM, FM Modulators – Direct Method(Varactor Diode Method), Indirect Method (Armstrong method), Simple Slope Detector, Balanced Slope Detector, Phase Locked Loop (PLL); **Analog Pulse Modulation**: Analog to Digital - The Need, Sampling Theorem, Natural and Flat-top Sampling, Quantization of Signals, Quantization Error, Pulse Amplitude Modulation, Pulse Width Modulation and Pulse Position Modulation.	**9 Hours**
Module-4	**Digital Pulse Modulation**: The PCM System, Bandwidth of PCM System, Delta Modulation(DM) and its limitations, Adaptive Delta Modulation, Differential PCM (DPCM), Comparison Between PCM, DM, and DPCM, Digital Transmission of Analog Signal - Digital Representation of Analog Signal, Line Codes, Companding, Time Division Multiplexing, Multiplexing PCM Signals.	**8 Hours**
Module-5	**Random Variables & Processes**: Probability, Random Variables, Useful Probability Density Functions, Useful Properties and Certain Application Issues, Mathematical Representation of Noise - Sources of Noise, Frequency-Domain Representation of Noise, Superposition of Noises, Linear Filtering of Noise, Noise Bandwidth.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. H. Taub, D. L. Schilling, and G. Saha, ***Principles of Communication System***, 4th *Ed.*, Tata McGraw Hill, 2013.

T2. R. P. Singh and S. D. Sapre, ***Communication Systems : Analog and Digital***, 3rd *Ed.*, McGraw Hill Education, 2012.

Reference Books:

R1. J. G. Proakis and M. Salehi, ***Communication System Engineering***, 2nd *Ed.*, PHI, 2002.
R2. S. Haykin and M. Moher, ***Communication Systems***, 5th *Ed.*, John Wiley & Sons, 2009.
R3. B. P. Lathi, Z. Ding, and H. M. Gupta, ***Modern Digital and Analog Communication Systems***, 4th *Ed.*, Oxford University Press, 2017.

Online Resources:

1. https://nptel.ac.in/courses/117105143: by Prof. G. Das, IIT Kharagpur
2. https://nptel.ac.in/courses/108104091: by Prof. A. Jagannathan, IIT Kanpur
3. https://nptel.ac.in/courses/117102059: by Prof. S. Prasad, IIT Delhi

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain types of signals and apply Fourier analysis for spectral representation in communication.
CO2	Explain and analyze AM techniques, modulators, detectors, and superheterodyne receivers.
CO3	Explain performance of angle modulation and various analog pulse modulation schemes.
CO4	Describe digital pulse modulation schemes and digital transmission of analog signals.
CO5	Analyze random variables, noise characteristics, and their effects on communication systems.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	3	2					1	2		1
CO2	3	3	3	3	3	2					2	3		1
CO3	3	3	3	3	3	2					2	3		1
CO4	3	2	2	3	3	3					2	3		1
CO5	3	3	3	2	3	3					2	2		1

Category	Code	Advanced Electrical Machines	L-T-P	Credits	Marks
HNS	EE3019		3-0-0	3	100

Objectives	The objective of this course is to provide students with a clear understanding of the construction, operating principles, and control strategies of special electrical machines used in autonomous systems, electric mobility, and renewable energy applications.
Pre-Requisites	Knowledge of electrical machines (DC and AC), electromagnetic theory, circuit analysis, along with differential equations and MATLAB/Simulink-based modelling is required.
Teaching Scheme	The course will be delivered through regular classroom lectures using ICT tools wherever necessary; sessions are designed to be interactive with a strong emphasis on derivations, concept visualization, and hands-on problem solving. Simulation-based demonstrations and case studies will be integrated into the delivery to build deeper insight into dynamic modeling and control of machines.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Synchronous Generators**: The ideal synchronous machine, synchronous machine inductances, Dynamic modelling and d–q axis concept, Armature reaction, Voltage regulation by ZPF method, power angle characteristics of salient and non salient pole machine, Equivalent circuit and vector diagram, Active and reactive power Load sharing in parallel operation, Effect of excitation and mechanical input, Capability curve of synchronous generators, Droop characteristics: P–f and Q–V control.	**9 Hours**
Module-2	**Synchronous Motors**: Principle of operation of synchronous motors, Torque-angle characteristics, Stability and hunting(qualitative). Industrial application: Control of reactive power through excitation, Power factor control; **Special Synchronous Machines**: Construction features, Principle and characteristics, Performance analysis and control strategies of Hysteresis motor, Synchronous Reluctance motor, Switched reluctance motor, Synchronous timing motor, Industrial applications.	**9 Hours**
Module-3	**Transformers**: Parallel operation and load sharing, Three-phase transformer connections and vector groups, Equivalent circuit of three-winding transformer, Determination of transformer parameters using OC and SC tests, Unbalanced three phase operation, Switching transient in transformers, Inrush current, Effect of harmonics, Tap-changing transformers.	**7 Hours**

Cont'd. . .

Module-#	Topics	Hours
Module-4	**Advanced Induction Machines & Performance Analysis**: Equivalent circuit and torque–slip characteristics, Double cage induction motor, Linear induction motor, Circle diagram, Induction generators – Grid-connected and standalone operation, Self-excitation mechanism, Capacitance requirement determination, Power factor improvement techniques, Variable-speed operation and performance analysis, Overview of double-field induction generators, Comparison of induction and synchronous generators, Starters and Modelling Concepts – Soft starters and dynamic capacitance, Per-phase modelling of machines.	**9 Hours**
Module-5	**Permanent Magnet Machines**: Brushless DC Motors (BLDC): Detailed analysis of magnetic circuits in BLDC motors, EMF and torque derivations for trapezoidal excitation, Role of electronic commutators in switching sequence, Advantages in compact and high-efficiency systems, Implementation of torque/speed control strategies using PWM in embedded controllers; Permanent Magnet Synchronous Motors (PMSM): Calculation of direct and quadrature axis reactance; Development of phasor diagrams for different load conditions; Converter interfaces including voltage-source inverters; Torque-speed characteristics in motoring and regenerative modes; Volt-ampere (V-A) requirement analysis for power electronic converters; Advanced control techniques using vector control and field-oriented control (FOC); Role of microcontroller and DSP-based implementations in precision motion applications.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. P. S. Bimbra, ***Generalized Theory of Electrical Machines***, 7th *Ed.*, Khanna Publishers, 2021.
T2. A. Hughes, ***Electric Motors and Drives: Fundamentals, Types and Applications***, 4th *Ed.*, Elsevier, 2013.
T3. A. E. Fitzgerald, C. Kingsley, and S. D. Umans, ***Electric Machinery***, 6th *Ed.*, McGraw-Hill, 2003.

Reference Books:

R1. R. Krishnan, ***Electric Motor Drives: Modeling, Analysis, and Control***, 1st *Ed.*, Pearson Education, 2015.
R2. T. J. E. Miller, ***Brushless Permanent-Magnet and Reluctance Motor Drives***, 1st *Ed.*, Oxford University Press, 1989.
R3. S. K. Pillai, ***A First Course on Electric Drives***, 3rd *Ed.*, New Age International, 2010.

Online Resources:

1. https://nptel.ac.in/courses/108102146: by Prof. G. Bhuvaneswari, IIT Delhi
2. https://nptel.ac.in/courses/108105131: by Prof. T. K. Bhattacharya, IIT Kharagpur

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand dynamic modelling, excitation control, and load sharing of synchronous generators.
CO2	Explain the operation, stability, and reactive power control of synchronous machines.
CO3	Analyze transformer performance, parallel operation, and transient behavior.
CO4	Evaluate performance and applications of advanced induction machines and induction generators.
CO5	Understand the analysis and control of permanent magnet machines (BLDC and PMSM).

P.T.O

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	2	2	2					1	3	2	2
CO2	3	3	2	2	3	2					2	3	3	3
CO3	3	3	1	3	3	2					1	3	2	3
CO4	3	3	2	3	3	2					1	3	3	3
CO5	3	2	2	2	2	2					1	3	2	3

Category	Code	Computer Organization & Architecture	L-T-P	Credits	Marks
MNR	CS2008		3-0-0	3	100

Objectives	The objective of this course is to familiarize students about hardware design including logic design, basic structure and behaviour of the various functional modules of a modern digital computer and how they interact to provide the processing power to fulfil the needs of the user.
Pre-Requisites	Knowledge of basic digital electronics and computer fundamentals is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Basic Structures of Computers**: Computer Architecture vs. Computer Organization, Functional units, Operational concepts, Registers, Bus Structure, Performance Consideration, SPEC rating.	**8 Hours**
Module-2	**Memory Location & Addresses**: Big-endian and Little-endian representation, Instruction format, Instruction set Architecture, RISC vs. CISC, Addressing modes, Instruction Sequencing, Subroutines.	**8 Hours**
Module-3	**Binary Arithmetic**: Addition and subtraction of signed numbers, Design of fast adders, Multiplication of positive numbers, Signed operand multiplication, Fast multiplication, Integer division, Representation of floating point numbers.	**8 Hours**
Module-4	**Memory System**: Basic Concepts, Speed, Size and cost, Cache memory concepts, Cache memory mapping techniques, Performance consideration; Virtual memory concepts, Translation look-aside buffer, Replacement techniques, Secondary Storage.	**10 Hours**
Module-5	**Basic Processing Units**: Fundamental concepts, Execution cycle, Single-Bus and Multi-Bus Organization, Execution of complete instruction, Hardwired control, Micro programmed control, Accessing I/O devices.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. C. Hamacher, Z. Vranesic, and S. Zaky, ***Computer Organization***, 5th *Ed.*, McGraw-Hill, 2017.
T2. W. Stallings, ***Computer Organization and Architecture***, 9th *Ed.*, Prentice Hall India, 2012.

Reference Books:

R1. M. M. Mano, ***Computer System Architecture***, 3rd *Ed.*, Pearson Education, 2007.
R2. B. Govindarajalu, ***Computer Architecture and Organization***, 5th *Ed.*, Tata McGraw-Hill, 2004.
R3. N. P. Carter, ***Schaum's Outline of Computer Architecture***, McGraw-Hill Education, 2002.

Online Resources:

1. https://nptel.ac.in/courses/106106166: by Prof. V. Kamakoti, IIT Madras
2. https://nptel.ac.in/courses/106104073: by Prof. B. Raman, IIT Kanpur
3. https://nptel.ac.in/courses/106103180: by Prof. J. K. Deka and Prof. A. Sarkar, IIT Guwahati
4. https://ocw.mit.edu/courses/6-823-computer-system-architecture-fall-2005/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain the architecture of a digital computer and the functions of its basic units.
CO2	Interpret instruction formats and apply addressing modes to solve basic problems.
CO3	Perform binary arithmetic operations using techniques for fixed & floating-point arithmetic.
CO4	Analyze memory hierarchy, explain cache & virtual memory mapping & replacement techniques.
CO5	Explain control unit and compare between hardwired & microprogrammed control techniques.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	2	2	2						1	2	2	2
CO2	3	3	2	2	3						1	3	3	2
CO3	3	3	2	3	3						2	2	3	2
CO4	3	3	2	3	3						2	3	2	1
CO5	2	3	2	2	2						1	2	2	1

Category	Code	Artificial Intelligence	L-T-P	Credits	Marks
MNR	CS2014		3-0-0	3	100

Objectives	The objective of this course is to provide a strong foundation to AI approaches to build intelligent systems with perception, logic, reasoning and learning abilities.
Pre-Requisites	Knowledge of basic mathematics, algorithms & data structures is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Definitions of AI, Four approaches to AI, Turing Test; Intelligent Agents: Agent function & programs, Rationality, Environment types, PEAS description, Structure of Agents, Types of Agent Programs, Problems solving by Searching - Example Problems, State space search; Uninformed Search Strategies: BFS, DFS, Depth Limited, Iterative Deepening DFS, Uniform Cost, Bi-directional Searches.	**9 Hours**
Module-2	**Search Algorithms & Reasoning**:Introduction, Evaluation and Heuristic functions, Greedy Best First Search, A* Search, Example Problems; Local Search Algorithms: Hill Climbing Search and Simulated Annealing; Constraint Satisfaction Problems: Introduction & types of CSPs, Backtracking Search for CSPs; Adversarial Search: Introduction, Game playing, Minimax and α-β Pruning; Knowledge & Reasoning: KB-based Agents, The Wumpus World problem.	**9 Hours**
Module-3	**Logic & Reasoning**: Logic, Propositional Logic, First-Order Logic (FOPL): Syntax & Semantics of FOPL, Inference in FOPL Forward and Backward Chaining, Knowledge Representation: Ontological Engineering, Categories and Objects, Semantic Nets, Frames.	**8 Hours**
Module-4	**Planning**: The Planning Problem, Planning with State-Space Search, Partial Order Planning, Planning Graphs, Hierarchical Planning; Uncertain Knowledge: Acting under Uncertainty, Bayes Rule & its use; Probabilistic Reasoning, Representing Knowledge in an Uncertain Domain, Semantics of Bayesian Networks.	**8 Hours**
Module-5	**Learning & Expert Systems**: Introduction to Learning, Learning Agent, Paradigms of learning, Learning from Observations, Inductive Learning, Information Gain, Learning Decision Trees; Statistical Learning, Instance Based Learning, Neural Networks: Introduction, Perceptron, Introduction to Reinforcement Learning; Introduction to Expert Systems: Definition, Architecture, Applications.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Russell and P. Norvig, ***Artificial Intelligence - A Modern Approach***, 4th *Ed.*, Pearson Education, 2020.

T2. D. W. Patterson, ***Introduction to Artificial Intelligence & Expert Systems***, 1st *Ed.*, Pearson Education, 2015.

Reference Books:

R1. E. Rich, K. Knight, and S. B. Nair, ***Artificial Intelligence***, 3rd *Ed.*, McGraw Hill Education, 2017.
R2. M. Negnevitsky, ***Artificial Intelligence: A Guide to Intelligent Systems***, 3rd *Ed.*, Addison Wesley, 2011.
R3. G. F. Luger, ***Artificial Intelligence: Structures and Strategies for Complex Problem Solving***, 6th *Ed.*, Pearson Education, 2008.

Online Resources:

1. https://nptel.ac.in/courses/106102220/: by Prof. Mausam, IIT Delhi
2. https://nptel.ac.in/courses/106106140/: by Prof. D. Khemani, IIT Madras
3. https://nptel.ac.in/courses/106105079/: by Prof. P. Dasgupta, IIT Kharagpur
4. https://nptel.ac.in/courses/106105077/: by Prof. A. Basu and Prof. S. Sarkar, IIT Kharagpur

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explore agents, environments, and search goal state using uninformed techniques.
CO2	Apply search techniques for game playing and solving constraint satisfaction problems.
CO3	Interpret logic, inference rules for decision making, and represent knowledge by semantic nets.
CO4	Apply planning and reasoning to handle uncertainty in real life problems.
CO5	Apply learning to solve complex real-life problems and design expert systems.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	2							3	1		2
CO2	2	3	3	2							2	2	1	2
CO3	3	3	3	2							2	2	1	2
CO4	3	3	2	2		1					2	2	1	2
CO5	3	3	2	2		2					3	2	1	2

Category	Code	CMOS VLSI Design	L-T-P	Credits	Marks
MNR	EC3032		3-0-0	3	100

Objectives	The objective of this course is to study the design, fabrication & testing of devices, circuits & systems using integrated micro fabrication technologies providing a broad coverage of VLSI technology.
Pre-Requisites	Fundamental knowledge of MOSFET, analog and digital electronics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction & Fabrication of MOSFETs**: VLSI Design Methodologies, VLSI Design Flow, Design Hierarchy, Concept of Regularity, Modularity & Locality, VLSI Design Styles; Fabrication of MOSFETs - Introduction, Fabrication Processes Flow - Basic Concepts, The CMOS n-Well Process, Layout Design Rules, Stick Diagrams of complex CMOS Logic Gates (Euler Method).	**9 Hours**
Module-2	**MOS Transistor**: The Metal Oxide Semiconductor (MOS) Structure, The MOS System under External Bias, Structure and Operation of MOS Transistor (MOSFET), MOSFET Current-Voltage Characteristics, MOSFET Scaling and Small-Geometry Effects, MOSFET Capacitance.	**8 Hours**
Module-3	**MOS Inverter Circuit**s: Introduction, Voltage Transfer Characteristics, Noise Margin Definitions, Resistive Load Devices, CMOS Inverters, Sizing Inverters; **Static MOS Gate Circuits**: Introduction, CMOS Gate Circuits, Complex CMOS Gates, Calculation of Inverter Equivalent for NAND, NOR and other Complex Logic Circuits.	**9 Hours**
Module-4	**Switching Characteristics & Interconnect Effects**: Introduction, Switching Time Analysis, Calculation of Interconnect Parasitics, Calculation of Interconnect Delay (Elmore Delay), Power Dissipation in CMOS Gates, Schematic of sequential circuits.	**8 Hours**
Module-5	**Transfer Gate & Dynamic Logic Design**: Introduction, Pass Transistor concepts, CMOS Transmission Gate, Dynamic logic; Basics of Semiconductor Memory - DRAM, SRAM Cell Design & Operation, Memory Architecture.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. -M. Kang and Y. Leblebici, ***CMOS Digital Integrated Circuits - Analysis and Design***, 3rd *Ed.*, Tata McGraw-Hill, 2002.

T2. D. A. Hodges, H. G. Jackson, and R. Saleh, ***Analysis and Design of Digital Integrated Circuits in Deep Submicron Technology***, 3rd *International Ed.*, McGraw Hill Education, 2004.

Reference Books:

R1. J. M. Rabaey, A. P. Chandrakasan, and B.Nikolić, ***Digital Integrated Circuits: A Design Perspective***, 2nd *Ed.*, Pearson Education, 2016.

R2. N. H. E. Weste, D. Harris, and A. Banerjee, ***CMOS VLSI Design - A Circuits and Systems Perspective***, 4th *Ed.*, Pearson Education, 2010.

R3. D. A. Pucknell and K. Eshraghian, ***Basic VLSI Design***, 3rd *Ed.*, PHI Learning, 1995.

Online Resources:

1. https://nptel.ac.in/courses/117101058: by Prof. A. N. Chandorkar, IIT Bombay
2. https://nptel.ac.in/courses/108107129: by Prof. S. Dasgupta, IIT Roorkee
3. https://nptel.ac.in/courses/117106149: by Prof. M. Rao, IIIT Bangalore

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Identify suitable VLSI design methods using proper design flow and fabrication steps.
CO2	Describe MOSFET structure & operation under bias, including effects of scaling & geometry.
CO3	Design and analyze inverter, combinational & sequential circuits using CMOS technology.
CO4	Analyze inverter switching to estimate delay, interconnect effects and power consumption.
CO5	Design and analyze transmission gates, memory cells and understand testing techniques.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	2	3	1	1	1			2	1	2		2
CO2	3	3	1	2	2							2	1	
CO3	3	3	3	2	1						1	3	2	3
CO4	2	2	3	3	2							2	1	2
CO5	3	3	3	3	1						1	3	2	2

Category	Code	Sensors & Transducers	L-T-P	Credits	Marks
MNR	EC3034		3-0-0	3	100

Objectives	The objective of this course is to learn the characteristics of different types of measurement systems and industrial applications of various transducers & sensors for design and construction of precise measuring instruments.
Pre-Requisites	Basic knowledge of physics, mathematics, electrical and electronics is required
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**General Measurement Systems**: Introduction, Significance of measurement, Functional elements of generalized measurement systems, Static Characteristics - Systematic and statistical characteristics, Calibration; Dynamic characteristics - Transfer functions of typical sensing elements, Step and frequency response of first and second order elements, Dynamic error in measurement systems.	**9 Hours**
Module-2	**Basic Sensing Elements**: Resistive Sensing – Potentiometers, Resistance Temperature Detector (RTD), Thermistors & Strain gages; Capacitive Sensing – Variable separation, Area & dielectric piezoelectric transducers; Inductive Sensing – LVDT displacement sensors.	**8 Hours**
Module-3	**Thermoelectric & Elastic Sensing Elements**: Laws, Thermocouple characteristics, Installation problems, Cold junction compensation, IC temperature sensor; Elastic sensing elements - Bourdon tube, Bellows & diaphragms for pressure sensing, Force measurement; Miscellaneous Sensors - Optical sensors, Principle, Intensity & phase-modulated sensors, FBG sensor.	**9 Hours**
Module-4	**Signal Conditioning Elements**: DC Bridge - Wheatstone Bridge, Calibration of the bridge, AC bridges, Linearization by Bridge circuit, Modulation and demodulation techniques, Signal conditioning system, Signal transmission.	**8 Hours**
Module-5	**Amplifiers**: Operational amplifier - Ideal & non-Ideal performances, Inverting, Non-inverting and differential amplifiers, Instrumentation amplifier, Filters, A.C. carrier systems, Phase sensitive demodulators and its applications in instrumentation.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. P. Bentley, ***Principles of Measurement Systems***, 4th *Ed.*, Pearson Education, 2005.
T2. A. K. Ghosh, ***Introduction to Measurement and Instrumentation***, 3rd *Ed.*, PHI Learning, 2009.

Reference Books:

R1. D. Patranabis, ***Sensors and Transducers***, 2nd *Ed.*, PHI Learning, 2013.
R2. D. V. S. Murthy, ***Transducers and Instrumentation***, 2nd *Ed.*, PHI Learning, 2008.
R3. E. O. Doeblin, ***Measurement Systems - Applications and Design***, 6th *Ed.*, McGraw Hill, 2007.
R4. C. Rangan, G. Sarma, and V. S. V. Mani, ***Instrumentation : Devices and Systems***, 2nd *Ed.*, McGraw Hill, 2017.

Online Resources:

1. https://nptel.ac.in/courses/108105088: by Prof. S. Mukhopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/108105062: by Prof. Mukhopadhyay and Sen, IIT Kharagpur
3. https://nptel.ac.in/courses/108105064: by Prof. A. Barua, IIT Kharagpur
4. https://nptel.ac.in/courses/108108147: By Prof. H. J. Pandya, IISc Bangalore

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain elements, characteristics and dynamic behavior of general measurement systems.
CO2	Describe resistive, capacitive and inductive sensing elements and their operating principles.
CO3	Explain thermoelectric, elastic and optical sensing elements and their measurement uses.
CO4	Analyze bridge circuits, modulation methods and signal conditioning techniques in measurement.
CO5	Apply operational and instrumentation amplifiers, filters, and demodulators in measurement.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	2					2	2	1	1
CO2	3	3	3	2	2	2					2	3	2	3
CO3	3	3	3	3	2	2					3	3	1	2
CO4	2	2	2	2	2	2					2	2	3	2
CO5	3	3	3	2	2	2					2	2	2	3

Category	Code	Human Resource Information Systems	L-T-P	Credits	Marks
MNR	MG3003		3-0-0	3	100

Objectives	This course aims to provide the students with a managerial understanding of Human Resource Information Systems (HRIS) as enterprise platforms supporting workforce operations, talent management, and decision-making. Students will learn how HRIS integrates people data, business processes, and digital technologies to enable efficient HR services, compliance, and analytics in modern organizations.
Pre-Requisites	Basic understanding of organizational concepts and familiarity with information systems, databases, use of online tools & platforms is desirable.
Teaching Scheme	Regular classroom lectures with the use of ICT and advanced tools as and when required; sessions emphasize interactive discussions, real-world case studies, and practical application of human resource information systems concepts.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**HRIS Fundamentals & Enterprise Roles**: HRIS, HRMS, HCM concepts and evolution, Overview of HR platforms, Enterprise system of record, Implementation lifecycle (strategy, design, build, test, deploy, support), High-level HRIS architecture, Requirements matrix, Core HR and employee master data, HR data architecture, Stakeholder roles (PM, architects, Security lead, Change manager) and interviews, Governance and ownership HRIS.	**8 Hours**
Module-2	**Organizational Data & Talent Acquisition**: Employee data model, Organization and job architectures, Matrix organization, Master and temporal data management, Employment types, Organizational hierarchy & reporting, ERD for core HR, Effective dating, Master data accuracy; Recruiting lifecycle (requisition, sourcing, screening, interviewing, offer, hire), Applicant tracking, Background checks, Assessment tools, Onboarding workflow, Swimlane diagrams, Candidate-to-employee data transition.	**9 Hours**
Module-3	**Workforce Operations, Payroll & Benefits**: Time and attendance systems, Workforce scheduling and leave management, Labor rule automation, Business rules engine, Time-to-payroll integration & challenges, Payroll process overview - earnings, deductions, pay cycles, Benefits administration overview - enrollment, life events, HRIS–payroll–benefits data flow, Employee data privacy and sensitivity.	**8 Hours**
Module-4	**Performance, Learning & Rewards Systems**: Performance management systems, SMART goal setting, Organization–individual alignment, OKRs, Feedback, Appraisal, Workflows, Performance–compensation linkage; LMS & HRMS integration, Skills & competency tracking, Career development, Succession and internal mobility; Salary structures, Merit and bonus planning, Pay equity, Total rewards.	**9 Hours**

Cont'd. . .

Module-#	Topics	Hours
Module-5	**HR Service Delivery, Integration & Analytics**: HR service delivery and self-service systems, HR case management, Knowledge base usage, Chatbot-enabled support; HRIS security - role-based access, Data privacy, Regulatory awareness, Audit & compliance; Change management, Testing strategies; HRIS integration with enterprise systems, APIs & data exchange fundamentals; Operational reporting vs strategic analytics, HR dashboards, KPIs, Data-driven decision-making.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. M. J. Kavanagh, M. Thite, and R. D. Johnson, ***Human Resource Information Systems: Basics, Applications, and Future Directions***, 4th *Ed.*, Sage Publications, 2018.

T2. S. M. Badgi, ***Practical Guide to Human Resource Information Systems (HRIS)***, 1st *Ed.*, PHI Learning, 2014.

T3. P. M. Gupta, ***HR Analytics: The Future of HR***, 1st *Ed.*, BPB Publications, 2019.

Reference Books:

R1. N. Khan, ***Introduction to People Analytics: A Practical Guide to Data-Driven HR***, 1st *Ed.*, Wiley India, 2020.

R2. S. D. Waters, ***The Practical Guide to HR Analytics***, 1st *Ed.*, Society for Human Resource Management (SHRM)/Kogan Page, 2019.

R3. C. Ostroff and A. Schweyer, ***Winning on HR Analytics: Leveraging Data for Competitive Advantage***, 1st *Ed.*, Pearson Education, 2016.

Online Resources:

1. https://nptel.ac.in/courses/110107492: By Prof. S. Rangnekar, Prof. A. Singh, IIT Roorkee, XLRI JSP
2. https://nptel.ac.in/courses/110103626: By Prof. A. C. Issac, IIT Guwahati
3. https://nptel.ac.in/courses/110105069: By Prof. A. Malik, IIT Kharagpur
4. https://www.coursera.org/learn/wharton-people-analytic
5. https://www.coursera.org/learn/human-resources-analytics

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain the role of HRIS as an enterprise system for workforce data and managerial decisions.
CO2	Analyze organizational and recruitment data structures used in HRIS for hiring and onboarding.
CO3	Describe workforce operations, payroll, and benefits enabled through integrated HRIS.
CO4	Evaluate performance, learning, and compensation systems using HRIS-based talent data.
CO5	Apply HRIS concepts for service delivery, system integration, security, and people analytics.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).

Cont'd. . .

PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1		2	2	1	1	2	1	1	1	2	2
CO2	2	3	2	1	2	1		1	1	1		2	2	1
CO3	2	2	3		2	2	1	1	1	2		1	2	2
CO4	2	2	2	1	2	1	1	1	1	2		1	2	2
CO5	2	2	2		3	3	2	2	3	2	2	2	3	3

Category	Code	Data Analytics with Python	L-T-P	Credits	Marks
MNR	MG3001		3-0-0	3	100

Objectives	The objective of this course is to learn the key aspects of business analytics and using Python as a programming tool for data analytics.
Pre-Requisites	Fundamentals of business analytics and python programming is required.
Teaching Scheme	Regular classroom lectures, power point presentations with use of ICT as required, with examples, real-life case studies, assignments and projects.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Review of Python**: Features, variables, input, output, operators; Control flow statements - if, nested if, if-elif-else, Loops - while, for, error and exception handling; Data Structures - List, tuples, dictionary, Modules – Math, random, statistics, array, string.	**7 Hours**
Module-2	**Data Wrangling with Python**: Introduction to NumPy arrays and vectorized computation, array creation, indexing, slicing and reshaping; DataFrame operations in Pandas - importing data, handling missing values, merging, grouping, filtering and sorting; Basic data cleaning and transformation for analytical readiness.	**9 Hours**
Module-3	**Visual Analytics with Python**: Creating and customizing visualizations — line charts, bar plots, histograms, scatter plots, boxplots, heatmaps and pairplots; Use of Matplotlib for fine-tuned control and Seaborn for statistical visualization, Emphasis on aesthetics, storytelling with data and communicating analytical findings effectively.	**8 Hours**
Module-4	**Exploratory Data Analysis with Python**: Understanding data distributions, identifying outliers and detecting correlations; Techniques for data cleaning, normalization, encoding categorical variables and feature scaling; Generating descriptive statistics and correlation matrices; Applying EDA concepts to real-world datasets using Pandas and Seaborn.	**9 Hours**
Module-5	**Applied ML with Scikit-Learn**: Overview of supervised learning techniques using Scikit-learn, Splitting datasets, Fitting models, Evaluating simple regression and classification models; Introduction to metrics - Accuracy, MAE, and R^2; Mini-project with data cleaning, visualization, and basic modeling using Python tools.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. J. Rogel-Salazar, ***Data Science and Analytics with Python***, 1st *Ed.*, CRC Press, 2017.
T2. W. McKinney, ***Python for Data Analysis***, 3rd *Ed.*, O'Reilly Media, 2022.

Reference Books:

R1. J. Vanderplas, ***Python Data Science Handbook***, 1st *Ed.*, O'Reilly Media, 2016.
R2. J. Grus, ***Data Science from Scratch: First Principles with Python***, 2nd *Ed.*, O'Reilly Media, 2019.
R3. A. Géron, ***Hands-On Machine Learning with Scikit-Learn, Keras and TensorFlow***, 3rd *Ed.*, O'Reilly Media, 2022.

Online Resources:

1. https://nptel.ac.in/courses/110107129: by Prof. G. Dixit, IIT Roorkee
2. https://nptel.ac.in/courses/106107220: By Prof. A. Ramesh, IIT Roorkee
3. https://nptel.ac.in/courses/106106361: by Prof. S. K. Mathew, IIT Madras

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Recall Python fundamentals, control structures and data types and solve analytical problems.
CO2	Apply NumPy and Pandas for data handling, cleaning, and transformation for analysis.
CO3	Design and interpret effective visualizations using Matplotlib and Seaborn to uncover insights.
CO4	Perform EDA with data preprocessing, and correlation analysis to derive meaningful insights.
CO5	Integrate data handling, visualization, and modeling to build and assess predictive workflows.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	2	2						2	2	1	1
CO2	2	2	2	3	2						3	3	2	2
CO3	2	2	3	3	2						3	3	3	2
CO4	2	3	3	3	2						3	3	2	2
CO5	2	3	3	3	3						3	3	3	3

Category	Code	Control Systems Engineering Lab	L-T-P	Credits	Marks
PCR	EE3005		0-0-2	1	100

Objectives	The objective of the course is to model systems using transfer functions and state-space methods, analyze them in time and frequency domains via simulation, implement physical systems, and design controllers and compensators.
Pre-Requisites	Knowledge of Dynamic equations of physical systems, Basic Electrical Engineering, Laplace Transform, and Matrix Theory is required.
Teaching Scheme	Regular laboratory experiments to be conducted using hardware and software tools under the supervision of teachers. Demonstration will be given for each experiment in the pre-lab session.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Study of Position control system using DC Servo motor and determination of its transfer function.
2	Study the characteristics of Synchro Transmitter and Receiver.
3	Observe the time response of a second order process with P, PI and PID controller using process control simulator.
4	Analyze a 2nd order system by plotting its step response using simulation and programming.
5	Verify the effect of P, PI, PD and PID Controller of a 2nd order system using simulation and programming.
6	Study of speed-torque and speed-voltage characteristics of two-phase ac servomotor and determination of its transfer function.
7	Determination of controllability and observability of a given system using simulation and programming.
8	Stability analysis of a given system using time domain and frequency domain plots using simulation and programming.
9	Study of frequency response of compensator networks and analysis of system stability with compensator using simulation and programming.
10	Study the frequency response of lead, lag compensator networks.
11	Study and validate the controllers (ON/OFF and PID) for a temperature control system.
12	Obtain reduced order model of a higher order system using simulation and programming.

Text Books:

T1. I. J. Nagrath and M.Gopal, ***Control Systems Engineering***, 5th *Ed.*, New Age Intl., 2010.
T2. K. Ogata, ***Modern Control Engineering***, 5th *Ed.*, PHI Learning, 2010.

Reference Books:

R1. B. C. Kuo, ***Automatic Control Systems***, 7th *Ed.*, Prentice Hall India, 2010.
R2. R. C. Dorf and R. H. Bishop, ***Modern Control Systems***, 8th *Ed.*, Addison Wesley, 2003.
R3. U. A. Bakshi and V. U. Bakshi, ***Control System Engineering***, 1st *Ed.*, Technical Publications, 2010.

Online Resources:

1. https://nptel.ac.in/courses/108102043/: by Prof. M. Gopal, IIT Delhi
2. https://nptel.ac.in/courses/108106098/: by Prof. R. Pasumarthy, IIT Madras

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Analyze control components' parameters and transfer functions and their real-world use.
CO2	Describe the compensator design and their applications across interdisciplinary systems.
CO3	Classify linear and nonlinear control actions and apply suitable schemes in industry.
CO4	Differentiate between transfer function and state-space models of systems using software.
CO5	Analyze & compare first- & second-order system performance in time domain using software.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	1	2	2					2	3	1	
CO2	3	3	2	2	3	2					2	3	2	1
CO3	3	3	2	2	3	2					3	3	1	
CO4	2	2	1	2	2	2					2	2	1	
CO5	2	2	1	2	3	2					3	3	2	1

Category	Code	Power Electronics Lab	L-T-P	Credits	Marks
PCR	EE3006		0-0-2	1	100

Objectives	The objective of this course is to provide practical exposure on analysis, design & testing of power electronics converters along with application of semiconductor devices for conversion & control of electrical energy.
Pre-Requisites	Knowledge of electrical components, semiconductor devices, analysis of electrical & magnetic circuits is required. Topics taught in theory classes are essential.
Teaching Scheme	Regular laboratory experiments to be conducted under supervision of teacher including demonstration, associated safety measures explained in pre-lab sessions.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Study the V-I characteristics of SCR & to measure the latching & holding current of a SCR.
2	Study of the V-I characteristics of UJT.
3	Study of the V-I characteristics of TRIAC.
4	Study of UJT triggering circuit & cosine controlled triggering circuit.
5	Study of single phase half & full wave (Bridge type) controlled rectifier with R & R-L Load.
6	Study of the single phase full wave controlled rectifier (Mid-point type) & semi-converter with R & R-L Load.
7	Study of 3 phase full wave controlled rectifier (Full and Semi converter) with R & R-L Load.
8	Study of the forward converter & flyback converter.
9	Study of the single-phase voltage source inverter with Sinusoidal pulse width modulation.
10	Study of dual converter in (i) circulating & (ii) non-circulating current modes.
11	Simulate various power electronics converter circuits & study their performance.

Text Books:

T1. M. H. Rashid, ***Power Electronics: Devices, Circuits, and Applications***, 4th *Ed.*, Pearson Education, 2017.
T2. P. S. Bhimbra, ***Power Electronics***, 6th *Ed.*, Khanna Publishers, 2014.

Reference Books:

R1. M. D. Singh and K. B. Khanchandani, ***Power Electronics***, 2nd *Ed.*, McGraw-Hill, 2017.
R2. P. C. Sen, ***Power Electronics***, 1st *Ed.*, McGraw Hill India, 2001.

Online Resources:

1. https://nptel.ac.in/courses/108102145: by Prof. G. Bhuvaneshwari, IIT Delhi
2. https://nptel.ac.in/courses/108101126: by Dr. L Umanand, IISc Bangalore
3. https://nptel.ac.in/courses/108105066: by Prof. D. Kastha, and others, IIT Kharagpur
4. https://nptel.ac.in/courses/108101038: by Prof. B. G. Fernandes and Prof. K. Chatterjee, IIT Bombay

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Interpret characteristics and triggering circuits of SCR, UJT, and TRIAC.
CO2	Analyze various power electronics converters.
CO3	Evaluate the performance of Dual converter and its applications.
CO4	Simulate different power electronic converters.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	2	2	1					1	3	2	
CO2	3	2	2	3	3	1					1	3	3	2
CO3	3	2	2	2	3	2					1	3	2	2
CO4	3	2	2	2	3	2					1	3	2	1

Category	Code	Electrical & Electronics Measurement Lab	L-T-P	Credits	Marks
PCR	EE3007		0-0-2	1	100

Objectives	The objective of the course is to learn the constructional features, working principle, testing and calibration of measuring instruments and measuring techniques.
Pre-Requisites	Basic knowledge of electrical components, analysis techniques of electrical and magnetic circuits. Topics taught in the theory classes are essential.
Teaching Scheme	Regular laboratory experiments conducted under supervision of the teacher including demonstration of associated safety measures.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Measurement of Low Resistance by Kelvin's Double Bridge Method.
2	Measurement of Self Inductance using Anderson's Bridge.
3	Measurement of unknown capacitance & loss factor using Schering Bridge.
4	Measurement of unknown inductance & capacitance value using Q-meter.
5	Calibration of Voltmeters & Ammeters using Crompton Potentiometer.
6	Measurement of Power in a single-phase circuit by using CTs & PTs.
7	Measurement of energy of single-phase circuit using Smart Energy Meter.
8	Measurement of temperature-voltage characteristics of J-type Thermocouple.
9	To study the temperature vs resistance characteristics of thermistor.
10	To plot the displacement versus voltage characteristic of the given LVDT

Text Books:

T1. E. W. Golding and F. C. Widdis, ***Electrical Measurements and Measuring Instruments***, 5th *Ed.*, Reem Publication, 2015.
T2. A. K. Sawhney, ***A Course in Electrical and Electronics Measurement and Instrumentation***, 19th *Ed.*, 2011.
T3. R. K. Rajput, ***Electrical and Electronic Measurement and Instrumentation***, S Chand & Co, 2016.

Reference Books:

R1. D. A. Bell, ***Electronic Instrumentation and Measurements***, 3rd *Ed.*, Oxford University Press, 2013.
R2. A. D. Helfrick and W. D. Cooper, ***Modern Electronic Instrumentation and Measurement Techniques***, 1st *Ed.*, Pearson Education, 2015.

Online Resources:

1. https://nptel.ac.in/courses/108102191: by Prof. A. Gupta, IIT Delhi

P.T.O

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Estimate the values of R, L & C accurately employing suitable bridges.
CO2	Measure power and energy with suitable measuring instruments.
CO3	Select appropriate electronic instruments for various measurements.
CO4	Explore the applications of various electronic instruments, sensors and transducers.
CO5	Utilize the electronic instruments, sensors and transducers in the real world applications.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	1	2							1	3	2	2
CO2	1	1	1	2							1	3	2	1
CO3	1	1	2	2							2	2	3	2
CO4	1	1	2	3							2	2	3	3
CO5	1		2	3							3	2	3	3

Category	Code	Soft Skills for Professionals	L-T-P	Credits	Marks
SEC	HS3001		0-0-2	1	100

Objectives	The objective of this laboratory course is to make learners understand aspects of soft skills, which are essential for all professionals, by making them participate in mock GD, PI, presentations & verbal ability tests.
Pre-Requisites	Knowledge of Technical Communication in English is required.
Teaching Scheme	Regular laboratory classes with various tasks designed to facilitate communication through pair and/or team activities with regular assessments, presentations, discussions, role plays, audio-visual supplements, writing activities, business writing practices & vocabulary enhancement.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	GD input and discussion
2	Mock GD 1: Content Development
3	Mock GD 2: Group Behaviour
4	GD test
5	Presentation inputs and discussions
6	PPT I
7	PPT II
8	PPT III
9	PPT IV
10	Writing an effective résumé
11	Mock PI I
12	Mock PI II
13	Verbal Ability I
14	Verbal Ability II

Text Books:

T1. B. K. Mitra, ***Personality Development and Soft Skills***, 3rd *Ed.*, Oxford University Press, 2024.

Reference Books:

R1. B. K. Das *et. al.*, ***An Introduction to Professional English and Soft Skills***, Cambridge University Press, 2009.
R2. B. K. Mitra, ***Effective Technical Communication - A Guide for Scientists and Engineers***, 1st *Ed.*, Oxford University Press, 2006.

Online Resources:

1. https://nptel.ac.in/courses/109107121: by B. Mishra, IIT Roorkee
2. https://owl.purdue.edu/owl/purdue_owl.html
3. https://www.usingenglish.com/
4. http://www.english-test.net/

5. https://www.ef.com/wwen/english-resources/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand and practice vital soft skills for professional success.
CO2	Participate actively in recruitment related group discussions.
CO3	Understand aspects of public speaking and apply them to make impactful multimedia presentations.
CO4	Compose compelling résumés and persuasive cover letters.
CO5	Perform efficiently and effectively in job interviews.

Program Outcomes Relevant to the Course:

PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1						3	2	3	3		2	1	1	1
CO2							2	3	3		2	1	1	1
CO3							2	3	3		2	1	1	1
CO4							2	3	3		2	1	1	1
CO5							3	3	3		2	1	1	1

Category	Code	Fundamentals of MPMC	L-T-P	Credits	Marks
PCR	EC3038		3-0-0	3	100

Objectives	The objective of this course is to analyze various microprocessors & microcontrollers, develop assembly-level programs, and interface with other external devices as per the requirements.
Pre-Requisites	Basic knowledge of digital electronics circuits is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on theory and programming activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Introduction to 8085 microprocessor and its organization, General architecture, Bus organization, Memory concepts, Pins and Signals, Instruction execution, Timing diagram, Instruction Set and Programming, Addressing modes, Interrupts, memory and I/O interfacing.	**9 Hours**
Module-2	**Intel 8086 Microprocessor**: Bus interface unit, Execution unit, Register organization, Memory segmentation, Pin architecture, Minimum and Maximum mode system configuration, Physical memory organization, Interrupts, Addressing modes, Instructions.	**8 Hours**
Module-3	**The 8051 Microcontroller**: Introduction to Microcontroller, CISC & RISC Processors, MCS-51 Architecture, Registers in MCS-51, 8051 Pin description, Memory organization, 8051 Addressing modes, MCS-51 Instruction set, 8051 Instructions and simple programs, Interrupts in MCS-51, Special function registers, Assembly language programming.	**9 Hours**
Module-4	**Microcontroller Applications**: 8051 Timers and Counters, Serial communication, I/O Interfacing using 8255, Light emitting diodes (LEDs), Push buttons, Relays and latch connections.	**8 Hours**
Module-5	**Interfacing with Peripheral ICs**: System level interfacing design with various ICs like 8255 Programmable peripheral interface, 8257 DMA Controller, 8259 Programmable interrupt controller, 8251 Programmable communication interface.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. M. Rafiquzzaman, ***Microprocessors and Microcomputer based System Design***, 2nd *Ed.*, UBS Publications, 2001.

T2. K. M. Bhurchandi and A. K. Ray, ***Advanced Microprocessors and Peripherals***, 3rd *Ed.*, McGraw-Hill Education,2012.

T3. M. A. Mazidi, J. G. Mazidi, and R. D. McKinlay, ***The 8051 Microcontroller and Embedded Systems : Using Assembly and C***, 2nd *Ed.*, Pearson Education, 2011.

Reference Books:

R1. R. S. Gaonkar, ***Microprocessor Architecture, Programming, and Applications with the 8085***, 6th *Ed.*, Penram International Publishing, 2013.

R2. B. Ram, ***Fundamentals of Microprocessors and Microcontrollers***, 9th *Ed.*, Dhanpat Rai Publications, 2019.
R3. K. Ayala, ***The 8086 Microprocessor : Programming & Interfacing the PC***, 1st *Ed.*, Delmar Cengage Learning, 2007.

Online Resources:

1. https://nptel.ac.in/courses/106108100: by Prof. K. Kumar, IISc Bangalore
2. https://nptel.ac.in/courses/108107029: by Dr. P. Agarwal, IIT Roorkee
3. https://nptel.ac.in/courses/108105102: by Prof. S. Chattopadhyay, IIT Kharagpur

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Analyze 8085 microprocessor architecture, instruction set, addressing, and I/O interfacing.
CO2	Comprehend 8086 microprocessor architecture, memory segmentation, and instruction set.
CO3	Develop assembly programs using 8051 microcontroller, its instruction set, and addressing.
CO4	Apply 8051 timers, serial communication, and I/O interfacing for practical applications.
CO5	Implement system-level interfacing with peripheral ICs like 8255, 8257, 8259, and 8251.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	1	1		1				1	2	1	1
CO2	3	3	2	3	2		1				1	3	2	1
CO3	3	3	2	2	2		1				1	3	2	1
CO4	3	3	2	2	2		1				1	3	3	2
CO5	2	2	3	2	2		1				1	2	3	1

Category	Code	Power Systems Operation & Control	L-T-P	Credits	Marks
PCR	EE3008		3-1-0	4	100

Objectives	The objective this course is to learn key aspects of power system operation and control in both single-area and interconnected systems including load flow methods, economic operation of power systems and strategies for maintaining frequency and voltage within acceptable limits.
Pre-Requisites	Basic knowledge of power system transmission and distribution, electrical machines and circuit theory is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with a strong emphasis on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction to Power Systems**: Single & Double Subscript Notations, Complex Power, Power Triangle, Direction of Power Flow, Per-Unit System, Single Line Diagram, Impedance and Reactance Diagram, Formation and Modification of YBUS Matrix, Incidence matrix, Y-Bus From Incidence Matrix, Gaussian Elimination, Node Elimination, Triangular Factorization, Sparsity.	**12 Hours**
Module-2	**Power Flow Solution**: The Power Flow Problem, Gauss-Seidel Method, Newton-Raphson Method, Decoupled Power Flow, Power Flow Studies in System Design and Operations, Load Flow Analysis With Distributed Sources.	**10 Hours**
Module-3	**Economic Operation of Power System**: Load distribution between units within a plant and between plants, transmission loss equation, interpretation of loss coefficients, classical economic dispatch with losses, penalty factors, unit commitment, dynamic programming; Introduction to Hydro-thermal Scheduling.	**11 Hours**
Module-4	**Automatic Load Frequency Control (ALFC)**: Single-Area Systems - Load-frequency relationship, speed-governing system, Hydraulic valve actuator, Turbine-generator response, Static performance of speed governor, Closing the ALFC loop, Concept of control area, Static & Dynamic response of ALFC loop, Physical interpretation of results, Secondary ALFC loop & Economic dispatch control, Multi-Area Systems - Two-area systems, Block diagram & Mechanical analog of two-area systems, Control of multi-area systems; **Automatic Voltage Regulator (AVR)**: Exciter Types, Exciter & Generator Modelings, Static & Dynamic Performance Of AVR Loop, Effect of Generator Loading.	**12 Hours**
Module-5	**Power System Stability**: The stability problem, rotor dynamics and the swing equation, Further considerations of the swing equation, Power angle equation, Synchronizing power coefficient, Equal-area criterion for stability, Additional applications of the equal-area criterion and multi-machine stability studies using the classical representation. Numerical Solution Of Swing Equation (SMIB system).	**11 Hours**
	Total	**56 Hours**

Text Books:

T1. J. J. Grainger and W. D. Stevenson, ***Power System Analysis***, 1st *Ed.*, McGraw-Hill, 2017.
T2. H. Sadaat, ***Power System Analysis***, McGraw-Hill Education, 2002.

Reference Books:

R1. O. I. Elgerd, ***Electric Energy Systems Theory - An Introduction***, 2nd *Ed.*, McGraw-Hill, 2017.
R2. D. P. Kothari and I. J. Nagrath, ***Modern Power System Analysis***, 4th *Ed.*, Tata McGraw-Hill, 2011.

Online Resources:

1. https://nptel.ac.in/courses/108105067: by Prof. A. K. Sinha, IIT Kharagpur
2. https://nptel.ac.in/courses/108107127: by Dr. V. Pant & Dr. B. Das, IIT Roorkee

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Construct admittance matrix and evaluate per-unit representation of power systems.
CO2	Analyze power flow, compute transmission losses, and optimize economic generation.
CO3	Apply economic dispatch and unit commitment techniques for efficient power system operation.
CO4	Examine load frequency and voltage regulation in single and multi-area power control systems.
CO5	Analyze rotor angle stability and estimate critical clearing time for stable power operation.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1		2	2					1	2		
CO2	3	3	1		2	2					1	3	1	
CO3	3	3	1		2	2					2	2		
CO4	3	3	2		3	2					2	3	2	2
CO5	3	3	2		2	2					1	2	1	3

Category	Code	Introduction to Digital Signal Processing	L-T-P	Credits	Marks
PCR	EC3009		3-0-0	3	100

Objectives	The objective of this course is to analyze signals and systems in time and frequency domains, apply Z and Fourier transforms and design stable IIR & FIR digital filters for various signal processing applications.
Pre-Requisites	Knowledge of signals & systems, complex numbers and basic calculus is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Signals & Systems**: Introduction to signals, Classification, Convolution of two signals (graphical & analytical), Introduction to system, Classification, Continuous-time and Discrete-time LSI system, System representation through differential & difference equations, Response of LSI system, Convolution sum, Correlation of discrete-time signals and its properties.	**9 Hours**
Module-2	**Discrete Time Signals**: Z-Transform, Region of convergence, Properties of Z-transform, Inverse Z-transform (power series & partial fraction methods); Analysis of LSI systems - Causality and stability using Z-transform, Pole-Zero concept and pole-zero cancellation, Transient & Steady state response, Unilateral Z-transform and its properties, Solution of difference equations.	**9 Hours**
Module-3	**Discrete Fourier Transform**: Basics of discrete time Fourier transform (DTFT), Frequency domain sampling and reconstruction of discrete time signals, Discrete Fourier Transform (DFT) and its properties, Linear filtering (overlap add method and overlap save method), Efficient computation of DFT, Fast Fourier transform (FFT) Algorithm (Radix-2 DIT & Radix-2 DIF).	**8 Hours**
Module-4	**Structure for Realization of Discrete Time Systems**: Structure for IIR systems - Direct form I, Direct form II, Cascade & Parallel form, Signal flow graph and transposed structure, Structure for FIR systems, Direct form, cascade form and frequency sampling structure.	**8 Hours**
Module-5	**Design of Digital Filters**: Causality and its implication, Design of FIR filters, Symmetric & Anti-symmetric, Design of linear phase FIR filters using windowing technique and frequency sampling technique, Design of IIR filters from analog filters using impulse invariance and bilinear transformation techniques.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. A. V. Oppenheim, A. S. Willsky, and S. H. Nawab, ***Signals and Systems***, 2nd *Ed.*, Prentice Hall India, 1992.

T2. B. P. Lathi, ***Principles of Signal Processing and Linear Systems***, 2nd *Ed.*, Oxford Univ. Press, 2009.

T3. J. G. Proakis and D. G. Manolakis, ***Digital Signal Processing : Principles, Algorithms and Applications***, 4th *Ed.*, Prentice Hall India, 2007.

T4. S. K. Mitra, ***Digital Signal Processing : A Computer Based Approach***, 4th *Ed.*, McGraw-Hill, 2013.

Reference Books:

R1. A. Ambardar, ***Analog and Digital Signal Processing***, 2nd *Ed.*, Brooks/Cole Publishing Company (an International Thomson Publishing Company), 1999.
R2. M. J. Roberts, ***Signals and Systems - Analysis using Transform Methods and MATLAB***, 2nd *Ed.*, McGraw-Hill, 2003.
R3. A. N. Kani, ***Signals and Systems***, 2nd *Ed.*, McGraw-Hill Education, 2010.
R4. A. N. Kani, ***Digital Signal Processing***, 2nd *Ed.*, McGraw-Hill Education, 2012.
R5. P. R. Babu, ***Digital Signal Processing***, 4th *Ed.*, SciTech Publication, 2011.

Online Resources:

1. https://nptel.ac.in/courses/117104074: by Prof. K. S. Venkatesh, IIT Kanpur
2. https://nptel.ac.in/courses/108105065: by Prof. T. K. Basu, IIT Kharagpur
3. https://nptel.ac.in/courses/108104100: by Prof. A. K. Jagannatham, IIT Kanpur
4. https://nptel.ac.in/courses/117101055: by Prof. V. M. Gadre, IIT Bombay

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Analyze and classify signals and systems using convolution, correlation and equations.
CO2	Apply Z-transform to analyze discrete-time systems for stability and system response.
CO3	Analyze discrete signals using DFT, FFT algorithms, and frequency domain methods.
CO4	Design and realize discrete-time systems using various IIR and FIR structures.
CO5	Design FIR and IIR digital filters using windowing, frequency sampling, and transformation.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	3	2	2						1	2	2	2
CO2	2	2	2	2	2						2	2	1	1
CO3	2	2	1	2	1						2	1	1	1
CO4	1	3	3	2	2						2	2	1	2
CO5	2	2	2	1	1						1	2	1	2

Category	Code	Flexible AC Transmission Systems	L-T-P	Credits	Marks
PEL	EE3013		3-0-0	3	100

Objectives	The objective of this course is to study the reactive power control techniques, shunt and series compensation, static VAR compensators and their applications, including Thyristor controlled series capacitors, STATCOM devices and FACTS controllers.
Pre-Requisites	Knowledge of Power Electronics and Power Systems is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: FACTS Concept & General System Considerations, Power Flow and Dynamic Stability, Considerations of a Transmission Interconnection, Relative Importance of Controllable Parameters, Types of FACTS Controllers, Description and Definitions of FACTS Controllers.	**6 Hours**
Module-2	**Static Shunt Compensation**: Objectives of Shunt Compensation, Methods of Controllable VAR Generation, Static VAR Compensator (SVC) and Static Compensator (STATCOM).	**11 Hours**
Module-3	**Static Series Compensators**: Objective of Series Compensation, Thyristor Switched Series Compensator (TSSC), Thyristor Controlled Series Compensator (TCSC), Variable Impedance Type Series Compensator, Switching Converter Type Series Compensator, Static Synchronous Series Compensator (SSSC).	**10 Hours**
Module-4	**Static Voltage & Phase Angle Regulators**: Objectives of Voltage and Phase Angle Regulators, Approaches to Thyristor Controlled Voltage Regulators (TCVR) and Thyristor Controlled Phase Angle Regulators (TCPAR).	**10 Hours**
Module-5	**Combined Compensators**: Introduction, Unified Power Flow Controller (UPFC), Interline Power Flow Controller (IPFC).	**4 Hours**
	Total	**42 Hours**

Text Books:

T1. N. G. Hingorani and L. Gyugyi, ***Understanding FACTS: Concepts & Technology of Flexible AC Transmission Systems***, 2nd *Ed.*, IEEE Press, Standard Publishers Distributors, 2004.

Reference Books:

R1. K. R. Padiyar, ***Facts Controllers in Power Transmission and Distribution***, 2nd *Ed.*, New Age International, 2016.

R2. E. Acha, C. F. Esquivel, H. A. Pérez, and C. A. Camacho, ***Modelling & Simulation in Power Networks***, 1st *Ed.*, Wiley India, 2012.

Online Resources:

1. https://nptel.ac.in/courses/108107114: by Prof. A. Bhattacharya, IIT Roorkee

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe power flow control, dynamic stability, and operation of various FACTS controllers.
CO2	Analyze shunt compensation techniques and performance of SVC and STATCOM controllers.
CO3	Analyze objectives & operating principles of series compensators like TSSC, TCSC, and SSSC.
CO4	Evaluate operation of TCVR and TCPAR for effective voltage and phase angle regulation.
CO5	Explore operation of UPFC & IPFC for effective series and shunt compensation in power systems.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	2	2	2						2	2	2	1
CO2	2	2	1	1	1						1	2	3	1
CO3	2	2	1	1	1						1	2	3	1
CO4	2	2	1	1	1						1	2	3	1
CO5	2	1	1	1	1						1	2	3	1

Category	Code	Advanced Power Electronics	L-T-P	Credits	Marks
PEL	EE3018		3-0-0	3	100

Objectives	The objective of this course is to learn the advanced topics in power electronics including rectifiers, inverters, resonant and soft-switching converters, power converters and its industrial applications.
Pre-Requisites	Knowledge of circuit topology, analysis of switching circuits, magnetics, power electronics, semiconductor devices and basic simulation skill is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on advanced topics of power electronics.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Non-isolated DC-DC Converters**: Buck, Boost, Buck-boost, Cuk, SEPIC (single-ended primary-inductor converter), Isolated DC-DC converters (Switched Mode Power Supplies (SMPS)): Forward converter, Flyback converter, Half bridge converter, Full bridge converter, Push-pull converter.	**12 Hours**
Module-2	**Resonant Converters**: Series resonant converters, Parallel resonant converters, Zero-voltage-switching(ZVS) resonant converters, Zero-current switching(ZCS) resonant converters, Resonant DC-link converters.	**7 Hours**
Module-3	**Switched Mode AC Power Supplies**: UPS systems, Resonant AC power supplies, Control techniques (PWM controller & isolation in feedback loop).	**5 Hours**
Module-4	**Inverters**: Voltage Source Inverters (VSIs), Pulse width modulation (PWM) techniques - Sine PWM (SPWM), Selected harmonic elimination PWM (SHEPWM), Space vector PWM (SVPWM), Hysteresis band current controlled PWM; Three level inverters, Resonant inverters, Soft switched inverters; Current Source Inverters (CSIs) - Load commutated inverters, Forced commutated inverters.	**12 Hours**
Module-5	**AC Voltage Controllers**: AC voltage controllers with PWM control; Applications - HVDC transmission, Active harmonic filter, Grid integration of renewable energy sources with energy storage system.	**8 Hours**
	Total	**44 Hours**

Text Books:

T1. M. H. Rashid, ***Power Electronics***, 3rd *Ed.*, PHI Learning, 2008.

T2. N. Mohan, T. M. Undeland, and W. P. Robbin, ***Power Electronics : Converters, Applications and Design***, 3rd *Ed.*, Wiley India, 2012.

T3. B. K. Bose, ***Modern Power Electronics and AC Drives***, 1st *Ed.*, Pearson Education, 2005.

Reference Books:

R1. B. W. Flynn and D. E. Macpherson, ***Switched Mode Power Supplies : Design and Construction***, 2nd *Ed.*, Universities Press, 1997.

Online Resources:

1. https://nptel.ac.in/courses/108102584: by Prof. B. Singh, IIT Delhi
2. https://nptel.ac.in/courses/108107128: by Prof. A. Bhattacharya, IIT Roorkee

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe the working of isolated and non-isolated type DC-DC converter with its analysis.
CO2	Explain operating principles & characteristics of major resonant converters in power systems.
CO3	Design and analyze various AC power supplies with their control techniques.
CO4	Analyze advanced inverter operation and PWM for soft-switching in power electronics.
CO5	Apply AC voltage controllers and power electronics devices in various real world scenarios.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	2	2						1	3	2	
CO2	3	2	2	3	3						1	3	3	2
CO3	3	1	2	2	3						1	3	2	2
CO4	3	2	2	2	3						2	3	2	1
CO5	3	3	3	3	2						3	2	2	1

Category	Code	Fiber Optic Communications	L-T-P	Credits	Marks
PEL	EC3015		3-0-0	3	100

Objectives	The objective of this course is to study various modes, configurations and transmission characteristics of optical fibers including fiber fabrications, optoelectronic sources, photo detectors, optical modulators, optical amplifiers and various types of optical networks.
Pre-Requisites	Basic knowledge of physics, particularly ray optics, and electromagnetic wave propagation through waveguides is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Fundamentals of fiber optics, Different generations of optical fiber communication systems, Optical fiber structure, Fiber types, Step index fiber, Graded index fiber, Basic optical laws and definitions, Ray propagation, Total internal reflection, Numerical aperture, Acceptance angle, Wave propagation in planar and cylindrical waveguides, Modal concept, V-number, Power flow in step and graded index fibers.	**9 Hours**
Module-2	**Transmission Characteristics**: Attenuation (absorption, scattering, and bending) and dispersion (inter and intramodal, chromatic, wave guide and polarization), Dispersion shifted and Dispersion flattened fibers; **Optical Fiber Cables and Connections**: Fiber fabrication, Double crucible method, Fiber optic cables, Connector and splice, Losses during coupling between source to fiber, fiber to fiber; Schemes for coupling improvement.	**9 Hours**
Module-3	**Optical Sources & Detectors**: Sources - Intrinsic and extrinsic materials - direct and indirect band gaps, LED: LED structures, Surface emitting and edge emitting LED, LED quantum efficiency, Modulation response of an LED, Injection LASER Diodes (ILDs) - Threshold conditions, LASER modes, Modulation response of ILDs, Optoelectronic Detectors - PIN AND APD, Responsivity, Band width, Detector noise equivalent circuit and SNR calculation.	**8 Hours**
Module-4	**Opto-electronic Modulators**: Basic principles, Electro-optic modulators - Electro-optic effect, Longitudinal modulator, Transverse modulator; Acousto-optic modulators - Raman-Nath modulator, Bragg modulator; **Optical Amplifiers**: Introduction, General applications of optical amplification, Semiconductor optical amplifier (SOA) - Characteristics, Limitations, Basic principles and Optical gain, Erbium-doped fiber amplifier (EDFA) - Characteristics, Operating principle and Optical gain.	**8 Hours**

Cont'd. . .

Module-#	Topics	Hours
Module-5	**WDM Components & Optical Switching**: WDM concept, Couplers, Isolators, Circulators, Filters, Optical Cross-connect (OXC), Optical Add/Drop Multiplexing (OADM); **Optical Networks**: Elements of optical Networks - SONET/SDH, Optical interfaces, SONET/SDH Rings, SONET/SDH Networks, Optical Ethernet.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. G. Keiser, ***Optical Fiber Communications***, 4th *Ed.*, Tata McGraw-Hill, 2013.
T2. J. M. Senior, ***Optical Fiber Communication: Principles and practice***, 3rd *Ed.*, Prentice Hall of India, 2009.

Reference Books:

R1. G. P. Agarwal, ***Fiber-Optic Communication Systems***, 4th *Ed.*, John Wiley & Sons, 2011.
R2. R. P. Khare, ***Fiber Optics and Optoelectronics***, Oxford University Press, 2004.

Online Resources:

1. https://nptel.ac.in/courses/117104127: by Dr. P. Kumar, IIT Kanpur.
2. https://nptel.ac.in/courses/108106167: by Prof. D. Venkitesh, IIT Madras.

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe fundamentals of fiber optics, modal concepts, and wave propagation in fibers.
CO2	Analyze transmission, connection, and coupling losses in optical fibers and cables.
CO3	Analyze principles, characteristics, and performance of optical sources and detectors.
CO4	Compare performance and characteristics of various optical modulators and amplifiers.
CO5	Apply WDM components and optical network elements for designing specific applications.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).

Cont'd. . .

PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	1		1			1		2	2	1	1
CO2	3	3	3	2		1			1		2	3	1	2
CO3	3	3	3	2		1			1		2	3	1	2
CO4	3	2	3	2		1			1		2	3	1	2
CO5	3	2	3	2		1			2		3	3	2	1

Category	Code	Power System Protection	L-T-P	Credits	Marks
PEL	EE3014		3-0-0	3	100

Objectives	The objective of this course is to learn the key aspects of power system protection, identify symmetrical/unsymmetrical fault conditions, calculation of the fault current, breaking the circuit and limiting the faulted zone.
Pre-Requisites	Basic knowledge of power system transmission and distribution, characteristics of different types of lines, and real and reactive power requirements is necessary.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Faults & Fault Analysis**: Introduction, Causes and effects of faults, Zones of protection, Primary and backup protection, Desirable qualities of protective relaying, Connection of trip circuit; Symmetrical & unsymmetrical faults, LLL & LLL-G fault, Positive, Negative and zero sequence components, Fault calculation, LG Fault, LL & LLG Fault, Short circuit analysis.	**10 Hours**
Module-2	**Relaying & Protection**: Classification of relays, Relay pick up, Reset or drop out, pick-up/drop-off ratio, Construction & working principles of electromagnetic relays, Theory of induction relay torque, General equation of electromagnetic & comparator relays; Over current, Differential, and Distance protection, Carrier-aided protection of transmission lines.	**8 Hours**
Module-3	**Apparatus Protection**: Transformer Protection – Types of faults, Percentage differential protection, Inrush phenomenon, High resistance ground faults, Inter-turn and Incipient faults; Generator Protection – Various faults and abnormal operation conditions, Stator & rotor faults, Transverse differential protection, Unbalanced loading, Over speeding, Loss of excitation, Loss of prime mover; Induction Motor Protection – Various faults and abnormal operation conditions, Starting of induction motor, Protection of small & large induction motor.	**8 Hours**
Module-4	**Circuit Breaking**: Fundamentals, Circuit breaker rating, Circuit constants and circuit conditions, Re-striking voltage transients, Characteristics of re-striking Voltage, Interaction between the breaker and circuit, Current chopping, Duties of switchgear; Conventional and Modern Circuit Breakers - Types of circuit breaker – Automatic switch, Air-break, Oil circuit and Air-blast circuit, SF6, Vacuum & DC circuit breakers.	**8 Hours**
Module-5	**Static Relays**: Comparators and different relays, Amplitude comparator, Phase comparator, Coincidence type phase comparator, Basic elements of a static relay, O.C. relays, Differential protection, Static distance protection; Numerical Relays – Block diagram, Numerical over-current protection, Numerical transformer differential protection, Numerical distance protection of transmission line.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. Y. G. Parithankar and S. R. Bhide, ***Fundamentals Of Power System Protection***, 2nd *Ed.*, PHI Learning, 2010.

T2. B. Ravindranath and M. Chander, ***Power System Protection and Switchgear***, 2nd *Ed.*, New Age International, 2018.

Reference Books:

R1. A. G. Phadke and J. S. Thorp, ***Computer Relaying for Power Systems***, 2nd *Ed.*, Wiley, 2012.

R2. S. S. Rao, ***Switchgear and Protection***, 1st *Ed.*, Khanna Publishers, 2019.

Online Resources:

1. https://nptel.ac.in/courses/108101039/: by Prof. S. A. Soman, IIT Bombay

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Apply symmetrical component to analyze different types of faults in the power system.
CO2	Analyze relay types, principles, and applications for effective power system protection.
CO3	Evaluate protection needs and fault-handling methods for transformers, generators, and motors.
CO4	Explain operation, selection, and rating of various circuit breakers used in power protection.
CO5	Explore static and numerical relays with modern techniques for efficient power protection.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	3						1	3	2	
CO2	2	2	1	1	2						2	3	2	1
CO3	2	3	1	2	2						2	3	2	2
CO4	3	3	2	2	3						2	2	3	2
CO5	3	2	3	3	2						3	2	3	3

Category	Code	Advanced Control Systems	L-T-P	Credits	Marks
PEL	EE3015		3-0-0	3	100

Objectives	The objective of this course is to study the concepts of discrete-time and non-linear control systems, state-space analysis, design of compensators for control systems and determine the performance using different measures.
Pre-Requisites	Basic knowledge on mathematics, digital signal processing and control system engineering is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Digital Control System**: Sample and Hold, A/D & D/A conversion. Z-transform, Inverse Z-transform, Z-Transform method for solving difference equations, Impulse sampling and Data hold, Sampling theorem, Folding, Aliasing, Pulse transfer function, Mapping between s-plane & z-plane, Stability analysis of closed loop systems in the z-plane by use of Bilinear transformation and Routh's stability criterion, Jury stability.	**10 Hours**
Module-2	**State Space Analysis**: Concept of state and state variables, State model of linear systems, State space representation using physical, phase and canonical variables, Derivation of Transfer function model from State space Model; Diagonalization - Eigenvalues & Eigenvectors, Solution of State Equations, State Transition Matrix, Cayley-Hamilton Theorem, Controllability and Observability, Pole placement by State feedback, State observer.	**8 Hours**
Module-3	**Phase Plane Analysis**: Common Physical Non Linearities - Saturation, Friction, Backlash, Relay and Multivariable Nonlinearity; Phase Plane Method: Basic Concepts, Singular Points, Nodal Point, Saddle Point, Focus Point, Vortex Point; Stability of Non Linear Systems: Limit Cycles, Construction of Phase Trajectories by Analytical Method and Graphical Methods.	**10 Hours**
Module-4	**Describing Function Method**: Basic Concepts, Derivation of Describing Functions; Stability Analysis by Describing Function Method: Stability Analysis by Gain-phase Plots, Jump Resonance, And Introduction to Liapunov's Stability Criterion.	**6 Hours**
Module-5	**Advanced Control Design**: Realization of compensators - Lag, Lead, and Lag-Lead compensator; Tuning of PID controller, Feedback compensation, Design of robust control system; Advances in control system: Introduction to optimal control, Performance measures like ISE, ITAE; Quadratic indices, Introduction to fuzzy control.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. K. Ogata, ***Discrete-Time Control Systems***, 2nd *Ed.*, Pearson Education, 2015.
T2. I. J. Nagrath and M.Gopal, ***Control Systems Engineering***, 5th *Ed.*, New Age Intl., 2010.

Reference Books:

R1. R. T. Stefani, B. Shahian, C. J. Savant, and G. H. Hostetter, ***Design of Feedback Control Systems***, 4th *Ed.*, Oxford University Press, 2009.
R2. K. Ogata, ***Modern Control Engineering***, 5th *Ed.*, Pearson Education, 2015.
R3. R. C. Dorf and R. H. Bishop, ***Modern Control Systems***, 12th *Ed.*, Pearson Education, 2013.
R4. M. Gopal, ***Control Systems - Principles & Design***, 4th *Ed.*, Tata McGraw-Hill, 2012.
R5. N. S. Nise, ***Control Systems Engineering***, 5th *Ed.*, Wiley India, 2008.

Online Resources:

1. https://nptel.ac.in/courses/108103007: by Prof. S. Majhi, IIT Guwahati
2. https://nptel.ac.in/courses/108106024: by Prof. A. Mahindrakar, IIT Madras
3. https://nptel.ac.in/courses/108103008: by Prof. I. Kar, Prof. S. Majhi, IIT Guwahati
4. http://web.mit.edu/2.14/www/Handouts/StateSpace.pdf

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Apply Z-transform methods to model sampled data systems and evaluate their stability.
CO2	Develop & solve state-space models to assess system dynamics & state feedback control.
CO3	Analyze physical nonlinearities and apply phase plane methods for nonlinear system stability.
CO4	Apply describing functions and perform stability analysis using advanced nonlinear techniques.
CO5	Design and tune compensators and PID controllers using optimal, robust, and fuzzy control.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	1	2						1	3	1	
CO2	3	3	2	2	3						1	3	2	1
CO3	3	3	3	2	3						1	3	1	
CO4	2	3	2	3	2						1	2	1	
CO5	2	2	2	2	3						1	3	2	1

Category	Code	Introduction to VLSI Design	L-T-P	Credits	Marks
PEL	EC3042		3-0-0	3	100

Objectives	The objective of this course is to study the design, fabrication, and testing of devices, circuits, and systems using integrated micro fabrication technologies, with an in-depth understanding of modern VLSI design and technology.
Pre-Requisites	Fundamental knowledge of MOSFET, analog and digital electronics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Historical perspective, VLSI Design methodologies, VLSI designs flow, Design hierarchy, Concept of regularity, Modularity and locality, VLSI design styles. Fabrication of MOSFETs - Introduction, Fabrication process flow – Basic concepts, The CMOS n-well process, Layout design rules, Stick diagrams and layout of complex CMOS logic gates (Euler method).	**8 Hours**
Module-2	**MOS Transistor**: The Metal oxide semiconductor (MOS) structure, The MOS system under external bias, Structure and operation of MOS transistor (MOSFET), MOSFET current-voltage characteristics, MOSFET scaling and small -geometry effects, MOSFET Capacitance.	**8 Hours**
Module-3	**MOS Inverter Circuits**: Introduction, Voltage transfer characteristics, Noise margin definitions, CMOS inverter, Sizing of inverters. Static MOS gate circuits - Introduction, CMOS gate circuits, Complex CMOS gates, MUX circuits, Calculation of inverter equivalent for NAND, NOR and other complex logic circuits.	**9 Hours**
Module-4	**Switching Characteristics & Interconnect Effects**: Introduction, Switching time analysis of CMOS inverter, Interconnect resistance & capacitance estimation, Calculation of Elmore delay, Power dissipation in CMOS inverter, Power delay product, Sequential MOS logic circuits - Introduction, SR-latch, Clocked-SR latch, Clocked JK latch.	**9 Hours**
Module-5	**Transfer Gate Logic Design**: Introduction, Basic concepts of pass transistor, CMOS transmission gate logic, Pseudo NMOS logic, Dynamic logic, Basics of semiconductor memory - DRAM, SRAM cell design & operation, Memory architecture.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. -M. Kang and Y. Leblebici, ***CMOS Digital Integrated Circuits - Analysis and Design***, 3rd *Ed.*, TMH, 2002.

T2. D. A. Hodges, H. G. Jackson, and R. Saleh, ***Analysis and Design of Digital Integrated Circuits in Deep Submicron Technology***, 3rd *International Ed.*, McGraw Hill Education, 2004.

Reference Books:

R1. J. P. Rabaey, A. P. Chandrakasan, and B.Nikolić, ***Digital Integrated Circuits: A Design Perspective***, 2nd *Ed.*, Pearson Education, 2016.

R2. N. H. E. Weste, D. Harris, and A. Banerjee, ***CMOS VLSI Design - A Circuits and Systems Perspective***, 4th *Ed.*, Pearson Education, 2010.
R3. R. J. Baker, ***CMOS Circuit Design, Layout, and Simulation***, 3rd *Ed.*, John Wiley & Sons, 2010.
R4. D. A. Pucknell and K. Eshraghian, ***Basic VLSI Design***, 3rd *Ed.*, PHI Learning, 1995.

Online Resources:

1. https://nptel.ac.in/courses/117101058: by Prof. A.N. Chandorkar, IIT Bombay
2. https://nptel.ac.in/courses/108107129: by Prof. Sudeb Dasgupta, IIT Roorkee
3. https://nptel.ac.in/courses/117106149: by Prof. Madhav Rao, IIIT Bangalore

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain VLSI design flow, methodologies, and CMOS fabrication with layout design rules.
CO2	Analyze MOSFET structure, operation, I-V characteristics, scaling, and capacitance.
CO3	Design and analyze CMOS inverters and logic gates with sizing and noise margin evaluation.
CO4	Evaluate CMOS inverter delay, power, interconnect effects, and sequential logic circuits.
CO5	Design transfer gate logic and analyze DRAM, SRAM cells, and memory architectures.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	2	3	1	1	1				1	2	1	2
CO2	3	3	1	2	2						2	2	2	1
CO3	3	3	3	2	1	1					1	3	2	3
CO4	2	2	3	3	2	2						2	1	2
CO5	3	3	3	3	1						1	3	2	2

Category	Code	Mobile Communication & Networks	L-T-P	Credits	Marks
PEL	EC3026		3-0-0	3	100

Objectives	The objectives of this course is to study the concepts of communication networks, wireless communication with its challenges & developments, wireless application protocols & standards, and Bluetooth technology.
Pre-Requisites	Basic knowledge of computer networking & wireless transmission is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on examples and latest trends.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Communication Networks**: LANs, MANs, WANs, Switching techniques, Wireless ATM networks, TCP/IP protocol architecture, OSI protocol Architecture, Internetworking.	**7 Hours**
Module-2	**Wireless Communication Technology**: Propagation modes, LOS transmission, Fading in the mobile environment, Free-space attenuation, Attenuation over reflecting surfaces, Radio wave propagation, Okumura-Hata propagation path-loss model.	**8 Hours**
Module-3	**Cellular Wireless Networks**: Principles of cellular network, Overview of cellular concept, Cell capacity, Frequency reuse, Introduction to 1G to 3G cellular networks, WCDMA/UMTS, LTE, LTE-A, VoLTE, Handoff; Mobile IP and Wireless access Protocol - Mobile IP, Wireless application protocol, Internet control message protocol (ICMP).	**9 Hours**
Module-4	**Wireless LAN Technology**: Overview, Infrared LANs, Spread spectrum LANs; IEEE 802.11 Wireless LAN - IEEE 802 protocol architecture, IEEE 802.11 MAC, IEEE 802.11 physical layer, Wi-MAX standards, Bluetooth low energy (BLE), Zig-bee.	**9 Hours**
Module-5	**5G Networks**: Introduction, Policy, Use Cases and Challenges; 5G System concept - Concept overview, Massive machine-type communication, 5G frequency spectrum, 5G RAN architecture; Introduction to 5G-IoT and beyond.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. U. Dalal, ***Wireless Communication and Networks***, 1st *Ed.*, Oxford University Press, 2015.
T2. I. S. Misra, ***Wireless Communication and Networks: 3G and Beyond***, 2nd *Ed.*, McGraw-Hill, 2017.
T3. A. Osseiran, J. F. Monserrat, P. Marsch, ***5G Mobile and Wireless Communications Technology***, 1st *Ed.*, Cambridge University Press, 2016.

Reference Books:

R1. V. K. Garg, ***Wireless Communication and Networking: Essential Reading***, Morgan Kaufman, 2008.
R2. T. S. Rappaport, ***Wireless Communications***, 2nd *Ed.*, Pearson Education, 2010.
R3. D. Tse and P. Viswanath, ***Fundamentals of Wireless Communication***, Cambridge University Press, 2005.
R4. S. Z. Asif, ***5G Mobile Communications Concepts and Technologies***, —edn1, CRC Press, 2018.

Online Resources:

1. https://nptel.ac.in/courses/106106167: by Prof. D. K. Pillai, IIT Madras
2. https://nptel.ac.in/courses/108105134: by Prof. S. S. Das, IIT Kharagpur
3. https://nptel.ac.in/courses/106105183: by Prof. Ghosh and Chakraborty, IIT Kharagpur
4. https://nptel.ac.in/courses/108108098: by Prof. T. V. Prabhakar, IISc Bangalore

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain fundamentals of mobile communication networks, switching, and protocols.
CO2	Analyze radio wave propagation, fading, attenuation, path loss, and channel modeling effects.
CO3	Explain and compare wireless protocols, Mobile IP, and standards like WiMAX, BLE, Zigbee.
CO4	Describe technical features, architecture, and standards of IEEE 802.11 wireless LANs.
CO5	Analyze 5G network concepts, architecture, use cases, spectrum, and 5G-IoT applications.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	3	2		1				2	2	2	2
CO2	3	3	2	3	2		1				2	2	2	2
CO3	3	3	2	3	2		1				2	2	2	2
CO4	3	3	2	3	2		1				2	2	2	2
CO5	3	3	2	3	2		1				2	2	2	2

Category	Code	Power Quality	L-T-P	Credits	Marks
PEL	EE3016		3-0-0	3	100

Objectives	The objective of this course is to learn the power quality problems in a power system, their causes, and methods to improve the quality of electrical power.
Pre-Requisites	Basic knowledge of power electronics and power systems is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Power Quality & Voltage Sags**: Introduction, Terms and definitions, Overloading - Under voltage, Over voltage, Transients - Short duration, Long duration, Sags & swells - Voltage sag, Swell, Imbalance, Fluctuation, Frequency variations; International standards of power quality, CBEMA curve; Voltage Sags and Interruptions - Sources, Estimating voltage sag performance, Thevenin's equivalent source, Analysis & calculation of various faulted conditions, Voltages sag due to induction motor starting, Estimation of sag severity, Mitigation of voltage sags, Active series compensators, Static & fast transfer switches.	**10 Hours**
Module-2	**Overvoltages**: Sources - Capacitor switching, Lightning, Ferro-resonance, Mitigation of voltage swells - Surge arresters, Low pass filters, Power conditioners, Lightning protection – Shielding, Line arresters, Protection of transformers & cables; Computer analysis of transients, PSCAD & EMTP.	**7 Hours**
Module-3	**Harmonics & Power System Response**: Harmonic sources from commercial and industrial loads, Locating harmonic sources, Power system response characteristics - Harmonics vs. transients, Effect of harmonics – Harmonic distortion, Voltage and current distortion, Harmonic indices, Inter-harmonics resonance, Harmonic distortion evaluation - Devices for controlling harmonic distortion, Passive & active filters, IEEE and IEC standards.	**7 Hours**
Module-4	**Power Quality Monitoring**: Monitoring considerations, Monitoring and diagnostic techniques for various power quality problems, Modeling of power quality (harmonics and voltage sag) problems by mathematical simulation tools, Power line disturbance analyzer, Quality measurement equipment, Harmonic/spectrum analyzer, Flicker meters, Disturbance analyzer, Applications of expert systems for power quality monitoring.	**8 Hours**
Module-5	**DSTATCOM & UPQC**: Reactive Power Compensation, Harmonics and unbalance mitigation in distribution systems using DSTATCOM and shunt active filters, Synchronous reference frame extraction of reference currents, Current control techniques for DSTATCOM; Voltage Sag/Swell Mitigation - Dynamic voltage restorer, Working principle and control strategies; Series Active Filtering; Unified Power Quality Conditioner (UPQC) - Working principle, capabilities and control strategies.	**10 Hours**
	Total	**42 Hours**

Text Books:

T1. R. C. Dugan, M. F. McGranaghan, S. Santoso, and H. W. Beaty, ***Electrical Power Systems Quality***, 3rd *Ed.*, McGraw-Hill, 2017.
T2. J. Arrillaga, N. R. Watson, and S. Chen, ***Power Systems Quality Assessment***, 1st *Ed.*, John Wiley & Sons, 2011.
T3. C. Sankaran, ***Power Quality***, 1st *Ed.*, CRC Press, 2001.

Reference Books:

R1. G. T. Heydt, ***Electric Power Quality***, 2nd *Ed.*, West Lafayette, 1994.
R2. G. J. Wakileh, ***Power Systems Harmonics – Fundamentals, Analysis and Filter Design***, 1st *Ed.*, Springer, 2007.
R3. E. Aeha and M. Madrigal, ***Power System Harmonics: Computer Modelling and Analysis***, 1st *Ed.*, Wiley India, 2012.
R4. R. S. Vedam and M. S. Sarma, ***Power Quality: VAR Compensation in Power Systems***, 1st *Ed.*, CRC Press, 2013.

Online Resources:

1. https://nptel.ac.in/courses/108107157: by Prof. A. Bhattacharya, IIT Roorkee
2. https://nptel.ac.in/courses/108102179: by Prof. Bhim Singh, IIT Delhi

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Identify and analyze power quality issues, voltage sags, and disturbances in electrical systems.
CO2	Assess overvoltage causes and apply mitigation techniques to protect power system equipment.
CO3	Analyze effects of harmonics on power quality and control distortion in power systems.
CO4	Apply various techniques and tools for monitoring and diagnosing power quality issues.
CO5	Design DSTATCOM and UPQC systems to mitigate harmonics, voltage sags, and power issues.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).

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PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	3	3					2	2	2	1
CO2	3	3	2	2	3	3					2	2	2	1
CO3	3	3	2	2	3	3					2	2	3	2
CO4	3	3	2	2	2	3					2	3	3	2
CO5	3	2	2	2	2	3					2	3	3	2

Category	Code	High Voltage Engineering	L-T-P	Credits	Marks
PEL	EE3017		3-0-0	3	100

Objectives	The objective of the course is to learn the key concepts and recent trends in the field of high voltage engineering, high voltage testing of various insulators and determination of their dielectric strengths.
Pre-Requisites	Knowledge of physics, chemistry, material science & power systems is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Conduction & Breakdown in Gases**: Gases as insulating media, Ionization and decay processes, Townsend's first & second ionization coefficients, Secondary electron emission by photon impact; Transition from non-self-sustained discharges to breakdown, Streamer mechanism of spark, Sparking voltage, Paschen's law, Breakdown in non-uniform fields - Partial breakdown, Corona discharges; Post breakdown phenomena and applications, Practical considerations in using gases for insulation purposes.	**10 Hours**
Module-2	**Conduction & Breakdown in Dielectrics**: Liquid dielectrics – Pure liquids and commercial liquids, Conduction and breakdown in pure liquids; Solid dielectrics – Intrinsic breakdown, Electromechanical breakdown, Thermal breakdown, Breakdown of solid dielectrics in practice.	**8 Hours**
Module-3	**Generation of High Voltages**: Direct voltages, Half & full wave rectifier circuits, Voltage multiplier circuits, Van de Graff generators, Electrostatic generators, Alternating voltages, Impulse voltages, Standard lightning and switching surge, Design and construction of impulse generator circuits, Marx circuit operation.	**8 Hours**
Module-4	**Measurement of High Voltages & Currents**: Measurement of high DC and Impulse voltages, Measurement of high DC, AC and Impulse currents, Cathode ray oscillographs for impulse voltage and current measurement.	**8 Hours**
Module-5	**High Voltage Testing**: Non-destructive testing of materials and electrical apparatus – Introduction, Measurement of DC resistivity, Measurement of dielectric constant and Loss factor, Partial discharge measurements; High voltage testing of electrical apparatus – Testing of insulators and bushings, Testing of isolators and circuit breakers, Cables, Testing of transformers, Surge Diverter Radio interference measurements.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. M. S. Naidu and V. Kamaraju, ***High Voltage Engineering***, 5th *Ed.*, McGraw-Hill Education, 2017.

Reference Books:

R1. E. Kuffel. W. S Zaengel, and J. Kuffel, ***High Voltage Engineering Fundamentals***, Newnes (Elsevier), 2008.

R2. C. L. Wadhwa, ***High Voltage Engineering***, 3rd *Ed.*, New Age International, 2015.

Online Resources:

1. https://nptel.ac.in/courses/108/104/108104048/: Prof. R. Arora, IIT Kanpur

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Analyze the concepts of breakdown phenomena in gas as a dielectric.
CO2	Provide deep insight on the breakdown phenomena in solid and liquid as dielectrics.
CO3	Design and analyse various circuits for generation of high voltage and currents.
CO4	Analyze various measurement methods of high voltages and high currents.
CO5	Perform testing of high voltage circuits using various high voltage electrical apparatus.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	1	2						2	3	2	
CO2	2	2	1	1	2						2	3	2	1
CO3	3	3	2	3	2						2	3	2	2
CO4	2	2	2	2	2						2	2	3	2
CO5	2	2	3	3	2						2	3	3	3

Category	Code	Digital Image Processing	L-T-P	Credits	Marks
PEL	EC3022		3-0-0	3	100

Objectives	The objective of this course is to learn the fundamentals, transformation, filtering, restoration, compression and segmentation of images and their applications in various real life problems.
Pre-Requisites	Basics of matrices, 1-D convolution and filters, DSP, DFT & DCT are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Image Fundamentals**: Fundamental steps in digital image processing, Image sensing and acquisition, Image formation model. Image sampling and quantization, Spatial and intensity resolution, Relationship between pixels, Distance measure, Basic intensity transformation functions, Image negative, Log transformation, Power-law transformations, Piece-wise linear transformation functions, Contrast stretching, Intensity-level slicing, Bit-plane slicing, Histogram Processing, Histogram equalization.	**8 Hours**
Module-2	**Spatial & Frequency Domain Filters**: Mechanics of spatial filtering, Spatial correlation and convolution, Smoothing spatial filters, Sharpening spatial filters, Unsharp masking and high-boost filtering, Filtering in frequency domain, Image smoothing and sharpening in frequency domain using ideal, Butterworth, Gaussian, and Homomorphic filters.	**8 Hours**
Module-3	**Image Restoration**: A model of image degradation/ restoration process, Noise models, Restoration in the presence of noise, Order statistics filters, Linear position invariant degradations, Estimating the degradation function, inverse filtering; Color Image Processing: Color fundamentals, Color models, Color conversions, Pseudo-color processing, Basics of full color image processing.	**8 Hours**
Module-4	**Image Segmentation**: Point, Line and edge detection, Edge linking and boundary detection, Thresholding, Global, Adaptive and region-based segmentation; **Image Compression**: Fundamentals, Redundancy, Entropy, Some basic compression methods, Huffman coding, Arithmetic coding, LZW coding, Block transform coding, Predictive coding, Lossy predictive coding.	**9 Hours**
Module-5	**Image Feature Extraction & Classification**: Dimensional Reduction - Principal Component Analysis, Morphological Operations - Dilation, Erosion, Opening, Closing, Boundary descriptors - Fourier descriptors, Statistical moments, Recognition based on decision theoretic methods: Minimum distance Classifier.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. R. C. Gonzalez and R. E. Woods, ***Digital Image Processing***, 3rd *Ed.*, Pearson Education, 2008.
T2. A. K. Jain, ***Fundamentals of Digital Image Processing***, 2nd *Ed.*, Prentice Hall of India, 2004.

Reference Books:

R1. S. Sridhar, ***Digital Image Processing***, 2nd *Ed.*, Oxford University Press, 2014.
R2. S. Jayaraman, S. Esakkirajan, and T. Veerakumar, ***Digital Image Processing***, 2nd *Ed.*, McGraw-Hill Education, 2013.

Online Resources:

1. https://nptel.ac.in/courses/117105079: by Prof. P. K. Biswas, IIT Kharagpur
2. https://nptel.ac.in/courses/117105135: by Prof. P. K. Biswas, IIT Kharagpur
3. https://nptel.ac.in/courses/106105032: by Dr. G. Harit, IIT Kharagpur
4. https://nptel.ac.in/courses/117104069: by Prof. S. Gupta, IIT Kanpur

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe fundamental concepts of image processing, its scope and applications.
CO2	Explain 2D convolution and filtering in spatial and frequency domains.
CO3	Apply restoration techniques and process images using color models and conversions.
CO4	Segment and compress images using suitable techniques for various applications.
CO5	Extract image features, apply morphology, and perform classification techniques.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	1	2		1				1	2	2	1
CO2	3	3	2	2	2		1				1	2	2	1
CO3	2	2	1	2	2		1				2	2	2	1
CO4	2	2	1	1	2		1				1	2	2	1
CO5	1	1	2	2	2		1				2	2	2	1

Category	Code	PLC & SCADA	L-T-P	Credits	Marks
PEL	EE3023		3-0-0	3	100

Objectives	The objective of this course is to learn programming and applications of Programmable Logic Controllers (PLC), data acquisition systems, SCADA systems, and their applications in power systems.
Pre-Requisites	Knowledge of programming, electronics, power and control systems is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Programmable Logic Controllers (PLCs)**: Introduction, Block diagram, PLC operations, Comparison with relays circuit, Basic instructions, Examples, Level control application, Latch instructions, Counters, Timers, Shift registers; PLC Hardware Components - The I/O section, Discrete, Analog, and Special I/O modules, I/O specifications, The CPU, Memory design, Memory types, Programming devices, Selection of wire types and size.	**8 Hours**
Module-2	**Fundamentals of Logic**: Hardwired logic vs. programmed logic, Ladder diagram, Functional block diagram, Instruction list, Structured text, Common elements of programming languages, Variables and data types, Functions, Function blocks, Timers - ON, OFF, PULSE, Counters - increment, decrement; Introduction to Ladder logic; Programming word level logic instructions; Converting relay schematics and Boolean equation into PLC ladder programs.	**8 Hours**
Module-3	**I/O Devices & Interfacing with PLC**: Types of input devices, Switches - Push button switches, Toggle Switches, Proximity switches, Temperature switch, Pressure switch, Level switch, Flow switches, Motor starters, Transducers and sensors, Transmitters etc. Types of output devices - Electromagnetic control relays, Latching relays, Contactors, Motors, Pumps, Solenoid valves.	**9 Hours**
Module-4	**SCADA**: Need of SCADA system, Distributed control Systems (DCS), General definition and SCADA components; Hardware architecture, Software architecture, Protocol detail, Discrete and analog control; Interfacing PLC with SCADA; PLCs vs. RTUs, RTU block diagram, MTU communication interface, Future trends, Internet based SCADA display system, Components of control systems in SCADA.	**9 Hours**
Module-5	**SCADA in Power Systems**: Main task in power systems - Planning, Operation, Accounting, Tasks of National & Regional control centers, Generating station control room, AGC-SCADA, SCADA in generation, Power distribution and Power grid.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Bhanot, ***Process Control: Principles and Applications***, 1st *Ed.*, Oxford University Press, 2011.
T2. M. Mitra and S. S. Gupta, ***PLC and Industrial Application***, 2nd *Ed.*, Penram International, 2017.
T3. S. A. Boyer, ***SCADA - Supervisory Control and Data Acquisition***, Instrument Society of America, 2004.

Reference Books:

R1. F. D. Petrusella, ***Programmable Logic Controller***, 4th *Ed.*, Tata McGraw-Hill, 2017.
R2. M. S. Thomas and J. D. McDonald, ***Power System - SCADA and Smart Grids***, 1st *Ed.*, CRC Press, 2015.
R3. J. W. Webb and R. A. Reis, ***Programmable Logic Controllers: Principles and Applications***, 5th *Ed.*, PHI Learning, 2009.

Online Resources:

1. https://nptel.ac.in/courses/108105062/: by Prof. S. Sen & Prof. S. Mukhopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/108106022/: by Dr. K. S. Swarup, IIT Madras

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain PLC fundamentals, operations & hardware components including I/O modules & CPU.
CO2	Apply programming concepts and logical instructions of PLC in industrial applications.
CO3	Interface various input and output devices with PLC based on specific application needs.
CO4	Integrate SCADA with PLC with proper interfacing for creating industrial control systems.
CO5	Apply SCADA for automation & control in power generation, grid, and distribution.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	2	2	1					1	3	2	
CO2	3	2	2	3	3	1					1	3	3	2
CO3	3	1	2	2	3	2					1	3	2	2
CO4	3	2	2	2	3	2					1	3	2	1
CO5	3	3	3	3	2	2					1	2	2	1

Category	Code	Advanced Power Transmission & Distribution	L-T-P	Credits	Marks
HNS	EE3020		3-1-0	4	100

Objectives	The objective of this course is to to provide an in-depth understanding of Extra High Voltage (EHV) AC transmission systems, modern power distribution system, and the modernization of power infrastructure along with regulation governing it.
Pre-Requisites	Knowledge of electric power transmission and distribution systems is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with a strong emphasis on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**AC Transmission System**: Layout design of substation, Busbar Schemes, Components of a grid substation, Grid stability; **Voltage Control of Grid**: Power circle diagram and its use, Voltage control using synchronous condensers, Cascade connection of shunt and series compensation, Sub-synchronous resonance in series capacitor, Compensated lines, Static VAR compensating systems.	**11 Hours**
Module-2	**High Voltage Transmission**: Major Components of HV transmission systems, Types of conductor configurations, Conductor accessories/clamps etc., Up-gradation of existing transmission lines, Design consideration of UHV substations, Comparison of AIS, Hybrid-AIS and GIS, Electric and magnetic fields, Insulation coordination for UHV systems.	**12 Hours**
Module-3	**Distribution Systems**: Load Modeling & Characteristics, Coincidence, Contribution & Loss Factor - Relationship between Load & Loss Factor, Classification of Loads, Load Management, Load forecasting, Distributed generation in distribution system, Design of Roof Top Solar System, Customer Billing, Backward Sweep Method for Distribution Power Flow, Optimal Capacitor Placement to Minimize Energy Costs & System Losses.	**12 Hours**
Module-4	**Distribution System Protection**: Types of Common Faults & Procedure for Fault Calculations, Protective Devices - Principle of Operation of Fuses, Circuit Reclosures, Line Sectionalizers & Circuit Breakers, Coordination of Protective Devices, General Coordination Procedure.	**13 Hours**
Module-5	**Regulations in T&D**: The Electricity Act 2003, Implementation, Role of Regulatory Mechanisms, Power Purchase Agreements, Green Energy Open Access Rules, Electricity (Amendment) Bill, 2025.	**8 Hours**
	Total	**56 Hours**

Text Books:

T1. T. Gonen, ***Electric Power Distribution System Engineering***, 3rd *Ed.*, Taylor & Francis, 2014.
T2. S. S. Rao, ***Electrical Substation Engineering & Practice: EHV-AC, HVDC AND SF6-GIS***, 3rd *Ed.*, Khanna Publishers, 1992.

Reference Books:

R1. M. K. Khedkar and Dr. G. M. Dhole, ***Electric Power Distribution Automation***, 1st *Ed.*, Laxmi Publications, 2017.

R2. V. Kamaraju, ***Electrical Power Distribution Systems***, 1st *Ed.*, McGraw-Hill, 2009.
R3. R. D. Begamudre, ***Extra High Voltage AC Transmission Engineering***, 5th *Ed.*, New Age International, 2023.
R4. A. S. Pabla, ***Electric Power Distribution***, 4th *Ed.*, Tata McGraw-Hill, 1997.
R5. S. Bhat, ***Energy Law and Policy in India***, 2nd *Ed.*, National Law School of India, University Press, 2016.

Online Resources:

1. https://nptel.ac.in/courses/108107112: by Prof. N. P. Padhy, and Prof. G Kumbhar, IIT Roorkee
2. https://nptel.ac.in/courses/108107112: by Prof. N P Padhy, Late. Prof. G. B. Kumbhar
3. https://nptel.ac.in/courses/108108099: by Prof. S. Reddy B, IISc, Bangalore

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Analyze the mechanisms of voltage regulation and structural stability within AC power transmission systems.
CO2	Evaluate the contemporary design standards for Ultra-High Voltage (UHV) transmission networks.
CO3	Understand the frameworks of electrical distribution systems and evaluate diverse load profiles using power-flow methodologies.
CO4	Compare complex power system faults, implement coordinated protection strategies.
CO5	Interpret the legal frameworks and technical standards regulating the electrical power sector.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

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Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2				2						2		
CO2	3	3	1		1	1					1	3	1	
CO3	3	3			2	2				1	2	2		
CO4	3	3			3					1	2	3	2	2
CO5	3	2	2		2	1				1		2	1	3

Category	Code	Design & Analysis of Algorithms	L-T-P	Credits	Marks
MNR	CS2002		3-1-0	4	100

Objectives	The objectives of this course is to introduce the techniques for designing efficient algorithms, apply them to solve problems, and analyze their complexities for application in different domains of computer science.
Pre-Requisites	Knowledge of Discrete Mathematics and Data Structures is essential.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction, Definition, Characteristics of algorithm, Growth of functions, Asymptotic analysis, Standard asymptotic notations and common functions, Recurrences, Solution of recurrences by iterative, Recursion tree, Substitution and Master method; Algorithm design techniques, Divide and conquer strategy for designing algorithms, Obtaining best, average, and worst-case running time of merge sort, quick sort and randomized quick sort.	**12 Hours**
Module-2	Heaps, Building a Heap, The heap sort algorithm, Priority Queue with their analysis; Lower bound of sorting algorithms; Dynamic Programming, Elements of dynamic programming, Matrix chain multiplication, Longest Common Subsequence, String matching algorithms (Naive, Rabin-Karp, Knuth Morris-Pratt algorithm).	**10 Hours**
Module-3	Greedy algorithms, Elements of Greedy strategy, Activity selection problem, Fractional Knapsack problem along with correctness proof, Huffman codes; Backtracking and Branch & Bound techniques (n-Queen, Knapsack, and Travelling Salesman problem); Data structure for disjoint sets, Disjoint set operations, Linked list representation, Path compression, Disjoint set forest.	**12 Hours**
Module-4	Graph algorithms and their characteristics, Breadth-first and Depth-first search, Minimum spanning trees, Kruskal and Prim's algorithms, Single source shortest path algorithms(Bellman-Ford, Dijkstra), All-pair shortest path algorithm (Floyd-Warshall) with their analysis.	**10 Hours**
Module-5	Maximum flow problem, Ford-Fulkerson algorithm and its analysis; NP completeness (Polynomial time, Polynomial time verification, NP completeness and reducibility), Cook's Theorem (without proof), Examples of NP complete problems (without proof)- Circuit satisfiability, 3-CNF satisfiability, Clique, Vertex cover, Ham-cycle, TSP (without proof); Approximation algorithm characteristics, Travelling Salesman Problem, Randomized algorithms (Max 3-CNF satisfiability).	**12 Hours**
	Total	**56 Hours**

Text Books:

T1. T. H.Cormen, C.E.Leiserson, R. L. Rivest, and C. Stein, ***Introduction to Algorithms***, 4th *Ed.*, PHI Learning, 2021.

T2. E. Horowitz, S.Sahni, and S. Rajasekaran, ***Fundamentals of Computer Algorithms***, 2nd *Ed.*, University Press, 2015.

T3. J. Kleinberg and É. Tardos, ***Algorithm Design***, 1st *Ed.*, Pearson Education, 2013.

Reference Books:

R1. M. T. Goodrich and R. Tamassia, ***Algorithm Design: Foundations, Analysis, and Internet Examples***, 1st *Ed.*, John Wiley & Sons, 2001.
R2. U. Manber, ***Introduction to Algorithms: A Creative Approach***, 1st *Ed.*, Addison-Wesley, 1989.
R3. S. Sridhar, ***Design and Analysis of Algorithms***, 1st *Ed.*, Oxford University Press, 2014.
R4. G. Sharma, ***Design & Analysis of Algorithms***, 4th *Ed.*, Khanna Publishers, 2019.

Online Resources:

1. https://nptel.ac.in/courses/106106131: by Prof. M. Mukund, Chennai Mathematical Institute
2. https://nptel.ac.in/courses/106101060: by Prof. Ranade, Diwan, and Viswanathan, IIT Bombay
3. https://nptel.ac.in/courses/106105164: by Prof. S. Mukhopadhyay, IIT Kharagpur
4. https://web.stanford.edu/class/archive/cs/cs161/cs161.1138/
5. https://ocw.mit.edu/courses/6-046j-design-and-analysis-of-algorithms-spring-2015/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Design algorithms, analyze their running time for best, worst, and average-cases, and understand divide & conquer strategy considering quick sort and merge sort as examples.
CO2	Compare Heapsort with other comparison based sorting algorithms and develop dynamic programming algorithms.
CO3	Apply disjoint-set data structure and various algorithm design techniques such as greedy, backtracking, and branch-and-bound in real life problems.
CO4	Model a given engineering problem using graphs and design the corresponding algorithms to solve the problem.
CO5	Compare various pattern matching algorithms, understand NP-Completeness and the need of approximation & randomized algorithms.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).

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PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	2					2	3	3	3
CO2	3	3	2	2	3	2					2	3		
CO3	3	3	3	3	3	2					3	3		3
CO4	3	3	3	3	3	2					3	3		1
CO5	3	3	1	2	2	1					2	2		2

Category	Code	Machine Learning	L-T-P	Credits	Marks
MNR	CS3002		3-1-0	4	100

Objectives	The objective of the course is to learn the fundamental concepts behind supervised, unsupervised and reinforcement learning, assess and select appropriate model and use cross validation to tune their parameters.
Pre-Requisites	Basic knowledge of engineering mathematics, linear algebra, probability and statistics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Supervised Learning Techniques**: Overview of supervised learning, K-nearest neighbour, Multiple linear regression, Shrinkage methods (Ridge & Lasso regressions), Logistic regression, Linear Discriminant Analysis, Feature selection.	**11 Hours**
Module-2	**Model Evaluation & Performance Metrics**: Bias, Variance and model complexity, Bias-variance trade off, Bayesian approach and BIC, Cross-validation, Performance of Classification algorithms (Confusion matrix, Precision, Recall and ROC Curve).	**11 Hours**
Module-3	**Advanced Classification Techniques**: Generative model for discrete data (Bayesian concept learning and Naïve Bayes classifier), SVM for classification and regression, Reproducing Kernels, Regression and classification trees, Random Forest.	**11 Hours**
Module-4	**Clustering & Feature Extraction**: Clustering (K-means, Spectral clustering), Feature Extraction (Principal Component Analysis (PCA), kernel based PCA, Independent Component Analysis (IDA), Non-negative matrix factorization and Collaborative filtering), Mixture of Gaussians, Expectation Maximization (EM) algorithm.	**12 Hours**
Module-5	**Ensemble Approaches & Reinforcement learning**: Bootstrap methods, Boosting methods - exponential loss and AdaBoost, Numerical Optimization via Gradient boosting; Introduction to Reinforcement learning, Elements of Reinforcement learning, Single state case: K-Armed Bandit, Model-based learning (Value and Policy Iterations).	**11 Hours**
	Total	**56 Hours**

Text Books:

T1. T. Hastie, R. Tibshirani, and J. Friedman, ***The Elements of Statistical Learning - Data Mining, Inference, and Prediction***, 9th *Ed.*, Springer, 2017.

T2. S. Haykin, ***Neural Networks and Learning Machines***, 3rd *Ed.*, Pearson Education, 2009.

T3. E. Alpaydın, ***Introduction to Machine Learning***, 2nd *Ed.*, Prentice Hall of India, 2010.

Reference Books:

R1. Y. G. James, D. Witten, T. Hastie, and R. Tibshirani, ***An Introduction to Statistical Learning with Applications in R***, 2nd *Ed.*, Springer, 2013.

R2. T. M. Mitchell, ***Machine Learning***, 1st *Ed.*, McGrow-Hill Education, 2013.
R3. C. M. Bishop, ***Pattern Recognition and Machine Learning***, 1st *Ed.*, Springer, 2006.

Online Resources:

1. https://nptel.ac.in/courses/106105152/: by Prof. S. Sarkar, IIT Kharagpur
2. https://nptel.ac.in/courses/106106139/: by Dr. B. Ravindran, IIT Madras

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Apply the concepts of supervised machine learning and its functionalities.
CO2	Determine most appropriate model in a specific context using model selection techniques.
CO3	Perform classification using Bayes classifier, SVM, Decision Tree, and Random Forest.
CO4	Reduce dimensionality using feature selection and apply unsupervised machine learning for different problems and use cases.
CO5	Apply the basic concepts of boosting methods and reinforcement learning to real life problems.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	2					2	3	3	3
CO2	3	3	3	2	2	3					2	3	2	3
CO3	3	3	3	2	2	3					2	3	3	3
CO4	3	2	2	2	2	2					2	3	3	3
CO5	3	3	2	2	2	3					2	3	3	3

Category	Code	VLSI Fabrication Technology	L-T-P	Credits	Marks
MNR	EC3033		3-1-0	4	100

Objectives	The objective of this course is to learn the fabrication flow and chip integration process of semiconductor devices and semiconductor integrated circuits in VLSI.
Pre-Requisites	Basic knowledge of semiconductor devices such as NMOS, PMOS, CMOS, BJT and digital VLSI design is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Moore's Law and material processing, Defects in crystals, Eutectic phase diagram, Solid solubility, Homogeneous nucleation, Heterogeneous nucleation; Growth Processes - Crystal Growth – Necking and dislocation free CZ crystal growth, Segregation of impurities along length and diameter, Defects in CZ crystals, FZ Crystal growth; Epitaxy - Vapor phase epitaxy, LPE, MBE, CVD deposition of poly-silicon, SILOX process.	**12 Hours**
Module-2	**Diffusion**: Constant and limited source diffusion, Concentration dependent diffusion, Field assisted diffusion, Junction depth, Diffusion sources; **Ion Implantation**: Basic process, Ion implantation systems, Ion penetration and profile, Ion implantation damage.	**10 Hours**
Module-3	**Annealing Oxidation**: Purpose, Dry and wet oxidation, Deal-Grove model, Oxidation system, Properties of oxides – Masking and charges in oxides; Deposition processes - Fundamentals of vacuum systems, Vacuum evaporation of thin films, DC and RF sputtering of thin films, Interconnects, Contacts and dielectrics in IC fabrication, Deposition of silicon nitride.	**12 Hours**
Module-4	**Lithography**: Pattern generation and mask making, Optical lithography – Contact, Proximity and projection printing, Photoresists – Negative, Positive, Lift-off process, Electron beam and X-ray lithographic techniques. Etching - Wet etching, Isotropic and anisotropic etching, Plasma etching, Reactive ion beam etching.	**12 Hours**
Module-5	**IC Process Integration**: Bipolar transistor fabrication, Isolation techniques, P-MOS, N-MOS and C-MOS processes.	**10 Hours**
	Total	**56 Hours**

Text Books:

T1. S. M. Sze, ***VLSI Technology***, 2nd *Ed.*, Tata McGraw Hill, 2003.
T2. S. K. Gandhi, ***VLSI Fabrication Principles: Silicon and Gallium Arsenide***, 2nd *Ed.*, Wiley India, 1994.

Reference Books:

R1. J. Plummer, M. Deal, and P. Griffin, ***Silicon VLSI Technology: Fundamentals, Practice, and Modeling***, Prentice Hall, 2000.
R2. M. J. Madou, ***Fundamentals of Micro Fabrication: The Science of Miniaturization***, 2nd *Ed.*, CRC Press, 2002.
R3. S. Mahajan, ***Principles of Growth and Processing of Semiconductors***, McGraw-Hill Education, 1999.

R4. S. A. Campbell, ***The Science & Engineering of Microelectronics Fabrication***, 2nd *Ed.*, Oxford University Press, 2001.

Online Resources:

1. https://nptel.ac.in/courses/108101089: by Prof. A. N. Chandorkar, IIT Bombay
2. https://nptel.ac.in/courses/113106062: by Prof. P. Swaminathan, IIT Madras
3. https://nptel.ac.in/courses/103106075: by Dr. S. Ramanathan, IIT Madras
4. https://nptel.ac.in/courses/117106093: by Dr. N. Dasgupta, IIT Madras
5. https://ocw.mit.edu/courses/6-780-semiconductor-manufacturing-spring-2003/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain fundamental concepts of IC fabrication including crystal growth, epitaxy and deposition.
CO2	Describe diffusion and ion implantation techniques and their role in IC fabrication processes.
CO3	Explain annealing oxidation and various material deposition techniques used in IC fabrication.
CO4	Analyze and explain lithography techniques and various etching processes in IC fabrication.
CO5	Analyze and explain the integration of bipolar, MOS and CMOS processes in IC fabrication.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	2	1		1					1	3	1	3
CO2	2	2	2	1		1					1	3	2	3
CO3	2	2	2	1							3	3	2	3
CO4	2	3	3	3		1					3	3	2	3
CO5	2	2	3	3		1					3	3	2	3

Category	Code	Embedded Systems & Microcontrollers	L-T-P	Credits	Marks
MNR	EC3035		3-1-0	4	100

Objectives	The objective of this course is to provide a fundamental understanding of embedded systems and their design principles along with programming and interfacing with 8051 and ARM controllers to develop embedded systems.
Pre-Requisites	Knowledge of digital electronics, computer organization, and programming is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on design and programming activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Embedded Systems**: Introduction, Embedded Systems vs General-Purpose Computing Systems, History, Classification, Applications and Domain Areas, Purpose, Wearable Devices, Embedded Technologies & Lifestyle, Core Components (Microprocessors, Microcontrollers, DSPs, ASICs, FPGAs), Memory (RAM, ROM, types, testing), Sensors and Actuators, Communication Interface (Serial, Parallel, Network, Wireless), Embedded Firmware, Other System Components (Timers, Watchdog Timers, Power Supply), PCB and Passive Components.	**11 Hours**
Module-2	**Embedded Architectures & Design**: Characteristics of Embedded Systems, Quality Attributes of Embedded Systems, Application-Specific Embedded System, Domain-Specific Examples of Embedded System, Designing Embedded System with Microcontrollers, Factors to be Considered in Selecting a Controller, FPGA and other Architectures.	**10 Hours**
Module-3	**8051 Architecture & Programming**: Performance Metrics, Comparison of Microprocessors and Microcontrollers, 8051 Microcontroller - Intel MCS-51 family features, 8051 Organization and Architecture, Registers, Addressing Modes, Instruction Set, Conditional Instructions.	**12 Hours**
Module-4	**ARM Architecture & Programming**: ARM and Microcontrollers, The ARM Family, ARM Architecture and Assembly Language Programming, General Purpose Registers, ARM Memory Map, Load and Store Instructions, ARM CPSR (Current Program Status Register), ARM Data Format and Directives, ARM Assembly Programming, Assembling an ARM Program, Program Counter and Program ROM Space, ARM Addressing Modes, RISC Architecture in ARM.	**12 Hours**
Module-5	**Advanced ARM Programming**: Arithmetic & Logic Instructions, Branch, Call and Looping, Memory Access and Stack, ARM Pipeline and CPU Evolution, Other CPU Enhancements, Design Case Studies, Embedded System Trends and Careers.	**11 Hours**
	Total	**56 Hours**

Text Books:

T1. S. Chattopadhayay, ***Embedded Systems Design***, 3rd *Ed.*, PHI Learning, 2023.
T2. K. V. Shibu, ***Introduction to Embedded Systems***, 2nd *Ed.*, Tata McGraw-Hill, 2017.

T3. R. Kamal, ***Embedded Systems – Architecture, Programming and Design***, 12th *Ed.*, McGraw-Hill, 2007.
T4. M. A. Mazidi *et al.*, ***ARM Assembly Language Programming & Architecture***, 2nd *Ed.*, Microdigitaled.com, 2016.

Reference Books:

R1. D. E. Simon, ***An Embedded Software Primer***, 1st *Ed.*, Addison Wesley, 1999.
R2. J. Ganssle, ***The Art of Designing Embedded Systems***, 2nd *Ed.*, Elsevier, 2008.
R3. K. Short, ***Embedded Microprocessor System Design***, 1st *Ed.*, Prentice Hall, 1998.
R4. C. Baron, J. Geffroy, and G. Motet (Eds), ***Embedded System Applications***, Springer, 1997.
R5. D. Gajski, ***Embedded System Design: Modeling, Synthesis and Verification***, Springer, 2009.

Online Resources:

1. https://nptel.ac.in/courses/117105234: by Prof. S. Chattopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/108106176: by Prof. L. S. Jayashree , IIT Madras

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe embedded systems, their classification, core components, interfaces, and applications
CO2	Explain embedded system design principles, quality attributes, and controller/FPGA selection.
CO3	Explain microcontrollers and the 8051 architecture, instruction set, and programming concepts.
CO4	Realize ARM architecture and develop basic assembly programs using RISC principles.
CO5	Apply advanced ARM features to analyze system design and understand industry trends.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	1				2		2	3	1	2
CO2	3	2	2	1	3				2		2	3	2	2
CO3	3	3	2	2	2				2		3	2	2	1
CO4	3	2	2	3	3				2		2	3	2	2
CO5	3	3	2	2	3				3		2	3	2	1

Category	Code	E-Commerce & Supply Chain Management	L-T-P	Credits	Marks
MNR	MG3004		3-1-0	4	100

Objectives	The objective of this course is to enable students to understand e-commerce systems & supply chain operations and apply analytical, data-driven approaches for product validation, customer acquisition, and scalable e-commerce growth.
Pre-Requisites	Basic understanding of internet technologies, databases, and introductory concepts of management and operations. Familiarity with data analysis fundamentals and web-based applications will be beneficial.
Teaching Scheme	Regular classroom lectures with the use of ICT tools as and when required; sessions emphasize interactive discussions, real-world case studies, and practical application of e-commerce and supply chain concepts.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**E-Commerce Foundations & Industry Roles**: Overview of digital commerce, Traditional and emerging e-commerce roles - Hiring trends, Skill requirements, Hybrid technical–business skill development, Website traffic acquisition, Payment gateways, Loyalty management, Customer retention; E-commerce marketplaces and quick commerce models: D2C, B2B, Supply Chain Management (SCM), Business development, Unit economics, Profitability drivers, Merchandising strategies, ROAS basics, Customer feedback analysis using NPS and loyalty metrics.	**12 Hours**
Module-2	**D2C Channels & Operations**: Genesis and evolution of D2C channels, D2C manufacturing, Fulfillment, Delivery optimization, Brand loyalty and customer intimacy, Case studies of D2C brands, White space identification, product opportunity analysis, Product design aligned to brand positioning, Accelerated product development and time-to-market, Early-stage D2C growth, Scaling, ROAS optimization, Channel mix strategies.	**11 Hours**
Module-3	**Product–Market Fit (PMF) & Minimum Viable Product (MVP)**: PMF and MVP concepts, PMF discovery and optimization, MVP-based pricing to reduce cost and risk, Customer acquisition, Iterative testing frameworks, Feature prioritization, Competitive positioning, Market research for validation, Customer feedback loops, Faster time-to-market through streamlined development processes.	**10 Hours**
Module-4	**Scaling & Performance Marketing**: Scaling from zero to one; Marketplace vs. owned-website strategy; Channel mix decisions across product categories; Spend management & attribution models; ROAS optimization techniques; Commerce media and retail advertising ecosystems; Vertical and B2B marketplaces; Data-driven scaling decisions.	**11 Hours**

Cont'd. . .

Module-#	Topics	Hours
Module-5	**Customer Acquisition & Growth Management**: Early-stage customer acquisition, Organic vs Paid growth, Scaling E-commerce operations from startup to large scale, Growth scaling through operational excellence and process optimization, Quality maintenance during growth, Customer feedback management, Bottlenecks and risk mitigations, SCM and fulfilment scaling, Operational challenges, Ethical, Legal, and Sustainability aspects of E-commerce growth.	**12 Hours**
	Total	**56 Hours**

Text Books:

T1. K. C. Laudon and C. G. Traver, ***E-Commerce: Business, Technology, Society***, 17th *Ed.*, Pearson Education, 2023.
T2. M. H. Hugos, ***Essentials of Supply Chain Management***, 4th *Ed.*, Wiley India, 2018.
T3. S. Chopra and P. Meindl, ***Supply Chain Management: Strategy, Planning, and Operation***, 7th *Ed.*, Pearson Education, 2021.

Reference Books:

R1. Harvard Business Review, ***HBR's 10 Must Reads on Platforms and Ecosystems***, 1st *Ed.*, Harvard Business Review Press, 2021.
R2. J. B. Ayers and M. A. Odegaard, ***Retail Supply Chain Management***, 2nd *Ed.*, McGraw-Hill Education, 2019.
R3. M. Christopher, ***Logistics and Supply Chain Management***, 6th *Ed.*, Pearson Education, 2016.

Online Resources:

1. https://nptel.ac.in/courses/110106045: By Prof. G. Srinivasan, IIT Madras
2. https://nptel.ac.in/courses/110108056: By Prof. N. Viswanadham, IISc Bangalore
3. https://nptel.ac.in/courses/110105083: Prof. M. Jenamani, IIT Kharagpur
4. https://www.hubspot.com/resources/courses/ecommerce
5. https://www.futurelearn.com/courses/digital-transformation-e-commerce

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain e-commerce systems, business models, industry roles, and core operational metrics.
CO2	Analyze D2C channel architectures, operational workflows, and data-driven design decisions.
CO3	Apply PMF and MVP validation frameworks using analytical and feedback-based methods.
CO4	Evaluate scaling, channel selection, and performance optimization using ROAS and analytics.
CO5	Analyze customer acquisition, growth control, and supply chain scaling in e-commerce systems.

Program Outcomes Relevant to the Course:

PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).

Cont'd...

PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1		1	1	1	1	1	1	1	1	2	2	1	1	2
CO2		2	1	2	2	1	1	2	1	3	3	1	2	2
CO3		1	2	1	2	1	2	2	2	3	3	2	3	3
CO4		1	2	1	2	2	1	2	2	3	3	2	3	3
CO5		2	1	2	2	2	1	1	2	2	3	2	2	3

Category	Code	Business Statistics & Predictive Modelling	L-T-P	Credits	Marks
MNR	MG3002		3-1-0	4	100

Objectives	The aim of this course is to learn the statistical and analytical skills required to interpret business data and make data-driven decisions applying statistical models and predictive techniques.
Pre-Requisites	Knowledge of mathematics, statistics and worksheet operations, and Python programming is required.
Teaching Scheme	Regular classroom lectures, power point presentations with use of ICT as required, with examples, real-life case studies, assignments and projects.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Foundations of Business Statistics**: Descriptive statistics, data types, data visualization, central tendency and dispersion, probability distributions (normal, binomial, Poisson), sampling and sampling distributions. Use of Excel or Python (Pandas, NumPy) to compute mean, variance, skewness, and kurtosis. visualize frequency distributions.	**10 Hours**
Module-2	**Hypothesis Testing & Confidence Intervals**: Null and alternative hypotheses, Type I & II errors, one & two-tailed tests, t-test, z-test, chi-square test, ANOVA and confidence intervals for mean and proportion. Hypothesis testing on sample datasets (sales performance, A/B testing).	**9 Hours**
Module-3	**Regression Analysis**: Simple and multiple linear regression, correlation, multicollinearity, model fit (R^2, adjusted R^2), residual analysis, logistic regression for classification problems; Building regression models for revenue forecasting or demand estimation; Applying logistic regression for churn prediction using Python statsmodels and scikit-learn.	**10 Hours**
Module-4	**Time Series Forecasting**: Components of time series (trend, seasonality, irregularity), moving averages, exponential smoothing, ARIMA models and model evaluation metrics (RMSE, MAPE); Forecasting monthly sales or price trends using spreadsheets or Python (statsmodels ARIMA); Visualizing trends and residual patterns.	**9 Hours**
Module-5	**Clustering & Classification**: Unsupervised learning concepts, K-means clustering, hierarchical clustering, decision trees, random forests and model evaluation (confusion matrix, ROC curve, AUC); Customer segmentation using K-means; Credit risk classification using decision trees.	**9 Hours**
Module-6	**Predictive Analytics**: Integrating statistical and predictive models, business problem formulation, model interpretation and communication of results; Case studies - Churn prediction, inventory management, sales forecasting and credit scoring; End-to-end mini project combining regression, classification and forecasting.	**9 Hours**
	Total	**56 Hours**

P.T.O

Text Books:

T1. J. Rogel-Salazar, ***Data Science and Analytics with Python***, 1st *Ed.*, CRC Press, 2017.
T2. W. McKinney, ***Python for Data Analysis***, 3rd *Ed.*, O'Reilly Media, 2022.

Reference Books:

R1. G. James, D. Witten, T. Hastie, and R. Tibshirani, ***An Introduction to Statistical Learning with Applications in Python***, Springer, 2021.
R2. D. R. Anderson, D. J. Sweeney, T. A. Williams, *et al.*, ***Statistics for Business and Economics***, Cengage Learning, 2020.
R3. S. C. Albright and W. L. Winston, ***Business Analytics: Data Analysis and Decision Making***, Cengage Learning, 2023.

Online Resources:

1. https://nptel.ac.in/courses/111106164: by Prof. S. Das, CMI
2. https://nptel.ac.in/courses/110107129: by Prof. G. Dixit, IIT Roorkee
3. https://nptel.ac.in/courses/106107220: By Prof. A. Ramesh, IIT Roorkee
4. https://nptel.ac.in/courses/106106361: by Prof. S. K. Mathew, IIT Madras

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe and summarize business data using descriptive statistics and visual tools.
CO2	Apply hypothesis testing and confidence intervals to draw inferences from data.
CO3	Develop and interpret regression and logistic regression models for prediction.
CO4	Build and evaluate time series forecasting models for business applications.
CO5	Apply clustering and classification models to segment and predict business outcomes.
CO6	Integrate statistical and predictive methods for end-to-end business analytics solutions.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	2	2	2						2	2	1	1
CO2	3	2	3	3	2						3	3	2	2
CO3	3	3	3	3	3						3	3	3	2
CO4	3	3	3	3	3						3	3	3	3
CO5	3	3	3	3	3						3	3	3	3
CO6	3	3	3	3	3						3	3	3	3

Category	Code	Fundamentals of MPMC Lab	L-T-P	Credits	Marks
PCR	EC3039		0-0-2	1	100

Objectives	The objective of the course is to provide hands-on practice on programming of different microprocessors and microcontrollers and their interfacing with external devices.
Pre-Requisites	Basic analytical and logical understanding including knowledge and usage of digital electronics is required.
Teaching Scheme	Regular laboratory experiments to be conducted using hardware and software tools under the supervision of the teacher; the experiments shall consist of programming assignments.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Program for arithmetic operations using 8085 microprocessors.
2	Program for finding the largest and smallest from a set of numbers using 8085.
3	Program for arranging numbers in ascending and descending order using 8085.
4	Programs for 16 bit arithmetic operations using 8086.
5	Programs for Sorting and Searching of Data (using 8086).
6	Programs for String manipulation operations (using 8086).
7	Interfacing ADC & DAC.
8	Parallel Communication between two MP Kits using Mode-1 & Mode-2 of 8255 PPI..
9	Programming using arithmetic, Logical and bit manipulation instructions of 8051 microcontroller.
10	Programming and verifying timer, interrupts and UART operations in 8051 microcontroller.
11	Interfacing and programming of Stepper motor and DC motor speed control.
12	Communication between 8051 microcontroller kit and PC.
13	A design problem using 8051 (such as multi-parameter data acquisition system, voltmeter, power meter, frequency counter, traffic simulation, digital clock).

Text Books:

T1. R. S. Gaonkar, ***Microprocessor Architecture, Programming, and Applications with the 8085***, 6th *Ed.*, Penram International Publishing, 2013.
T2. D. A. Patterson and J. H. Hennessy, ***Computer Organization and Design: The Hardware/Software Interface***, 5th *Ed.*, Morgan Kaufman, 2013.

Reference Books:

R1. D. Hall, ***Microprocessors and Interfacing***, 3rd *Ed.*, McGraw Hill Education, 2017.
R2. K. J. Ayala, ***The 8051 Microcontroller***, 3rd *Ed.*, Cengage Learning, 2007.
R3. K. Kant, ***Microprocessors and Microcontrollers: Architecture, Programming and System Design 8085, 8086, 8051, 8096***, 2nd *Ed.*, Prentice Hall India, 2013.

Online Resources:

1. https://nptel.ac.in/courses/106108100: by Prof. K. Kumar, IISc Bangalore
2. https://nptel.ac.in/courses/108107029: by Prof. P. Agarwal, IIT Roorkee
3. https://nptel.ac.in/courses/108105102: by Prof. S. Chattopadhyay, IIT Kharagpur

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Develop assembly programs for arithmetic and logical operations using 8085/8086.
CO2	Implement data handling, sorting, and string operations on microprocessors.
CO3	Interface ADC, DAC, and I/O devices with microprocessors and microcontrollers.
CO4	Program 8051 microcontroller for timers, interrupts, UART, and motor control.
CO5	Design and test embedded applications using 8051 for real-time control systems.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	1	1	1							2	1	1
CO2	3	2	3	2	2						1	2	1	1
CO3	3	2	3	2	3						1	2	2	
CO4	3	2	3	3	3						1	3	1	1
CO5	3	2	2	2	2						1	2	1	1

Category	Code	Power Systems Lab	L-T-P	Credits	Marks
PCR	EE3021		0-0-2	1	100

Objectives	The objective of this course is to practically learn of the operating principles, calculation of various equipment components, line flows and utilize software analysis for power system problem-solving.
Pre-Requisites	Basic knowledge of power system transmission & distribution, characteristics of different types of lines, real and reactive power requirements is required.
Teaching Scheme	Regular laboratory experiments will be conducted under the supervision of the teacher; demonstrations and necessary safety measures will be explained during the pre-lab sessions.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Study of the Ferranti Effect and voltage profile in overhead transmission lines.
2	Determination of A, B, C & D parameters of long transmission lines.
3	Study of different types of compensation in transmission lines.
4	Determination of positive, negative & zero sequence synchronous reactance of an alternator.
5	Formation of the YBUS matrix from line data.
6 – 7	Load flow analysis using the Gauss-Seidel Method.
8	Determination of transient & sub-transient direct-axis & quadrature-axis reactance of an alternator.
9	Study of characteristics of over current and three-phase differential relays.
10	Determination of string efficiency of a chain insulator.
11	Determination of breakdown strength of transformer oil.
12	Determination of earth resistance.
13	Design of an automatic power factor correction unit with a fixed capacitor.
14	Study of the corona effect in high voltage overhead transmission lines.

Text Books:

T1. J. J. Grainger and W. D. Stevenson, ***Power System Analysis***, 1st *Ed.*, McGraw-Hill, 2017.
T2. H. Sadaat, ***Power System Analysis***, McGraw-Hill Education, 2002.

Reference Books:

R1. O. I. Elgerd, ***Electric Energy Systems Theory - An Introduction***, 2nd *Ed.*, McGraw-Hill, 2017.
R2. D. P. Kothari and I. J. Nagrath, ***Power System Analysis***, 4th *Ed.*, McGraw-Hill, 2011.

Online Resources:

1. https://nptel.ac.in/courses/108105067: by Prof. A. K. Sinha, IIT Kharagpur
2. https://nptel.ac.in/courses/108107127: by Dr. V. Pant & Dr. B. Das, IIT Roorkee

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain the characteristics of long, short and medium transmission lines.
CO2	Analyze power flow through any transmission line under steady-state conditions.
CO3	Determine the optimal utilization of resources distributed throughout the power system.
CO4	Simulate different types of frequency control mechanisms.
CO5	Analyze various components of equipment and line flows in power systems.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	1	2	1					2	3	1	
CO2	3	3	2	2	3	2					2	3	2	1
CO3	3	3	2	2	3	2					3	3	1	
CO4	2	2	1	2	2	1					2	2	1	
CO5	2	2	1	2	3	2					3	3	2	1

Category	Code	Emerging Technologies Lab	L-T-P	Credits	Marks
SEC	IP3005		0-0-4	2	100

Objectives	The objective of this course is to introduce advanced concepts and recent trends in Electrical & Electronics Engineering. The course will prepare the students to design electrical machines, power electronics converters using latest technologies and analyze power systems through modern software tools.
Pre-Requisites	Knowledge of Network Theory, Electrical Machine, Power Electronics, Power Systems Analysis, and Engineering Mathematics is required.
Teaching Scheme	Regular laboratory experiments executed by the students under supervision of the teacher. Demonstration as required shall be given for each experiment.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1 – 6	Computer aided design of electrical machines using AutoCAD/Ansys/MATLAB.
7 – 12	Design (using PSIM/MATLAB etc.), implementation and control of power electronic converters.
13 – 18	Design (using MiPower/PSCAD/MATLAB etc.), installation and integration of distributed renewable energy sources in distribution systems with IoT based monitoring and control.
19 – 23	Static and dynamic analysis of interconnected power systems using classical machine models using programming.
24 – 26	Performance analysis of DSP based electric drive systems
27 – 28	Mini Project.

Reference Books:

R1. M. A. Pai, ***Computer Techniques in Power System Analysis***, 3rd *Ed.*, McGraw-Hill, 2017.
R2. M. H. Rashid, ***Power Electronics: Devices, Circuits and Applications***, 4th *Ed.*, Pearson Education, 2017.
R3. R. K. Chauhan and K. Chauhan, ***Distributed Energy Resources in Microgrids***, 1st *Ed.*, Elsevier, 2019.
R4. D. K. Tyagi, ***Design, Installation, and Operation of Solar PV Plants***, 1st *Ed.*, Magnolia Publication, 2019.
R5. V. Rajini and V. S. Nagarajan, ***Electrical Machine Design***, 1st *Ed.*, Pearson Education, 2018.
R6. B. K. Bose, ***Modern Power Electronics and AC Drives***, 1st *Ed.*, Pearson Education, 2005.
R7. P. Kundur, ***Power System Stability and Control***, 1st *Ed.*, McGraw-Hill Education, 2006.
R8. M. V. Deshpande, ***Design and Testing of Electrical Machines***, 3rd *Ed.*, Prentice Hall India, 2009.

Online Resources:

1. https://nptel.ac.in/courses/108106023: by Prof. K. Vasudevan, IIT Madras
2. https://nptel.ac.in/courses/103103206: by Prof. V. V. Goud, IIT Guwahati
3. https://nptel.ac.in/courses/108102157: by Prof. A. Das, IIT Delhi

P.T.O

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Design electrical machines and create machine drawings using computer aided tools.
CO2	Design, develop, and implement power electronics converters.
CO3	Design and integrate renewable energy sources in distributed systems.
CO4	Analyze the static and dynamic characteristics of power systems.
CO5	Analyze the performance of electric drives through simulation.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1		1	1						1	3	1	
CO2	3	1	3	1	3						2	3	1	
CO3	3	2	3	2	1	1				1	2	3	2	
CO4	3	1	1	2	2						2	3	2	
CO5	3	3	3		1	1				1	2	2	3	

Category	Code	Technical & Research Writing	L-T-P	Credits	Marks
SEC	HS3002		0-0-2	1	100

Objectives	The objective of this course is to hone the professional writing skills of the learners, especially pertaining to technical reports, proposals and research writing.
Pre-Requisites	Knowledge of Technical Communication in English is required.
Teaching Scheme	Regular laboratory classes with tasks designed to facilitate communication through pair and/or team activities with regular assessment of writing activities.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Introduction to technical writing
2	Reports: importance, types, report language
3	Writing an informational report: parts, format
4	Writing an analytical report: parts, executive summary
5	Proposals: importance, format, writing a short proposal.
6	Writing proposal for grants: format
7	What is research? Elements of academic research writing.
8	Ethics in research.
9	Review of Literature.
10	Writing an abstract.
11	Writing a research article - I.
12	Writing a research article - II.
13	Preparing works cited list as per MLA/APA format.
14	Dealing with plagiarism: paraphrasing.

Text Books:

T1. K. Samantray, ***Academic and Research Writing***, 1st *Ed.*, Orient Black Swan, 2011.
T2. R. Chaturvedi, S. Pandey, and P. K. Pandey, ***Research Methodology & Scientific Writing***, 1st *Ed.*, Book Rivers, 2023.
T3. Modern Language Association of America, ***MLA Handbook***, 9th *Ed.*, MLA, 2021.
T4. American Psychological Association, ***Publication Manual of the American Psychological Association***, 7th *Ed.*, APA, 2019.

Reference Books:

R1. W. Zinsser, ***On Writing Well: The Classic Guide to Writing Nonfiction***, 1st *Ed.*, Harper Perennial, 2020.
R2. W. Strunk Jr., ***The Elements of Style***, 1st *Ed.*, Fingerprint Publishing, 2020.

Online Resources:

1. https://nptel.ac.in/courses/110105091: Prof. A. Malik, IIT Kharagpur
2. https://library.leeds.ac.uk/info/14011/writing/114/report-writing
3. https://www.anu.edu.au/students/academic-skills/research-writing

4. https://initiatives.iitgn.ac.in/scientificwriting/thesis-dissertation-writing/
5. https://www.babson.edu/media/babson/assets/teaching-research/writing-a-successful-proposal.pdf

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Develop analytical and informational reports with proper structure, tone and language.
CO2	Compose executive summaries, proposals and abstracts for technical or research work.
CO3	Apply citation styles, paraphrasing and ethical writing practices to avoid plagiarism.

Program Outcomes Relevant to the Course:

PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1							2	2	3		3	1	1	1
CO2							2	2	3		3	1	1	1
CO3							3	2	3		3	1	1	1

Category	Code	Applied Linear Algebra	L-T-P	Credits	Marks
OEL	MT4001		3-0-0	3	100

Objectives	The objective of this course is to learn how to handle computation with matrices, difference equation, and similarity transformation for key engineering applications.
Pre-Requisites	Knowledge of complex numbers, matrix algebra, and vector space is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Geometry of Linear Equations, Gauss Elimination, Concept of Matrices with Applications, Vector Spaces and Subspaces, Echelon Form, Solution in Matrix Method, L.I, Basis & Dimension, Four Fundamental Subspaces, Linear Transformations.	**9 Hours**
Module-2	Orthogonal Vectors and Subspaces, Cosines and Projections on to Lines, Projections and Least Squares, Orthogonal Bases and Gram-Schmidt Process.	**8 Hours**
Module-3	Introduction and Properties of Determinants, Formulas for Determinant, Applications of Determinants, Introduction to Eigen values & Eigenvectors, Diagonalization of Matrix, Difference Equations, Complex Matrices, Similarity Transformations.	**8 Hours**
Module-4	Maxima, Minima and Saddle Points, Tests for Positive Definiteness, Singular Value Decomposition, Minimum Principles.	**8 Hours**
Module-5	Introduction to Computations with Matrices, Matrix Norm and Condition Number, Computation of Eigen values, Iterative Methods.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. G. Strang, ***Linear Algebra and Its Applications***, 4th *Ed.*, Cengage Learning, 2007.

Reference Books:

R1. G. Strang, ***Introduction to Linear Algebra***, 3rd *Ed.*, Wellesley-Cambridge, 2003.

Online Resources:

1. https://nptel.ac.in/courses/108101371: by Prof. D. Mukherjee, IIT Bombay
2. https://nptel.ac.in/courses/111101115: by Prof. I. K. Rana, IIT Bombay
3. https://nptel.ac.in/courses/111106135: by Prof. P. Haridas, IIT Madras
4. https://nptel.ac.in/courses/111107106: by Prof. P.N. Agrawal, IIT Roorkee
5. https://nptel.ac.in/courses/111107164: by Prof. P. Bera, IIT Roorkee
6. https://nptel.ac.in/courses/111105165: by Prof. S. Khare, IIT Kharagpur

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Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain and apply matrix methods for solving a system of linear equations.
CO2	Describe orthogonal & projection in vector space and apply it to least square solution.
CO3	Identify and apply Eigen values and Eigen vectors to diagonalization.
CO4	Explain and apply Singular Value Decomposition and to obtain pseudo inverse of a matrix.
CO5	Develop algorithms and write programs to solve linear algebra problems on computers.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	3	3							2	1	1
CO2	3	3	3	3	3							2	1	1
CO3	3	2	1	1	2							2	1	1
CO4	3	3	2	2	2							2	1	1
CO5	3	3	2	2	3							2	1	1

Category	Code	Stochastic Processes	L-T-P	Credits	Marks
OEL	MT4002		3-0-0	3	100

Objectives	The objectives of this course is to gain mathematical maturity by equipping the students to handle computing probability in different conditions and studying the concepts of Markov chain & Queuing theory.
Pre-Requisites	Knowledge of Sets, Probability, and Linear Algebra is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Review of basics of Probability - Probability of an event, Conditional probability, Independent event and Bayes' formula, Random variables, Discrete and Continuous, Distribution functions, Joint distribution & independent random variables, Expectation, Variance and covariance, Variance of a sum, Conditional distribution & conditional expectation (discrete case), Conditional distribution & conditional expectation (continuous case), Computing expectation & variance by conditioning, Computing probabilities by conditioning.	**8 Hours**
Module-2	Stochastic Processes and Markov Chain - Introduction and definition, Chapman-Kolmogorov equations, Classification of states, Limiting probabilities, Some application problems, Mean time spent in transient state, Branching processes, Time reversible Markov chains.	**11 Hours**
Module-3	Markov decision process, Hidden Markov chain, Exponential distribution and its properties, Counting process & definition of Poisson process, Inter arrival & waiting time distribution, Further properties of Poisson process, Non-homogeneous Poisson process.	**8 Hours**
Module-4	Continuous-time Markov chain, Birth & death process, The transition probability function, Limiting probabilities, Time reversibility, Computing the transition probabilities.	**7 Hours**
Module-5	Terms & notations in Queuing Theory, Steady state probabilities, A single server exponential queuing system (M/M/1), M/M/1 system with finite capacity, An application problem, The system M/G/1, Multiserver queues.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. M. Ross, ***Introduction to Probability Models***, 10th *Ed.*, Academic Press, 2009.

Reference Books:

R1. J. Medhi, ***Stochastic Processes***, 4th *Ed.*, New Age International, 2019.

P.T.O

Online Resources:

1. https://nptel.ac.in/courses/110101141: by Prof. M. Hanawal, IIT Bombay
2. https://nptel.ac.in/courses/111105901: by Prof. S. R. Khare, Prof. A. J. Budkuley, IIT Kharagpur
3. https://nptel.ac.in/courses/111104089: by Prof. J. Dutta, IIT Kanpur
4. https://nptel.ac.in/courses/103101354: by Prof. Y. S. Mayya, IIT Bombay

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Apply probability models to real life engineering problems.
CO2	Explain Markov chain and classification of states.
CO3	Solve problems using the concepts of hidden Markov chain and Poisson process.
CO4	Apply Markov chain in problems of different field of engineering.
CO5	Apply Queuing theory in engineering and daily life situations.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	3	3							2	1	1
CO2	3	3	2	3	3							2	1	1
CO3	3	3	3	3	3							2	1	1
CO4	3	3	3	3	3							2	1	1
CO5	3	3	3	3	3							2	1	1

Category	Code	Numerical Optimization	L-T-P	Credits	Marks
OEL	MT4003		3-0-0	3	100

Objectives	The objective of this course is to learn how to handle the linear and nonlinear problems of optimization in different fields of engineering.
Pre-Requisites	Knowledge of coordinate geometry, calculus and matrix algebra is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Linear Programming: Graphical Method, Simplex Method, Methods of Artificial Variables, Alternate Optima, Redundancy & Degeneracy.	**8 Hours**
Module-2	Mathematics of Simplex Method (without proof), the Revised Simplex Method, Dual Problem, Construction of Dual, Duality Theorem (without proof), Dual Simplex Method, Post Optimal analysis.	**9 Hours**
Module-3	Integer Linear Programming: Gomory's Cutting Plane Method for All Integer & Mixed Integer Programming, Branch & Bound Method, Convex Function, Convex Programming Problem, Quadratic Programming and Wolfe's Method.	**8 Hours**
Module-4	Optimality Conditions, Lagrangian & Lagrange Multipliers, KKT Necessary/Sufficient Optimality Conditions, Duality in Non-linear Programming, Unconstrained Optimization – Line Search Methods for Uni-modal Functions, Steepest Descent Method, Newton's Method, Modified Newton's Method, Conjugate Gradient Method.	**9 Hours**
Module-5	Constrained Optimization – Frank Wolfe's Method, Rosen's Gradient Projection Method, Penalty function method, Barrier function method.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Chandra, Jayadeva, and A. Mehera, ***Numerical Optimization with Applications***, 1st *Ed.*, Narosa Publisher, 2013.

Reference Books:

R1. D. G. Luenberger and Y. Ye, ***Linear & Nonlinear Programming***, 1st *Ed.*, Springer, 2016.
R2. S. S. Rao, ***Engineering Optimization - Theory and Practice***, 4th *Ed.*, John Wiley & Sons, 2013.
R3. K. Dev, ***Optimization for Engineering Design - Algorithms and Examples***, 2nd *Ed.*, PHI, 2012.

Online Resources:

1. https://nptel.ac.in/courses/111105100: by Prof. A. Goswami and Prof. D. Chakraborty, IIT Kharagpur
2. https://nptel.ac.in/courses/112101298: by Prof. A. A. Kulkarni, IIT Bombay
3. https://nptel.ac.in/courses/111104644: by Prof. D. Thirumulanathan, IIT Kanpur
4. https://nptel.ac.in/courses/108101371: by Prof. D. Mukherjee, IIT Bombay

P.T.O

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Apply simplex method to solve linear programming problems.
CO2	Explain the concepts behind simplex method and apply it to sensitivity analysis.
CO3	Apply integer programming and convex programming methods in optimization problems.
CO4	Explain the concepts and conditions of non-linear programming problems and its application.
CO5	Solve constrained optimization problems by applying advanced optimization techniques.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	3	3					1		2	1	1
CO2	3	3	3	3	3					1	1	2	1	1
CO3	2	2	1	1	2					1		2	1	1
CO4	3	3	2	2	3					1		2	1	1
CO5	3	3	2	2	3					1		2	1	1

Category	Code	Simulation & Modelling	L-T-P	Credits	Marks
OEL	MT4004		3-0-0	3	100

Objectives	The objective of this course is to learn the basic concepts and steps of statistical simulation along with some modeling problems for engineering, scientific, business, and social science processes in the real life.
Pre-Requisites	Basic knowledge of probability and statistics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Basic concepts of Queue, M/M/1 and M/M/s queues, Queues involving non exponential distributions, Inventory models, Deterministic Continuous review model, Deterministic Periodic review model.	**8 Hours**
Module-2	Random number generation and its application to integration, Estimation of π and other problems, Generating discrete random variable - Inverse transform method, Generating geometric random variable and Bernoulli random variable, Generating Poisson and Binomial random variable, The Acceptance rejection method, The composition Approach, Programming for generation of discrete random variable.	**9 Hours**
Module-3	Generation of Continuous random variable - The Inverse transform method, The rejection Method, Generating normal random variable by different methods, Generating Poisson Process, Simulating a single server queuing system, A queuing system with two servers in series, A queuing system with two servers in parallel, An Inventory Model, An Insurance Risk model.	**10 Hours**
Module-4	Simulation of a repair model, Programming for simulation model, Reduction of variance using antithetic variables, Estimation of system reliability using antithetic variables, Application problems, Reduction of variance using control variates, Application problems, Variance by conditioning, Application problems.	**8 Hours**
Module-5	Stratified sampling, Reduction of variance using stratified sampling, Goodness of fit for discrete data, Kolmogorov-Smirnov test for continuous data, Goodness of fit test when some parameters are unspecified, Two sample problem.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. F. S. Hillier and G. J. Lieberman, ***Introduction to Operations Research***, 8th *Ed.*, McGraw-Hill, 2005.
T2. S. M. Ross, ***Simulation***, 5th *Ed.*, Academic Press, 2012.

Reference Books:

R1. A. M. Law and W. D. Kelton, ***Simulation Modeling and Analysis***, 4th *Ed.*, McGraw-Hill Higher Education, 2005.
R2. H. A. Taha, ***Operations Research***, 8th *Ed.*, Pearson Education, 2006.

Online Resources:

1. https://nptel.ac.in/courses/112107214: by Prof. P. M. Pathak, IIT Roorkee
2. https://nptel.ac.in/courses/103105215: by Prof. S. Mondal, IIT Kharagpur
3. https://nptel.ac.in/courses/103107096: by Prof. V. K. Agrawal, IIT Roorkee

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand the queue and inventory model and solve related problems.
CO2	Create discrete random variable.
CO3	Generate continuous random variable and simulate queues and inventory models.
CO4	Understand and apply the variance reduction methods in simulation.
CO5	Test the goodness of a simulation by analyzing the simulated data.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	2								2	1	1
CO2	3	3	2	2	2								2	1	1
CO3	3	3	2	2	3								2	1	1
CO4	3	3	1	2	2								2	1	1
CO5	3	3	1	1	2								2	1	1

Category	Code	Fluid Mechanics	L-T-P	Credits	Marks
OEL	ME4001		3-0-0	3	100

Objectives	The objective of this course is to study the properties and behavior of fluids including fluid statics, kinematics, dynamics, inviscid flow, flow of viscous fluids, measuring instruments and fluid motive devices.
Pre-Requisites	Basic knowledge of the material properties of solids, liquids and gases and some knowledge of calculus and differential equations are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on engineering applications.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Fluid properties – Density, Specific weight, Specific gravity, Viscosity, Vapor pressure, Compressibility; Pressure at a point, Pascal's law, Pressure variation with temperature, Density with altitude; Pressure measurement—Simple and differential manometers, Piezometer, Pressure gauges; Hydrostatic forces on submerged surfaces, Forces on horizontal and vertical plane surfaces; Buoyancy and flotation, Archimedes' principle, Stability of immersed and floating bodies, Determination of metacentric height.	**9 Hours**
Module-2	Kinematics of fluid flow, Acceleration of fluid particles, Lagrangian and Eulerian descriptions; Conservation of mass—Continuity equation, Differential equation of continuity, Continuity equation in 3D flow; Flow visualization—Streamlines, Path lines, Streak lines, Stream tubes; Classification of fluid flow—Steady and unsteady, Uniform and non-uniform, Laminar and turbulent, Rotational and irrotational, One-, two-, and three-dimensional flows; Stream function, Velocity potential function.	**8 Hours**
Module-3	Dynamics of inviscid flows, Surface and body forces, Euler's equation, Bernoulli's equation; Applications – Venturi meter, Orifice meter, Current meter, Pitot tube; Momentum balance equation, Control volume approach; Dynamics of viscous fluids, Navier–Stokes equations (explanation only), Navier–Stokes equations in Cartesian form, Applications to simple geometries, Couette and Poiseuille flows.	**9 Hours**
Module-4	Pipe flow, Friction losses, Moody's diagram, Hydraulic diameter; Water level, Velocity and discharge measurement; Notches and weirs; Impact of jet and relevant equations.	**8 Hours**
Module-5	Hydraulic turbines – Impulse turbine, Reaction and mixed flow turbines, Construction and working; Hydraulic pumps – Centrifugal pumps, Positive displacement pumps, Construction and working; Principles of dimensional analysis and similarity.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. K. Som, G. Biswas, and S. Chakraborty, ***An Introduction to Fluid Mechanics and Fluid Machines***, 3rd *Ed.*, McGraw-Hill, 2017.

T2. E. Rathakrishnan, ***Fluid Mechanics - An Introduction***, 3rd *Ed.*, Prentice Hall India, 2012.

Reference Books:

R1. R. K. Rajput, ***Fluid Mechanics and Hydraulic Machines***, 4th *Ed.*, S. Chand Publications, 2008.
R2. R. K. Bansal, ***A Textbook of Fluid Mechanics and Hydraulic Machines***, 9th *Ed.*, Laxmi Publications, 2010.

Online Resources:

1. https://nptel.ac.in/courses/105103192: by Prof. S. Dutta, IIT Guwahati
2. https://nptel.ac.in/courses/112105269: by Prof. S. Chakraborty, IIT Kharagpur

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain and apply the principles of fluid mechanics to solve problems in hydro-statics.
CO2	Describe the principles of fluid mechanics to solve problems in fluid kinematics.
CO3	Apply the concepts to fluid dynamics for the flow measuring devices.
CO4	Analyze and design free surface and pipe flows for real-world applications.
CO5	Design the working proportions of hydraulic machines.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2							1	1	1	
CO2	3	3	2	2							1		1	
CO3	3	2	2	2	1						1	1	2	1
CO4	3	2	3	2	1						1	1	1	1
CO5	3	3	3	3							1	1	2	1

Category	Code	Power Plant Engineering	L-T-P	Credits	Marks
OEL	EE4001		3-0-0	3	100

Objectives	The objective of this course is to impart a basic understanding of the different types of power plants, site selection criteria, cooling tower operations etc., and basics of hydroelectric, diesel, and nuclear power generation.
Pre-Requisites	Basic knowledge of thermodynamics, fluid mechanics, environmental sciences and engineering chemistry is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Energy sources for generation of electric power, types of power plants, their special features and applications; Steam Power Plant Cycles: Rankine cycle, modified Rankine cycles, reheat cycles, regenerative cycles.	**8 Hours**
Module-2	**Steam Power Plant**: Selection of sites, general layout of modern steam power plant, pollution control equipment, high pressure boilers, super heater and air preheater, fluidized bed boilers, fuel and ash handling equipments, water treatment plant, spray ponds and cooling towers, steam condenser type and calculation.	**9 Hours**
Module-3	**Steam Turbines and Nozzle**: Introduction to Steam Flow through Nozzles, Steam Turbines. Types of nozzles, Isentropic flow through nozzles, Effect of friction, Nozzle efficiency, Critical Pressure ratio and maximum discharge, throat and exit area. Classification of turbines: impulse and reaction turbines, types of power in steam turbine, steam turbine governing and control.	**9 Hours**
Module-4	**Hydroelectric Power Station**: Potential power with reference to rainfall and catchments area, Water storage, Equipment used in hydroelectric power stations, Characteristics of hydraulic turbines; Diesel power stations – Application of Diesel in power sector, Comparison of the factors governing the cost of hydro, steam and diesel power stations.	**8 Hours**
Module-5	**Nuclear Power Plant**: Classifications and essential component of nuclear reactors, heavy water moderator and cooled reactors, CANDU reactors, light water reactor, gas cooled reactors, liquid metal cooled reactors, disposal of nuclear waste.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. P. K. Nag, ***Power Plant Engineering***, 2nd *Ed.*, Tata McGraw-Hill, 2019.
T2. M. M. El-Wakil, ***Power Plant Technology***, 2nd *Ed.*, Tata McGraw-Hill, 2010.

Reference Books:

R1. S. Domkundwar and C. Arora, ***Power Plant Technology***, 6th *Ed.*, Dhanapat Rai & Sons, 2011.
R2. M. Verma, ***Power Plant Engineering***, 3rd *Ed.*, Metropolitan Book Company, 1976.

P.T.O

Online Resources:

1. https://nptel.ac.in/courses/112107216: by Prof. R. Kumar, IIT Roorkee
2. https://nptel.ac.in/courses/112103277: by Dr. V. Kulkarni, IIT Guwahati
3. https://nptel.ac.in/courses/127106135: Prof. T. N. C. Anand, IIT Madras
4. https://www3.nd.edu/~powers/ame.20231/notes.pdf

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe the concepts of power cycles, sources of energy, their principles and applications.
CO2	Evaluate the different criteria of power plant layout and site selection and be familiar with the working principles of the various components of power plant and their uses.
CO3	Analyze the principle of steam turbines, nozzles, and their industrial applications.
CO4	Evaluate the design layout and working of hydroelectric & diesel power plants.
CO5	Explain the principles and working of nuclear power plants.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	1						1	2	2	1
CO2	3	3	2	2	2						1	3	2	1
CO3	3	3	2	2	1						1	3	2	2
CO4	3	2	2	1	1						1	3	2	1
CO5	3	2	2	1	1						1	2	3	1

Category	Code	Project Management	L-T-P	Credits	Marks
OEL	ME4002		3-0-0	3	100

Objectives	The objective of this course is to study the fundamental tools and behavioral skills necessary to successfully launch, lead, and realize benefits, develop the skills for planning and controlling, and understanding key factors to drive successful project outcomes.
Pre-Requisites	General knowledge of any organization and its operations is sufficient.
Teaching Scheme	Regular classroom lectures with use of ICT as needed. Each session is planned to be interactive with real-life examples.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Objective of Project Management, Projects vs Operations, Stakeholders - Clients, Vendors, Regulators, Users, Types of Projects, Project Life Cycle, Project Initiation, Project Planning - Predictive vs Adaptive Planning, Project Execution, Project Closure; Analysis of a Project - Market demand analysis, Technical analysis and financial estimation, Project Success Criteria - Cost, Quality, Value Delivered.	**8 Hours**
Module-2	Commonly used techniques for Project Management, Network techniques - PERT, CPM, Crashing of a project network, Line of balance (LOB): Application area of LOB, Input of LOB, Steps of LOB, Line balancing - Rank Positional weight method; Project Resource Management - Allocation, Leveling and Smoothing methods, Rolling-wave Planning, Managing schedule uncertainty, Trade-offs between time, scope, cost, and quality, HR constraints in real world projects.	**9 Hours**
Module-3	Project Selection technique, Investment criteria (NPV, IRR, Benefit Cost Ratio), Project cash flows, Cost of capital; Risk analysis - Sources, Measures and perspectives of risk, Sensitivity analysis, Scenario analysis, Break-even analysis, Simulation analysis, Decision tree analysis; Managing risk - Project selection under risk, Technical risk vs execution risk, Managing changes during project execution, Risk registers and mitigation tracking.	**8 Hours**
Module-4	Project Financing, Capital structure, Sources of finance, internal accrual, securities, term loans, working capital, Equity and Debt, Venture capital and private equity, Cost overruns and financial risk in projects - Lifecycle costing, Economic vs financial viability, Sustainability and long term project impact.	**8 Hours**
Module-5	Social Cost Benefit Analysis (SCBA): Rationale for SCBA, UNIDO Approach, Net Benefit In terms of Economics (efficiency) Prices; Project Audit - Project failure & reasons for Audit, Phases of Project Audit; Project monitoring & control mechanisms - Performance tracking using simple dashboards, Lessons learned and post project reviews, Ethics, safety, and societal responsibility in projects, Project Management tools - Spredsheet-based dashboards, GanttProject, LibreProject.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. P. Chandra, ***Projects Planning, Analysis, Selection, Financing, Implementation and Review***, 9th *Ed.*, McGraw-Hill Education, 2019.
T2. R. Paneerselvam and P. Senthilkumar, ***Project Management***, 1st *Ed.*, PHI Learning, 2009.

Reference Books:

R1. C. Gray, E. Larson, and G. Desai, ***Project Management The Managerial Process***, 7th *Ed.*, McGraw-Hill Education, 2013.
R2. B. Punmia and K. Khandelwal, ***Project Planning and Control with PERT and CPM***, 4th *Ed.*, Laxmi Publications, 2006.

Online Resources:

1. https://nptel.ac.in/courses/110104073: by Prof. R. Sengupta, IIT Kanpur
2. https://nptel.ac.in/courses/110107081: by Prof. S. K. Gupta & Prof. M. K. Barua, IIT Roorkee
3. https://help.ganttproject.biz/uploads/default/original/1X/ae5fa52935b40a26960ee3c350dbbb311822b542.pdf
4. https://www.projectlibre.com/projectlibre-desktop/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe the fundamental project management tools and behavioral skills.
CO2	Explain the basic concept of various network techniques for project management.
CO3	Optimally utilize the resources for successful completion of a project.
CO4	Perform cost-benefit analysis of a project considering various factors involved.
CO5	Plan, monitor, control, and administer projects using computerized PMIS tools.

Program Outcomes Relevant to the Course:

PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1						1			1		1	1		1
CO2					2				1		1	1	1	1
CO3					2	1	1	1	1		2	1	1	1
CO4					2		1	1	1		2	1	2	1
CO5					3	1	1	1	1		3	1	1	1

Category	Code	Organizational Behaviour	L-T-P	Credits	Marks
OEL	HS4001		3-0-0	3	100

Objectives	The objective of this course is to learn the human interactions in an organization and develop the skills required for leadership, conflict resolution and taking rational decisions to attain business goals.
Pre-Requisites	Basic knowledge of standard operations of an established organization is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when needed. Each session is planned to be interactive with real-life examples.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Organizational Behaviour (OB)**: Definition, Importance; Learning – Nature, Learning Cycle, Components; Theories; Personality - Definition, Determinants of Personality, Personality Traits, Personality and OB.	**9 Hours**
Module-2	**Perception**: Definition, Perceptual Process, Importance of Perception in OB; Motivation -– Nature, Importance, Herzberg's Two Factor Theory, Maslow's Need Hierarchy Theory, Alderfer's ERG Theory.	**8 Hours**
Module-3	**Organizational Behaviour Process**: Communication – Importance, Types, Gateways, Barriers, Communication as a tool for improving Interpersonal Effectiveness; Groups in Organizations - Nature, Types, Group Cohesiveness, Group Decision-making, Managerial Implications, Effective Team Building; Leadership: Leadership & Management, Theories of Leadership; Conflict – Nature of Conflict and Conflict Resolution.	**9 Hours**
Module-4	**Organizational Culture**: Definition, Culture and Organizational Effectiveness; Introduction to Human Resource Management - Selection, Orientation, Training and Development, performance Appraisal.	**8 Hours**
Module-5	**Organizational Change**: Importance of Change, Planned Change and OB techniques; International Organizational Behavior – Trends in International Business, Cultural Differences and Similarities, Individual and Interpersonal Behavior in Global Perspective.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. K. Davis, ***Organisational Behaviour***, 9th *Ed.*, McGraw-Hill, 1992.
T2. K. Aswathappa, ***Organisational Behaviour***, 12th *Revised Ed.*, Himalaya Publishing House, 2016.
T3. U. Pareek and S. Khanna, ***Understanding Organizational Behaviour***, 4th *Ed.*, Oxford University Press, 2016.

Reference Books:

R1. S. P. Robbins, ***Organisational Behaviour***, 8th *Ed.*, Prentice Hall of India, 2018.
R2. K. B. L. Srivastava and A. K. Samantaray, ***Organizational Behaviour***, 1st *Ed.*, India Tech, 2009.

P.T.O

Online Resources:

1. https://nptel.ac.in/courses/110105033: by Dr. S. Mukhopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/110105120: by Prof. K. B. L. Srivastava, IIT Kharagpur
3. https://www.studocu.com/en/search/organizational-behaviour: by different universities

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe the concepts of OB and the micro approaches inside an organization.
CO2	Explain perception process and analyze motivation theories in organizational behaviour.
CO3	Evaluate communication, group behaviour, leadership approaches, and conflict resolution.
CO4	Examine organizational culture and HRM functions influencing effectiveness.
CO5	Articulate the change processes and cross-cultural behaviour in global organizations.

Program Outcomes Relevant to the Course:

PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1		1	1			1	2	3	3	2	1	1		
CO2		1	1			1	2	3	3	2	1	1	1	
CO3		1	1			1	2	3	3	2	1	1	1	1
CO4		1	1			1	2	3	3	2	1	1	1	1
CO5		1	1			1	2	3	3	2	1	1		1

Category	Code	Entrepreneurship Development	L-T-P	Credits	Marks
OEL	HS4002		3-0-0	3	100

Objectives	The objective of this course is to learn various aspects of becoming an entrepreneur by starting own business and making it successful so as to adopt entrepreneurship as a career option for graduating engineers.
Pre-Requisites	General knowledge of any business and its operations is sufficient.
Teaching Scheme	Regular classroom lectures with use of ICT as needed. Each session is planned to be interactive with real-life examples & case studies.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Concept of Entrepreneurship, Characteristics of successful entrepreneur, Growth of entrepreneurship in India. Role of Entrepreneurship in Economic Development, The Entrepreneurial Process, Entrepreneurial Motivation. Entrepreneurial Competencies. Developing Entrepreneurial Competencies.	**8 Hours**
Module-2	Ideas to Reality, creativity, innovation and Entrepreneurship, Identifying and recognizing Opportunities, Techniques for generating Ideas, Encouraging and Protecting the new ideas and selecting the right project, Ensuring your market, Market survey and Research.	**8 Hours**
Module-3	Business Plan - Meaning, Contents and significance, Formulation, Presentation to the investors, Techno-economic Feasibility Assessment - A preliminary Project Report, Details Project Report, Project Appraisal, Methods of Project Appraisal.	**9 Hours**
Module-4	Creating a successful financial plan, Basic financial statements, Ratio Analysis, Break-even Analysis; Marketing Management of SMEs, Problems of HRM – Relevant Labour – laws, Forms of Business ownership, Institutional Finance to entrepreneurs, Source of financing, Institutional support to entrepreneurs.	**9 Hours**
Module-5	The importance of Intellectual Property, Patents, Trade Mark, Copyrights, Trade secrets, Intellectual property audit, Start up Policy of Centre, State, and MSME sectors, Problems of MSME, Sickness in small scale enterprises, Govt. policies on revival of sickness and remedial measures.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. B. R. Barringer and R. D. Ireland, ***Entrepreneurship***, 2nd *Ed.*, Pearson Education, 2008.

T2. Z. Thomas and S. Norman, ***Essentials of Entrepreneurship and Small Business Management***, 5th *Ed.*, PHI Learning, 2009.

T3. S. S. Khanka, ***Entrepreneurial Development***, 4th *Ed.*, S. Chand & Co., 2010.

Reference Books:

R1. P. Chavantimath, ***Entrepreneurship Development and Small Business Enterprises***, 3rd *Ed.*, Pearson Education, 2018.

R2. P. C. Jain, ***Hand Book for New Entrepreneurs***, 4th *Ed.*, Oxford University Press, 2004.

R3. J. A. Timmons and S. Spinelli Jr., ***New Venture Creation: Entrepreneurship for the 21st Century***, 8th *Rev. Ed.*, Tata McGraw-Hill, 2009.

Online Resources:

1. https://nptel.ac.in/courses/110106141: by Prof. C. B. Rao, IIT Madras
2. https://nptel.ac.in/courses/127105007: by Prof. M. K. Mondal, IIT Kharagpur
3. https://nptel.ac.in/courses/110107094: by Prof. V. Sharma & Prof. R. Agrawal, IIT Roorkee

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe entrepreneurship concepts, roles in economic development, and competencies.
CO2	Apply creativity and opportunity recognition techniques to identify viable ventures.
CO3	Prepare and evaluate business plans using techno-economic feasibility and appraisal.
CO4	Analyze financial planning, SME marketing, HR issues, and sources of finance.
CO5	Explore intellectual property rights, startup policies, and challenges of MSMEs.

Program Outcomes Relevant to the Course:

PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1		1	2	1		2	1	1	2	3	2		2	2
CO2		2	2	1		2	2	1	2	3	2		2	3
CO3		2	2	1		2	2	1	2	3	2		2	3
CO4		2	2	1		2	2	1	2	3	2		2	2
CO5		1	1	1		2	1	1	2	3	1		3	3

Category	Code	Security Analysis, Investment & Trading	L-T-P	Credits	Marks
OEL	MG4001		3-0-0	3	100

Objectives	The objective of this course is to equip the students with the knowledge of analyzing equities, indices, commodities and other securities by the help of advanced technical analysis tools and techniques.
Pre-Requisites	Basic knowledge of mathematics and skill in spreadsheets is required.
Teaching Scheme	Regular classroom lectures with use of ICT as needed; sessions shall be interactive with problem solving activities and real-life examples with demonstration.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Capital Market**: Bonds, Equities, Currencies, Funds, etc., Players in the space – FII, DII, Prop Desk, Retail, Regulatory Bodies - SEBI, Rules and Regulations; Trading Platforms – Trading View, Chart IQ, Multiple Broker Platforms like Zerodha, Fyers, ICICI Direct, Dhan, Alice Blue; Types of Activities – Long Term, Short Term, Swing, Day Trading, Scalping, High Frequency Trading (HFT).	**8 Hours**
Module-2	**Security Analysis**: Fundamental Analysis – Qualitative and Quantitative Analysis; Technical Analysis, Dow Theory, Wycoff Theory, Candlestick Patterns – Single, Double and Tripple candles.	**7 Hours**
Module-3	**Chart Patterns**: Rounding Top & Bottom, Head & Shoulder and Inverse, Price Action Approaches - Gap Up & Down, Price Rejections, Technical Indicators – Pivot, Exponential Moving Average (EMA), Super Trend, Bollinger Band, Parabolic Stop & Reverse (PSAR), Volume Weighted Average Price (VWAP).	**10 Hours**
Module-4	**Oscillators**: Relative Strength Index (RSI), Stochastics, Moving Average Convergence / Divergence (MACD), Commodity Channel Index (CCI), Average True Range (ATR), Average Directional Index (ADX), Trading Strategy Development, Screener Development, Back Testing and Optimization.	**11 Hours**
Module-5	**Advanced Techniques**: Fibonacci Trading Approach, Fundamentals of Options, Option Chain Analysis, Algorithmic Trading and AI in FinTech, Capital Management, Best Practices and Success Factors.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. R. Chakrabarty and S. De, ***Capital Markets in India***, 1st *Ed.*, SAGE Response, 2010.
T2. B. Graham and D. Dodd, ***Security Analysis***, 6th *Ed.*, McGraw-Hill Education, 2008.
T3. M. J. Pring, ***Technical Analysis Explained: The Successful Investor's Guide to Spotting Investment Trends and Turning Points***, 5th *Ed.*, McGraw-Hill Education, 2014.

Reference Books:

R1. J. J. Murphy, ***Technical Analysis of Financial Markets***, New York Institute of Finance, 1999.
R2. B. Graham, ***The Intelligent Investor: The Definitive Book on Value Investing***, 1st *Revised Ed.*, Harper Brothers, 2003.

R3. C. Boroden, ***Fibonacci Trading: How to Master the Time and Price Advantage***, 1st *Ed.*, McGraw-Hill Education, 2008.
R4. A. Damodaran, ***Damodaran on Valuation: Security Analysis for Investment and Corporate Finance***, 2nd *Ed.*, Willey Finance, 2006.

Online Resources:

1. https://in.tradingview.com/
2. https://www.investing.com/
3. https://chartink.com/
4. https://www.valueresearchonline.com/
5. https://www.screener.in/
6. https://www.investopedia.com/terms/t/technicalanalysis.asp
7. https://zerodha.com/varsity/
8. https://www.moneycontrol.com/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain the capital market structure and describe the rules and regulations.
CO2	Utilize fundamental analysis tools to screen securities for investment and trading.
CO3	Apply technical analysis tools to identify and evaluate investment and trading opportunities.
CO4	Combine different technical analysis tools and techniques to identify high probability trades.
CO5	Apply technical analysis to create screeners& strategies and back tests for optimization.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.

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PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1		2		1				1	1	2	1	1	1
CO2			1					1			2	1	1	1
CO3		1		1		1	1	1			2	2	2	2
CO4	1		1		1					2	2	2	3	2
CO5			1		1		1	1	2	1	2	2	3	2

Category	Code	Circular Economy	L-T-P	Credits	Marks
OEL	MG4002		3-0-0	3	100

Objectives	The objective of this course is to provide students with an understanding of circular economy principles, sustainable development and innovative business models, while developing skills in environmental impact assessment, waste reduction and implementation of circular economy strategies within legal and policy frameworks.
Pre-Requisites	Basic understanding of economics, environmental science, and sustainability principles. Familiarity with business or management concepts is helpful for grasping circular business models.
Teaching Scheme	Regular classroom lectures with use of ICT as needed. Each session is planned to be interactive with focus on real-world problem solving.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Environmental Economics**: Institutional Framework for a Circular Economy; Linear Economy and its emergence & disadvantages, Replacing with Circular Economy, Development of Concept, Sustainable Development - Concepts, Theories and Principles of Sustainable Development; Sustainable Development and Waste Management, Global context and relevance for sustainable development goals (SDGs).	**9 Hours**
Module-2	**Circular Economy**: Environmental and social benefits of CE, The 3R, 6R, and 9R frameworks; Public Good; Economic instruments for solving environmental problems, Externalities – Public goods, Market failure, Property rights, Material recovery, Waste reduction, Reducing negative externalities, Explaining Butterfly diagram, Concept of loops, Solid Waste & wasterwater management.	**9 Hours**
Module-3	**Circular Design & Innovation**: Zero waste – Waste Management in context of CE, Circular design, Research and innovation, Life cycle assessment, Measuring environmental performance, Circular business models, Product-as-a-Service (PaaS), Sharing economy & collaborative consumption, Reverse logistics and industrial symbiosis, Design for durability, Disassembly and remanufacturing, Role of innovation, Digitalization and Industry 4.0.	**8 Hours**
Module-4	**Environmental Impact Assessment & Green Startup**: Natural Systems, Green Startup Ecosystems and Opportunities on Global and National Level; Green Business models, Environmental Impact Assessment; Environment Impact Assessment Valuation Techniques – Stated Preference approaches, Surrogate Market approaches, Conventional market approach, Household production Function approach.	**8 Hours**
Module-5	**Environment Policy of India**: Objectives & implementation, Role of Governments & networks, Sharing best practices, Universal CE policy goals, India's CE strategy, ESG, Environmental legislation related to CE, Implementation of CE on macro level.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. G. Bhalla, ***Circular Economy: (Re)Emerging Movement***, 1st *Ed.*, Invincible Publishers, 2020.
T2. K. Webster, ***The Circular Economy: The Future of Sustainable Development***, 2nd *Ed.*, Ellen McArthur Foundation, 2017.
T3. A. M. Hussan, ***Principles of Environmental Economics and Sustainability***, 3rd *Ed.*, Routledge Publication, 2018.

Reference Books:

R1. A. Kumar, ***The Circular Economy: The Future of Sustainable Development***, 1st *Ed.*, AG Publishing House, 2025.
R2. S. K. Ghosh, ***Circular Economy: Recent Trends in Global Perspective***, 1st *Ed.*, Springer Nature, 2021.
R3. S. S. Shukla, M. Jain, and A. Jain, ***The Circular Economy: Changing the Future of India***, —edn1, IGI Global, 2024.
R4. N. Hanley, J. F. Shogren, and B. White, ***Environmental Economics in Theory and Practice***, 1st *Ed.*, Macmillan Press,1997.

Online Resources:

1. https://nptel.ac.in/courses/109107171: by Prof. D. Nayak and S. P. Singh, IIT Roorkee
2. https://nptel.ac.in/courses/105105184: by Prof. B. K. Dubey, IIT Khragpur

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain environmental & circular economy concepts and their relevance to sustainability.
CO2	Analyze CE principles & economic tools to assess waste reduction and resource recovery.
CO3	Apply circular design, innovation and digitalization to build sustainable models.
CO4	Evaluate impacts using EIA techniques and explore green startup models and opportunities.
CO5	Examine legal & policy frameworks for CE in India to promote sustainable growth.

Program Outcomes Relevant to the Course:

PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

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Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1			3			3	1	1		2	3		1	2
CO2			3			3	1	1		3	3		1	3
CO3			2			3	2	1		3	2		1	2
CO4			2			2	2	1		3	3		1	3
CO5			1			3	3	3		3	2		2	2

Category	Code	Electric & Hybrid Vehicles	L-T-P	Credits	Marks
HNS	EE4002		3-0-1	4	100

Objectives	The objective of this course is to learn the concepts of electric and hybrid electric vehicles including their architecture and standards, different motor drives, design aspects, charging and energy storage systems.
Pre-Requisites	Knowledge of power electronics and electric drives is required. Familiarity with programming using Python, C, or MATLAB, and basic understanding of data structures and algorithms will be beneficial.
Teaching Scheme	Regular classroom lectures with ICT support and interactive sessions on programming and embedded design. Hands-on problem solving, simulations, and case studies to build practical understanding of EVs, autonomy, connectivity, and AI-based mobility using software tools and real-world examples.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Electric & Hybrid Vehicles**: EV configurations, Performance, Traction motor characteristics, Tractive effort and transmission requirements, Vehicle performance, Tractive effort in normal driving, Energy consumption; Hybrid electric drive concepts and architectures – Series and parallel; EV standards; Performance analysis of a BEV using simulation tools.	**7 Hours**
Module-2	**Energy Storage for EV & HEV**: Energy storage requirements; Battery-based storage and analysis; Fuel cell principles, Types, PEMFC operation and modeling; Supercapacitors; Flywheel storage and analysis; Hybridization of energy storage devices; Performance analysis of EV/HEV energy storage systems using simulation tools.	**14 Hours**
Module-3	**Electric Propulsion & Braking**: EV consideration, DC motor drives and speed control, Induction & permanent magnet motor drives, Switch reluctance motor drive for electric vehicles configuration and control of drives, Vehicle performance, Operating fuel economy, Brake performance. Drive cycle simulation for electric vehicle propulsion and regenerative braking.	**9 Hours**
Module-4	**Design of EVs & HEVs**: Series hybrid drive design – Operating patterns, Control strategies, Sizing of major components, Traction motor and engine/generator power rating, PPS design; Parallel hybrid drive design – CControl strategies, Engine power capacity, Electric motor drive capacity, Transmission design, Energy storage design; Hybrid powertrain design and component sizing using simulation tools.	**14 Hours**
Module-5	**Power Electronic Converters for Battery Charging**: Battery charging methods and termination techniques; Grid charging; Z-converter and its design for battery charging; Isolated bidirectional DC-DC converters; High-frequency transformer-based isolated and transformer-less charger topologies; EV charging stations and their types; Modeling of power electronic converters for EV battery charging using simulation tools.	**9 Hours**
	Total	**56 Hours**

Text Books:

T1. M. Ehsani, Y. Gao, S. Gay, and A. Emadi, ***Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design***, 3rd *Ed.*, CRC Press, 2017.
T2. I. Husain, ***Electric and Hybrid Vehicles: Design Fundamentals***, 2nd *Ed.*, CRC Press, 2011.
T3. C. Mi, M. A. Masrur, and D. W. Gao, ***Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives***, 2nd *Ed.*, Wiley Publication, 2017.

Reference Books:

R1. S. S. Williamson, ***Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles***, 1st *Ed.*, Springer 2013.
R2. C. C. Chan and K. T. Chau, ***Modern Electric Vehicle Technology***, 1st *Ed.*, Oxford University Press, 2001.
R3. J. Larminie and J. Lowry, ***Electric Vehicle Technology Explained***, 2nd *Ed.*, Wiley India, 2012.

Online Resources:

1. https://nptel.ac.in/courses/108102121: by Prof. A. Jain, IIT Delhi
2. https://nptel.ac.in/courses/108106182: by Prof. A. Jhunjhunwala, et. al, IIT Madras
3. https://nptel.ac.in/courses/108103009: by Prof. S. Majhi and Dr. P. Kumar, IIT Guwahati

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand the concept of emerging technologies and the working mechanism of EVs.
CO2	Analyze components of electric and hybrid vehicle architectures and evaluate standards.
CO3	Analyze propulsion and braking systems, compare motor drives, and evaluate performance.
CO4	Explore the concepts and methods of battery charging and charging stations.
CO5	Illustrate the operation of power electronic converters in electric and hybrid vehicles.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).

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PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	2	2	1	1				1	2	1	
CO2	2	2	2	3	2	1	2				1	1	2	1
CO3	3	2	2	1	2	3	1				2	2	3	
CO4	3	2	2	2	3	2	1				1	1	3	1
CO5	3	2	3	2	2	1	1				2	1	2	2

Category	Code	Relational Database Systems	L-T-P	Credits	Marks
MNR	CS4023		3-0-1	4	100

Objectives	The objective of this course is to learn and implement the key concepts of relational databases including data models, structured query language, database design, transaction processing, concurrency control, storage and indexing.
Pre-Requisites	Knowledge of data structures and programming concepts is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required; sessions are planned to be interactive with focus on problem solving and hands-on practice activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction, Basic database concepts, Three-schema architecture, Types of data models, Database user types, E-R models, Different types of Constraints, Demonstration of E-R diagrams, Extended E-R models, Mapping of E-R model to relational schema, DBMS architecture.	**10 Hours**
Module-2	Relational Algebra and operations, Join operations, Relational Calculus; Structured Query Language (SQL) - Implementation of SQL queries for DDL, DML, DQL operations, Grouping & Aggregation, Hands-on of Grouping & Aggregation, Execution of Joins and views in SQL.	**14 Hours**
Module-3	Functional dependencies, Armstrong axioms, Attribute closure; Types of Normalization (1NF, 2NF, 3NF, BCNF, 4NF, and 5NF), Testing for lossless design, Dependency Preserving Decomposition, Case study implementation for Normalization.	**10 Hours**
Module-4	Storage Architecture, File & Record Organization; Types of Indexes - Implementation of indexing techniques, B tree & B+ tree; Evaluation of Relational Algebra expressions, Query Optimization.	**11 Hours**
Module-5	Overview of Transaction Processing, ACID properties, Serializability, Concurrency Control Schemes (Lock-based and Timestamp-based), Deadlock handling and prevention; Database recovery techniques (log-based recovery and checkpoint, shadow paging), Implement Commit & Rollback operations.	**11 Hours**
	Total	**56 Hours**

Text Books:

T1. A. Silberschatz, H. F. Korth, and S. Sudarshan, ***Database System Concepts***, 6th *Ed.*, McGraw-Hill Education, 2013.
T2. R. Elmasri and S. B. Navathe, ***Fundamentals of Database Systems***, 7th *Ed.*, Pearson Education, 2016.
T3. T. Nield, ***Getting Started with SQL: A Hands-On Approach for Beginners***, 1st *Ed.*, Shroff/O'Reilly, 2016.

Reference Books:

R1. R. Ramakrishnan and J. Gekhre, ***Database Management Systems***, 3rd *Ed.*, McGraw-Hill, 2003.
R2. R. P. Mahapatra and G. Verma, ***Database Management Systems***, 1st *Ed.*, Khanna Publishing, 2013.
R3. R. O. Obe and L. S. Hsu, ***PostgreSQL: Up and Running: A Practical Guide to the Advanced Open Source Database***, 3rd *Ed.*, O'Reilly Media, 2017.

Online Resources:

1. https://nptel.ac.in/courses/106104135: by Dr. A. Bhattacharya, IIT Kanpur
2. https://nptel.ac.in/courses/106105175: by Prof. P. P. Das et. al., IIT Kharagpur
3. https://nptel.ac.in/courses/106106095: by Prof. P. S. Kumar, IIT Madras
4. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-830-database-systems-fall-2010/lecture-notes/
5. https://www.postgresql.org/files/documentation/pdf/18/postgresql-18-A4.pdf

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain the fundamentals of DBMS and design E-R diagrams for real-world scenarios.
CO2	Construct different types of queries using relational algebra, relational calculus, and SQL.
CO3	Design relational databases and apply appropriate normalization techniques.
CO4	Analyze storage structures, implement indexing, and optimize query performance.
CO5	Realize concurrency control and recovery mechanisms in relational database systems.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	1						2	3	1	2
CO2	3	3	1		2						3	1	2	2
CO3	3	2	3	1							3	2	3	3
CO4	3	1		2	2						3	2	3	3
CO5	3	2	1	2	2						3	2	2	3

Category	Code	Internet Technology & Applications	L-T-P	Credits	Marks
MNR	CS4024		3-0-1	4	100

Objectives	This course aims to provide conceptual understanding and hands-on exposure to Internet architecture, web protocols, web development technologies, data interchange standards, and web service communication.
Pre-Requisites	Prior experience with programming languages is required.
Teaching Scheme	Regular class room lectures with use of ICT as required; sessions are planned to be interactive with focus on programming and implementation activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**The Internet & Web**; History, Evolution, and Architecture of Internet; IPv4 & IPv6, DNS, Structure of URL; TCP/IP protocol suite; HTTP & HTTPS traffic inspection; HTTP Request/Response model, Headers, Methods, and Status codes; Web hosting, Web security – SSL/TLS, Digital Certificate.	**6 Hours**
Module-2	**HTML**; Document structure and tags; Text formatting, HTML entities, Fonts, Colors; Lists and nested lists; Hyperlinks and Bookmarks; Tables, Merging of cells, Nested tables; Forms and form elements; Layout using div and span; HTML 5 Semantic Elements – header, nav, section, article, footer, aside; Multimedia – audio, video, canvas, iframe; Form validation and global attributes; Accessibility – alt, labels, ARIA roles; SEO – meta & viewport tag.	**10 Hours**
Module-3	**CSS**: Syntax, Selectors, Inline, Internal & External CSS; Style properties – Fonts, Colors, Alignment, Backgrounds; CSS Box Model – Margin, Padding, Border, Content; Display & visibility; Positioning – Static, Relative, Absolute, Fixed, Sticky; Float and Clear; Responsive layouts using flexbox and grid; Styling tables and forms; Responsive web design using media queries.	**10 Hours**
Module-4	**JavaScript**: Variables, Data types, Operators, Expressions; Conditional and looping Constructs; Functions and scope; Arrays and objects using string and array Methods; DOM access and manipulation; Event handling for interactive UI; Client-side form validation; Dynamic effects using DHTML; ES6 features.	**10 Hours**
Module-5	**Backend & Data Storage**: Web application architecture; Web server functionality and request routing; Static vs dynamic content; Server response flow; Session management and cookies; Authentication and authorization; Data persistence using databases; CRUD operations; ACID vs BASE tradeoffs; Cloud storage and database hosting; API–based data access.	**10 Hours**
Module-6	**Web Services**: Interoperability & data exchange; XML – Syntax, Elements, Attributes, Namespaces; XML validation using DTD and XSD; JSON – Syntax, Key–Value Pairs, Arrays; XML vs JSON; SOAP Architecture – Envelope, Header, Body; WSDL; REST Architecture - Principles and Statelessness; HTTP Methods mapping to CRUD operations; RESTful URI Design; API Authentication – API Keys, Tokens, OAuth; API Testing Tools.	**10 Hours**
	Total	**56 Hours**

Text Books:

T1. J. Dean, ***Web Programming with HTML5, CSS, and JavaScript***, 1st *Ed.*, Jones & Bartlett, 2018.
T2. T. A. Powell and F. Schneider, ***JavaScript: The Complete Reference***, 3rd *Ed.*, McGraw-Hill, 2012.
T3. M. Kleppmann, ***Designing Data-Intensive Applications***, 2nd *Ed.*, O'Reilly Media, 2017.

Reference Books:

R1. P. J. Deitel, A. Deitel, and H. M. Deitel, ***Internet and World Wide Web: How to Program***, 5th *Ed.*, Pearson Education, 2018.
R2. B. Frain, T. Firdaus, and B. LaGrone, ***HTML5 and CSS3: Building Responsive Websites***, 1st *Ed.*, Packt Publishing, 2016.
R3. D. Goodman, ***JavaScript & DHTML Cookbook: Solutions & Examples for Web Programmers***, 1st *Ed.*, O'Reilly Media, 2007.
R4. G. Alonso et al., ***Web Services: Concepts, Architectures and Applications***, 1st *Ed.*, Springer, 2004.

Online Resources:

1. https://nptel.ac.in/courses/106105084: by Prof. I. Sengupta, IIT Kharagpur
2. https://developer.mozilla.org/en-US/docs/Web
3. https://developer.mozilla.org/en-US/docs/Web/API/Document_Object_Model
4. https://www.restapitutorial.com/
5. https://www.tutorialspoint.com/soap/index.htm

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain Internet architecture, TCP/IP protocols, and HTTP/HTTPS communication.
CO2	Design web pages using HTML structure, forms, multimedia, accessibility, and SEO.
CO3	Apply CSS styling, layout techniques, and responsive design using Flexbox and Grid.
CO4	Develop interactive web pages using JavaScript, DOM manipulation, events, and ES6.
CO5	Implement backend logic with sessions, authentication, and database persistence.
CO6	Design and test web services using XML/JSON, SOAP, REST, and API authentication.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1		3	1					1	3		1
CO2	1	1	1		2	1					2	3	3	2
CO3	1	1	1		2	1					2	3	2	2
CO4	2	2	1		3	1					2	3	3	2
CO5	2	2	2		3	2					3	3	3	3
CO6	2	2	1		3	1					2	3	2	2

Category	Code	Human Language Processing	L-T-P	Credits	Marks
MNR	CS4025		3-1-0	4	100

Objectives	The objective of this course is to learn fundamentals, algorithms and techniques of Human Language Processing (HLP) to enable processing of natural languages by computers in order to design human-computer interactive systems.
Pre-Requisites	Knowledge on grammar rules, statistics, regular expressions, and automata theory is required.
Teaching Scheme	Regular class room lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction, Applications, Phases of HLP, Issues and Processing complexities, Language modeling, Grammar-based and Statistical language models, n-gram model, Smoothing techniques.	**10 Hours**
Module-2	Word level analysis and Regular expressions, Finite state automata, Finite state transducers, Text pre-processing, Tokenization, Normalization, Stop word removal, Stemming, Lemmatization, Part-of-speech tagging, Named-entity recognition, Spelling error detection and correction.	**10 Hours**
Module-3	Syntactic analysis, Top-down & bottom-up parsings, Earley, CYK and Probabilistic parsing, Semantic analysis, Meaning representation languages, Dependency parsing, Word sense disambiguation, Discourse and pragmatic analysis.	**12 Hours**
Module-4	Word representations - BoW, TF-IDF, Word embeddings - Word2Vec (CBoW, Skip-gram); Word senses and Contextual embeddings, Word similarity measures, ML for HLP, Sentiment analysis, Evaluation metrics, Introduction to LLM.	**12 Hours**
Module-5	Machine translation, Information retrieval & extraction, Text summarization, Question answering system, Natural language generation, Chatbots and Dialogue systems, Advanced applications of HLP.	**12 Hours**
	Total	**56 Hours**

Text Books:

T1. D. Jurafsky and J. H. Martin, ***Speech and Language Processing - An introduction to Language Processing, Computational Linguistics, and Speech Recognition***, 2nd *Ed.*, Pearson Education, 2013.
T2. T. Siddiqui and U. S. Tiwary, ***Natural language Processing and Information Retrieval***, 1st *Ed.*, Oxford University Press, 2008.

Reference Books:

R1. J. Allen, ***Natural Language Understanding***, 2nd *Ed.*, Pearson Education, 2008.
R2. C. D. Manning and H. Schütze, ***Foundations of Statistical Natural Language Processing***, 2nd *Ed.*, MIT Press, 2000.

P.T.O

Online Resources:

1. https://nptel.ac.in/courses/106101007/: by Prof. P. Bhattacharyya, IIT Bombay
2. https://nptel.ac.in/courses/106105158/: by Prof. P. Goyal, IIT Kharagpur
3. https://nlp.stanford.edu/fsnlp/
4. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-863j-natural-language-and-the-computer-representation-of-knowledge-spring-2003/lecture-notes/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain the fundamental concepts and language models for human language processing.
CO2	Apply word-level analysis techniques to prepare raw text for analysis.
CO3	Perform syntactic, semantic and discourse level analysis of natural language text.
CO4	Design various statistical and machine learning models for HLP tasks.
CO5	Implement applications of HLP in human-computer interactive systems.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	2					2	3	2	2
CO2	3	3	3	3	3	3					3	3	3	3
CO3	3	3	3	3	3	2					3	3	2	2
CO4	3	3	3	3	3	3					3	3	3	3
CO5	3	3	3	3	3	3					3	3	3	3

Category	Code	Advanced Machine Learning	L-T-P	Credits	Marks
MNR	CS4026		3-0-1	4	100

Objectives	The objective of the course is to learn the concepts behind regularization of parameters, deep neural networks, probabilistic graphical models, dimensionality reduction etc., and their use to solve related machine learning problems in real world applications.
Pre-Requisites	Knowledge of mathematics and basics of machine learning is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving and hands-on activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Regularization for Deep Learning - Parameter Norm Penalties, Norm Penalties as Constrained Optimization, Dataset Augmentation, Noise Robustness, Early Stopping, Parameter Tying and Parameter Sharing, Sparse Representations, Bagging and Other Ensemble Methods, Dropout; Optimization for Training Deep Models - Challenges in Neural Network Optimization, Basic Algorithms, Parameter Initiali-zation Strategies, Algorithms with Adaptive Learning Rates and implementations.	**12 Hours**
Module-2	Convolutional Networks - The Convolution Operation, Motivation, Pooling, Implementation of a CNN architecture, Variants of Basic Convolution Function, Efficient Convolution Algorithms, Transposed Convolution and Implementation, Random or Unsupervised Features; Deep Convolutional Models - LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet.	**12 Hours**
Module-3	Sequence Modeling - Recurrent Nets - Unfolding Computational Graphs, Recurrent Neural Networks (RNN) and Implementation, Bidirectional RNNs, Encoder-Decoder Sequence-to-Sequence Architecture, Deep Recurrent Networks, Challenges of Long-Term Dependencies, Long Short-Term Memory and Implantation, Other Gated RNNs, Applications.	**11 Hours**
Module-4	Graphical Models - Directed Graphical Models (Bayesian Networks), Hidden Markov Models and Markov Random Fields; Expectation Maximization algorithm and Gaussian Mixture Model.	**11 Hours**
Module-5	Review of SVM - Multiclass SVM, Multiple Kernels, Kernels for Texts, Strings, and Graphs and their applications; Dimensionality Reduction - Orthogonal Feature Selection, LLE, Auto Encoder and Implementation, Matrix Factorization and Applications (Image Processing and Collaborative Filtering).	**10 Hours**
	Total	**56 Hours**

Text Books:

T1. I. Goodfellow, Y. Bengio, and A. Courville, ***Deep Learning***, MIT Press, 2016.
T2. C. C. Aggarwal, ***Neural Networks and Deep Learning: A Textbook***, 2nd *Ed.*, Springer, 2023.
T3. K. P. Murphy, ***Probabilistic Machine Learning: Advanced Topics***, The MIT Press, 2023.

Reference Books:

R1. D. Koller and N. Friedman, ***Probabilistic Graphical Models: Principles and Techniques***, 1st *Ed.*, MIT Press, 2009.
R2. A. Geron, ***Hands-on Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems***, 2nd *Ed.*, O'Reilly Media, 2019.
R3. D. Barber, ***Bayesian Reasoning and Machine Learning***, 1st *Ed.*, Cambridge University Press, 2012.
R4. M. A. Nielsen, ***Neural Networks and Deep Learning***, 1st *Ed.*, Determination Press, 2015.

Online Resources:

1. https://nptel.ac.in/courses/106106184: by Prof. S. Iyengar, IIT Roper
2. https://nptel.ac.in/courses/108103192: by Prof. M. K. Bhuyan, IIT Guwahati

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Analyze regularization techniques and deep network optimization to improve generalization.
CO2	Apply convolutional neural network design principles for image-based learning tasks.
CO3	Evaluate sequence modeling architectures, including RNNs, LSTMs, and encoder–decoder.
CO4	Explain graphical models and EM algorithm for probabilistic learning.
CO5	Compare SVM variants, kernel functions, and dimensionality reduction for ML applications.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	3	1	1					3	3	2	1
CO2	3	2	3	2	2	1					3	3	3	2
CO3	3	3	2	3	1	1				1	3	3	3	2
CO4	3	3	1	2		2				1	2	3	3	3
CO5	3	3	2	2	2	3				1	3	3	3	3

Category	Code	VLSI Chip Design & Verification	L-T-P	Credits	Marks
MNR	EC4001		4-0-0	4	100

Objectives	The objective of this course is to study the Verilog HDL techniques for the design and analysis of digital circuits and systems.
Pre-Requisites	Fundamental knowledge on digital electronic circuits and MOSFETs is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Hierarchical modeling - Modules, Instances, Basic concepts - Lexical conventions, Whitespace, Comments, Operators, Data types – Value set, Nets, Registers, Vectors, Arrays, Parameters, Strings modules and ports - Modules, Port declaration, Port connection rules, Connecting ports to external signals.	**9 Hours**
Module-2	**Combinational Circuit Design - I**: Dataflow modeling – Continuous assignments, Delays, Expressions, Operators and operands, Operator types, Examples; Gate level modeling - Gate types, Gate delays, Rise, Fall and turn-off delays, Min/Typical/Max values; Switch level modeling - Switch-modeling elements, MOS switches, CMOS switches.	**12 Hours**
Module-3	**Combinational Circuit Design - II**: Behavioral modeling - Initial statement, Always statement, Adders, Subtractors, Comparator, MUX and DeMUX (using if...else and case Construct), Loops - While loop, For loop, Repeat loop, Forever loop (with relevant examples), Structural modeling - 4-bit Adders, 2-bit multiplier, 4-bit comparator, 8:1-MUX and 1:8-DeMUX.	**12 Hours**
Module-4	**Multiplexer as Universal Logic**: Design of basic gates, Boolean expressions and other combinational logic circuits using multiplexers; Decoders and Encoders - 1:2 Decoders, 2:4 Decoder, Test bench of decoder, Priority encoders, Test bench of priority encoder; Latches and Flip-Flops - D Latch, Flip-flop, Positive and negative edge-triggered D Flip-Flop.	**12 Hours**
Module-5	**Sequential Circuit Design**: Synchronous and asynchronous reset, Counter design using synthesizable constructs – Synchronous counters, Asynchronous counter, BCD up–down counter; Finite State Machine (FSM) - Melay & Moore machines, Verilog implementation of sequence detector (Overlapping permitted and non-overlapping), Vending machine.	**11 Hours**
	Total	**56 Hours**

Text Books:

T1. S. Palnitkar, ***Verilog HDL: A guide to Digital Design and Synthesis***, 4th *Ed.*, SunSoft Press, 1996.
T2. V. Taraate, ***Digital Logic Design Using Verilog***, 2nd *Ed.*, Springer, 2016.

Reference Books:

R1. S. Ramachandran, ***Digital VLSI Systems Design***, 2nd *Ed.*, Springer, 2006.
R2. C. H. Roth Jr., L. K. John, B. K. Lee, ***Digital Systems Design Using Verilog***, 2nd *Ed.*, Cengage Learning, 2015.

R3. D. E. Thomas, P. R. Moorby, ***The Verilog Hardware Description Language***, 5th *Ed.*, Kluwer Academic Publishers, 2002.
R4. M. D. Ciletti, ***Advanced Digital Design with Verilog HDL***, 2nd *Ed.*, Pearson Education, 2010.

Online Resources:

1. https://nptel.ac.in/courses/108103179: by Prof. S. R. Ahamed, IIT Guwahati
2. https://www.chipverify.com/verilog/verilog-tutorial
3. https://www.edaplayground.com/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain fundamentals and syntax of Verilog HDL for digital IC design and verification.
CO2	Design and analyze combinational logic circuits using data flow, gate and switch level modeling.
CO3	Apply structural modeling of Verilog HDL to design combinational logic circuits.
CO4	Design combinational logic circuits using multiplexer as universal logic through Verilog HDL.
CO5	Apply synthesizable constructs of Verilog to design sequential and FSM based circuits.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2				3	1					1	3	1	1
CO2	2	2	3	2	3	1					1	2	2	1
CO3	2	2	3	2	3	1						2	2	1
CO4	1	3	3	3	2	1						1	3	2
CO5	1	3	3	3	2	1					1	1	3	1

Category	Code	Analog Integrated Circuit Design	L-T-P	Credits	Marks
MNR	EC4002		4-0-0	4	100

Objectives	The objective of this course is to study analysis and design of analog integrated circuits and systems for various applications including single-stage, differential & operational amplifiers, current mirrors & bandgap reference circuits with different specifications.
Pre-Requisites	Fundamentals of MOSFET, Analog electronics and network theory are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Review of Circuits & Systems**: Circuit elements and their constitutive relations, Network theory, Superposition (linearity) and time-invariant principle, Design and analysis of LTI systems, KCL, KVL, Node Equation procedure, Thevenin and Norton method, Matrix formulation for CAD solution, Analysis of non-linear circuits - Analytical, Graphical and incremental solution, Dynamic circuit analysis - Solution to a first-order differential equation.	**10 Hours**
Module-2	**Integrated Circuit Devices**: Diodes – Basic operation and large-signal modeling, MOS transistor, Large & small signal (low & high frequency) modeling, Advanced MOS modeling (subthreshold, mobility degradation); SPICE modeling - Introduction, Diode model, MOS transistors, Advanced SPICE models for MOS transistors, Passive devices - Resistors and capacitors, Reading process parameters from foundry documents.	**12 Hours**
Module-3	**CMOS Processing and Layout**: CMOS processing, Layout and design rules, Reading design rules from foundry documents, Analog layout considerations - variability, Mismatch, Matching, Noise consideration; Single-Stage Amplifiers – Common source, Source follower, Common gate, Examples, Impedance matching.	**12 Hours**
Module-4	**Operational Amplifier**: Differential Amplifier, Telescopic, Folded cascode, Two stage amplifier design, Stability - Frequency response, Feedback, Compensation, Current mirrors, Simple current mirror, Cascode current mirror, Wide swing current mirror, Matching.	**12 Hours**
Module-5	**Bandgap References and LNA**: Low power band gap reference design. Low Noise Amplifier (LNA) - Design of low noise amplifier.	**10 Hours**
	Total	**56 Hours**

Text Books:

T1. T. C. Carusone, D. A. Johns, and K. A. Martin, ***Analog Integrated Circuit Design***, 2nd *Ed.*, Wiley India, 2012.

T2. B. Razavi, ***Design of Analog CMOS Integrated Circuits***, Indian Edition, McGraw-Hill Education, 2002.

T3. D. Holberg and P. Allen, ***CMOS Analog Circuit Design***, 3rd *Ed.*, Oxford University Press, 2013.

Reference Books:

R1. P. Gray, P. Hurst, S. Lewis, and R. Meyer, ***Analysis and Design of Analog Integrated Circuits***, 4th *Ed.*, John Wiley & Sons, 2001.
R2. R. J. Baker, ***CMOS Circuit Design, Layout and Simulation***, IEEE Inc., 2008.
R3. A. Agarwal and J. Lang, ***Foundations of Analog and Digital Electronic Circuits***, 1st *Ed.*, Elsevier, 2005.

Online Resources:

1. https://nptel.ac.in/courses/117106030: by Dr. N. Krishnapura, IIT Madras
2. http://cmosedu.com
3. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/
4. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-374-analysis-and-design-of-digital-integrated-circuits-fall-2003/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Analyze linear and nonlinear circuits using network theorems, CAD tools, and dynamics.
CO2	Explain operation and modeling of diodes, MOS devices, and passive components using SPICE.
CO3	Apply CMOS processing, layout design rules, and single-stage amplifier configurations.
CO4	Design & analyze differential, cascode, and 2-stage op-amps with feedback & compensation.
CO5	Design low-power bandgap references and low-noise amplifiers for analog VLSI circuits.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	1	1						1	2	1	
CO2	3	2	1	2	2						2	2	2	
CO3	3	3	3	2	3	1						3	2	2
CO4	2	3	3	3	2	1						3	2	1
CO5	2	3	3	3	2	1						2	2	2

Category	Code	Realtime Embedded System Design	L-T-P	Credits	Marks
MNR	EC4003		4-0-0	4	100

Objectives	This course focuses on real-time and embedded system concepts, including task scheduling, synchronization, and inter-process communication to design reliable, responsive, and efficient real-time applications for time-critical embedded systems.
Pre-Requisites	Fundamental knowledge of basic electronics, digigal electronic circuits, microprocessor and microcontrollers, and embedded systems is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving and applications.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Embedded system design and its characteristics, Real-time systems - Characteristics and classification, Hard, Soft and Firm real-time systems, Responsiveness, Latency, CPU utilization, Deadlines and timing requirements, Real-time applications and case overviews.	**12 Hours**
Module-2	**RTOS & Scheduling**: Operating system basics, Types of operating systems, Tasks, Process and threads, Multiprocessing and multitasking, Task scheduling, Non-preemptive scheduling - FIFO, LIFO, Shortest job first (SJF), Priority based scheduling, Preemptive scheduling-Shortest remaining time (SRT), Round robin, Priority based scheduling.	**12 Hours**
Module-3	**RTOS Advanced Scheduling & Services**: Earliest deadline first (EDF) scheduling, Rate monotonic algorithm (RMA), Issues associated with RMA, Issues in using RMA in practical situations threads, Processes and scheduling, Introduction to handling sharing and dependencies among real time tasks and scheduling real time tasks in multiprocessor.	**12 Hours**
Module-4	**Processes, Threads and IPC**: Multiple processes, Threads in an application, Tasks, Task states, Task and data, ISRs, Concept of Semaphores, Introduction to message queue function, Mailbox function, Pipe, Socket and RPC function.	**11 Hours**
Module-5	**Application & Case Studies**: Design process and design examples, Automatic chocolate vending machine, Digital camera, Adaptive Cruise control, Smart card.	**9 Hours**
	Total	**56 Hours**

Text Books:

T1. R. Kamal, ***Embedded Systems : Architecture, Programming and Design***, 12th Reprint, Tata McGraw-Hill, 2007.
T2. K. V. Shibu, ***Introduction to Embedded Systems***, 2nd *Ed.*, McGraw-Hill Education, 2017.
T3. R. Mall, ***Real-Time Systems***, 2nd *Ed.*, Pearson Education, 2010.

Reference Books:

R1. D. E. Simon, ***An Embedded Software Primer***, Addison Wesley, 1999.
R2. C. Baron, J. Geffroy, and G. Motet (Eds), ***Embedded System Applications***, Springer, 1997.
R3. S. Iyer and P. Gupta, ***Embedded Real time Systems Programming***, 1st *Ed.*, McGraw-Hill, 2017.
R4. Q. Li and C. Yao, ***Real-Time Concepts for Embedded Systems***, 1st *Ed.*, CRC Press, 2003.

R5. K. V. K. Prasad, ***Embedded / Real-Time Systems: Concepts, Design and Programming***, 1st *Ed.*, Wiley India, 2003.

Online Resources:

1. https://nptel.ac.in/courses/117105234: by Prof. S. Chattopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/108106176: by Prof. L. S. Jayashree, IIT Madras

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe components, characteristics, and design metrics of embedded and real-time systems.
CO2	Explain RTOS concepts and analyze task scheduling methods in real-time embedded systems.
CO3	Apply advanced RTOS scheduling and task management for efficient real-time system design.
CO4	Implement IPC and process synchronization in real-time embedded systems.
CO5	Explore modern embedded trends and real-time applications through case studies.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	2			1				2	1		3
CO2	3	3	1	3			1				2	2	1	2
CO3	3	3	2	3	1		1				2	2	1	2
CO4	3	3	3	2	2	1	2				2	1	2	2
CO5	3	3	3	1	2	1	2				2	3	1	2

Category	Code	Industrial Internet of Things	L-T-P	Credits	Marks
MNR	EC4004		4-0-0	4	100

Objectives	The objective of this course is to learn the design & implementation of IoT applications for industrial automation by connecting the sensors to the cloud and extracting the data from cloud to the connected devices.
Pre-Requisites	Knowledge of IoT protocols and architecture is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions shall focus on design, programming and applications of IoT.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Background, Key technologies, Use cases of the IIoT; IoT & IIoT - Similarities and differences, IoT Analytics and AI, Industry environments, scenarios covered by IIoT.	**10 Hours**
Module-2	**The Industrial Process**: The CIM Pyramid; The IIoT data flow - MODBUS-TCP, OPC-UA, MQTT, PROFINET, CAN, Edge devices, Gateway with preprocessing and filtering, Enterprise applications, Condition monitoring, Production insights.	**10 Hours**
Module-3	**The IIoT Data Flow**: IIoT data flow in the factory, Measurements and the actuator chain, Controllers, Industrial Protocols, SCADA, ERP & MES.	**11 Hours**
Module-4	**Implementing Industrial IoT**: IoT Data Flow, Discovering OPC, OPC Classic, OPC UA, Understanding the IIoT edge, Implementing the IIoT data flow.	**12 Hours**
Module-5	**Implementing IIoT on Cloud**: AWS Technical requirements - AWS Architecture, Registering for AWS, IoT Core, Storing Data, AWS Analytics, Understanding Diagnostics Maintenance; Predictive Analytics - Technical Requirements, Different classes of analytics, IIoT Analytics Technologies, Building IIoT Analytics, Understanding the role of the Infrastructure, Deploying Analytics.	**13 Hours**
	Total	**56 Hours**

Text Books:

T1. G. V. A. Capasso, ***Hands-On Industrial Internet of Things***, Packt Publishers, 2018.
T2. I. Butun, ***Industrial IoT***, 1st *Ed.*, Springer, 2020.
T3. A. Suresh, M. Nandagopal, P. Raj, E. A. Neeba, and J-W. Lin, ***Industrial IoT: Application, Architectures and Use Cases***, 1st *Ed.*, CRC Press, 2020.

Reference Books:

R1. O. Hersent, D. Boswarthick, and O. Elloumi, ***The Internet of Things: Key Applications and Protocols***, Student Edition, John Wiley & Sons, 2016.
R2. A. Gilchrist, ***Industry 4.0: The Industrial Internet of Things***, 1st *Ed.*, Apress, 2017.

Online Resources:

1. https://nptel.ac.in/courses/106105195: by Prof. S. Misra, IIT, Kharagpur
2. https://nptel.ac.in/courses/106105166: by Prof. S. Misra, IIT, Kharagpur
3. https://nptel.ac.in/courses/108105064: by Prof. A. Barua, IIT, Kharagpur

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain technical requirements, key technologies, and use cases of Industrial IoT (IIoT).
CO2	Analyze industrial processes, devices, data flow, and communication protocols in IIoT systems.
CO3	Design network protocols and software layers for industrial data flow and device integration.
CO4	Implement IIoT data flow from edge to cloud using OPC UA and Node-RED platforms.
CO5	Develop cloud-based IIoT solutions and perform analytics for real-world industrial applications.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	3	3	2	2	2				2	2	2	2
CO2	2	3	3	3	2	2	2				2	2	2	2
CO3	3	2	3	2	2	2	2				2	3	3	2
CO4	3	2	3	2	3	3	2				3	3	2	2
CO5	2	2	2	2	2	2	2				3	2	2	2

Category	Code	Financial Management	L-T-P	Credits	Marks
MNR	MG4005		3-1-0	4	100

Objectives	This course introduces the fundamentals of financial management to evaluate technology projects, interpret financial information, and make informed decisions considering cost, risk, and business outcomes.
Pre-Requisites	Basic understanding of mathematics and engineering economics is required.
Teaching Scheme	Regular classroom lectures with the use of ICT tools as and when required; sessions emphasize interactive discussions, real-world examples and spreadsheet-based financial analysis.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Role of finance in Engineering organizations; Objectives and scope of financial management; Interface of finance with engineering, operations, and marketing; Revenue, cost, and profit concepts; Financial statements – Profit and Loss statement, Balance sheet, Cash flow statement; Financial planning and forecasting; Risk–return relationship; Financial vs technical success of projects.	**10 Hours**
Module-2	**Financial Planning & Capital Budgeting**: Financial planning in Engineering and IT projects; Project cost and cash flow estimation; Time value of money; Capital budgeting process; Cash flow techniques – Payback period, Net Present Value (NPV), Internal Rate of Return (IRR); Comparison of alternative engineering projects; Sensitivity analysis, risk evaluation, and capital rationing; Evaluation of new technology and automation investments.	**12 Hours**
Module-3	**Cost of Capital & Investment Decisions**: Sources of long-term finance – equity and debt; Cost of capital – concept and significance; Cost of equity, debt, and retained earnings (basic understanding); Weighted Average Cost of Capital (WACC) in investment decisions; Financial vs technological risk in projects; Decision contexts – Cloud vs on-premise infrastructure, Buy vs build, Outsourcing vs in-house development.	**10 Hours**
Module-4	**Working Capital & Operational Finance**: Working capital in project-driven organizations; Cash budgeting and short-term financial planning; Sources of short-term finance; Inventory management – Economic Order Quantity (EOQ); Receivables and payables management; Monitoring and control of inventory and receivables; Impact of project delays and cost overruns on cash flows; Cost optimization and operational efficiency.	**12 Hours**
Module-5	**Financial Decision Making**: Budgeting and variance analysis for engineering projects; Financial dashboards and performance indicators; Financial KPIs in organizations; Project performance and financial feasibility evaluation; Long-term financial sustainability and impact of engineering decisions; Ethical considerations in financial decisions; Integrated evaluation of projects considering technical feasibility, financial viability, risk, and sustainability.	**12 Hours**
	Total	**56 Hours**

Text Books:

T1. F. Crundwell, ***Finance for Engineers***, 1st *Ed.*, Springer Publications, 2008.
T2. I. M. Pandey, ***Financial Management***, 13th *Ed.*, Vikas Publishing House, 2025.
T3. L. J. Gitman and C. J. Zutter, ***Principles of Managerial Finance***, 13th *Ed.*, Pearson Education, 2017.

Reference Books:

R1. M. Y. Khan and P. K. Jain, ***Financial Management: Text, Problems and Cases***, 8th *Ed.*, McGraw-Hill, 2018.
R2. P. Chandra, ***Financial Management: Theory and Practice***, 11th *Ed.*, McGraw-Hill, 2022.
R3. S. N. Maheshwari and S. K. Maheshwari, ***Financial Management: Principles and Practice***, 13th *Ed.*, S. Chand & Sons, 2021.
R4. R. M. Kishore, ***Financial Management***, 8th *Ed.*, Taxmann Publications, 2022.

Online Resources:

1. https://nptel.ac.in/courses/110107144: by Prof. A. K. Sharma, IIT Roorkee
2. https://nptel.ac.in/courses/110107073: by Prof. A. K. Sharma, IIT Roorkee
3. https://nptel.ac.in/courses/111103126: by Prof. N. Selvaraju and S. P. Chakrabarty, IIT Guwahati
4. https://ocw.mit.edu/courses/15-414-financial-management-summer-2003/pages/lecture-notes/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain the role of finance, financial statements, and risk–return concepts in projects.
CO2	Apply capital budgeting techniques to evaluate engineering and technology investments.
CO3	Analyze cost of capital and financial risks in technology investment decisions.
CO4	Apply working capital concepts for short-term financial planning and operations.
CO5	Evaluate engineering projects using financial indicators and feasibility analysis.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).

Cont'd. . .

PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	2	1	1	1	1	2		1	2	1	1	1	2
CO2	2	3	1	2	2	2	3		1	3	2	1	2	3
CO3	2	3	2	2	2	2	3		2	3	2	2	2	3
CO4	2	2	2	2	1	1	2		2	3	1	2	1	2
CO5	1	2	1	1	1	2	2		1	2	2	2	2	2

Category	Code	Business Strategy	L-T-P	Credits	Marks
MNR	MG4006		3-1-0	4	100

Objectives	The objective of this course is to equip technical students with strategic thinking skills to analyze markets, develop technology-driven strategies, and manage innovation in engineering and technology enterprises.
Pre-Requisites	Basic understanding of mathematics and business operations in an engineering project environments is required.
Teaching Scheme	Regular classroom lectures with the use of ICT tools as and when required; sessions emphasize interactive discussions, real-world examples and case studies.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Strategy Foundations**: Concept of strategy and strategic management, Strategic thinking vs strategic planning, Levels of strategy – Corporate, Business, Functional, Strategic management process, Vision, Mission, Goals and strategic intent, Stakeholders and corporate governance, Strategy in engineering and technology organizations, Strategy frameworks and analytical tools.	**10 Hours**
Module-2	**Industry Analysis**: External environment analysis, PESTLE analysis, Industry structure and competition, Porter's Five Forces model, Industry life cycle and technology evolution, Competitor analysis and benchmarking, Technology disruption and digital competition, Market positioning in technology industries.	**12 Hours**
Module-3	**Resources & Innovation**: Internal analysis of firms, Resources and capabilities, Core competencies in technology organizations, Value chain analysis in manufacturing and digital firms, VRIO framework, Innovation and R&D strategy, Technology commercialization, Intellectual property and knowledge assets.	**10 Hours**
Module-4	**Strategy Design**: Business strategies – Cost leadership, Differentiation, Focus strategy, Platform and ecosystem strategies, Startup and entrepreneurial strategies, Strategic alliances, Mergers and acquisitions in technology sectors, Strategy implementation, Organizational structure and project-based organizations.	**12 Hours**
Module-5	**Digital & Global Strategy**: Strategic control and evaluation, Balanced scorecard and KPIs, Risk management and governance, Sustainability and responsible innovation, Digital transformation strategies, AI and data-driven strategy, Case studies of global technology companies and engineering enterprises.	**12 Hours**
	Total	**56 Hours**

Text Books:

T1. F. T. Rothaermel, ***Strategic Management***, 6th *Ed.*, McGraw-Hill Education, 2023.

T2. R. M. Grant, ***Contemporary Strategy Analysis***, 11th *Ed.*, Wiley, 2021.

T3. M. A. Hitt, R. D. Ireland, and R. E. Hoskisson, ***Strategic Management: Competitiveness and Globalization***, 13th *Ed.*, Cengage Learning, 2022.

Reference Books:

R1. R. Rumelt, ***Good Strategy/Bad Strategy: The Difference and Why It Matters***, 1st *Ed.*, Crown Business, 2011.
R2. W. C. Kim and R. Mauborgne, ***Blue Ocean Strategy***, Expanded Edition, Harvard Business Review Press, 2015.
R3. C. M. Christensen, ***The Innovator's Dilemma***, Revised Edition, Harvard Business Review Press, 2016.
R4. E. Ries, ***The Lean Startup***, 1st *Ed.*, Crown Business, 2011.

Online Resources:

1. https://nptel.ac.in/courses/110108047: by Prof. R. Srinivasan, IISc Bangalore
2. https://nptel.ac.in/courses/110106157: by Prof. C. B. Rao, IIT Madras
3. https://nptel.ac.in/courses/110105161: by Prof. S. Chowdhury, IIT Kharagpur
4. https://nptel.ac.in/courses/110106164: by Prof. C. B. Rao, IIT Madras

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain strategy concepts, strategic intent, and decision making in organizations.
CO2	Analyze industry structure and external environment using strategic tools.
CO3	Evaluate resources, capabilities, and innovation for competitive advantage.
CO4	Formulate business and corporate strategies for technology-driven firms.
CO5	Assess strategic performance, risks, and digital transformation initiatives.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	1					1	2	1	1	1	2
CO2	1	3	1	2					1	1	1	1	2	2
CO3	1	2	3				1				2	2	2	2
CO4	1	2	3				1		1	1	2	1	2	3
CO5	1	2	1	1			2		2	1	3	2	1	2

Category	Code	Business Intelligence & Visualization	L-T-P	Credits	Marks
MNR	MG4003		3-1-0	4	100

Objectives	The objective of this course is to enable students to create dashboards and illustrate data stories effectively using modern BI tools.
Pre-Requisites	Knowledge of statistics with programming and spreadsheet tools is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples, case-studies and latest trends.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Business Intelligence & Data Warehousing**: Introduction to Business Intelligence (BI); Role of BI in organizations; OLTP vs OLAP systems; Data warehousing concepts and architecture; ETL process – Extract, Transform, Load; Data marts; Star and Snowflake schema; Fact and dimension tables; Understanding sample data warehouse schema; Designing simple Star schema for retail or sales dataset.	**8 Hours**
Module-2	**Relational Databases & SQL**: Relational database concepts – Tables, Keys, Relationships; SQL queries – SELECT, WHERE, ORDER BY, GROUP BY, HAVING, Aggregation functions (SUM, AVG, COUNT); Joins – INNER, LEFT/RIGHT; Subqueries; Basic data cleaning using SQL; Writing MySQL queries and extracting KPIs from transactional data.	**10 Hours**
Module-3	**Data Visualization**: Importance of visual communication; Chart types and usage – Bar, Line, Pie, Scatter, Heat map; Avoiding misleading visualizations; Colour theory and perception; Data-ink ratio; Designing for clarity and impact; Visual best practices; Improving poor visualizations; Selecting charts for business scenarios.	**8 Hours**
Module-4	**Dashboard Design & KPIs**: Dashboards and their purpose; Types – Strategic, Operational, Analytical; Key Performance Indicators (KPIs); Designing KPIs for Sales, Finance, Marketing, Operations; Layout & usability principles; Interactive filters & drill-downs; Real-time vs static dashboards; KPI framework design for a case company; Dashboard layout wireframe.	**10 Hours**
Module-5	**Using Power BI / Tableau**: Connecting to data sources; Data transformation using Power Query / Tableau Prep; Calculated fields and measures; Visualizations and dashboards; Filters and slicers; Publishing and sharing reports; Basic DAX (Power BI); Parameters and calculated fields (Tableau); Dashboard development from raw datasets; Industry datasets – Retail, Automobile, Manufacturing, Healthcare; Publishing dashboard.	**12 Hours**
Module-6	**Storytelling with Data**: Data storytelling concepts; Structuring business narratives; Framing business problems; Insight vs information; Executive presentation of dashboards; Business recommendations; Pitfalls in BI reporting; Mini project – Problem definition, Data analysis, Dashboard creation, Presentation to mock management panel.	**8 Hours**
	Total	**56 Hours**

Text Books:

T1. C. N. Knaflic, ***Storytelling With Data: A Data Visualization Guide For Business Professionals***, 1st *Ed.*, Wiley, 2015.
T2. R. Kimball and M. Ross, ***The Data Warehouse Toolkit***, 2nd *Ed.*, Wiley, 2013.

Reference Books:

R1. R. N. Prasad and S. Acharya, ***Fundamentals of Business Analytics***, 2nd *Ed.*, Wiley, 2011.
R2. S. Sringeswara, P. Tiwari, and U. D. Kumar, ***Data Visualization: Storytelling Using Data***, 1st *Ed.*, Wiley, 2022.
R3. B. Dykes, ***Effective Data Storytelling***, 1st *Ed.*, Wiley, 2019.

Online Resources:

1. https://www.youtube.com/watch?v=Jy9tn9iR9Oo: by Prof. S. Quader, NPTEL-NOC IITM
2. https://www.youtube.com/watch?v=JhjpC2tbFxs: by Simplilearn
3. https://www.youtube.com/playlist?list=PLahhVEj9XNTdg4FnhAo_OQ-bSDd86VBcH: by Microsoft Learn

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain BI concepts, data warehousing architecture, and dimensional modeling.
CO2	Write SQL queries to retrieve, aggregate, and analyze data from relational databases.
CO3	Apply data visualization principles to create clear and effective charts.
CO4	Design dashboards and define KPIs for business performance monitoring.
CO5	Develop interactive dashboards using Power BI or Tableau for data analysis.
CO6	Present business insights using data storytelling and structured narratives.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2			1							2	1	1
CO2	2	3	2	2	3							2	2	2
CO3	2	3	3	2	2							3	3	2
CO4	2	3	3	2	3						2	3	3	3
CO5	2	3	2	3	2						2	2	2	3
CO6	1	2	2	1	1						1	2	2	2

Category	Code	Business Analytics Using Power of AI	L-T-P	Credits	Marks
MNR	MG4004		3-1-0	4	100

Objectives	The objective of this course is to apply business analytics, BI, and AI tools to solve real-world, industry-style problems using structured and unstructured data while considering ethics and governance.
Pre-Requisites	Knowledge of mathematics, statistics and worksheet operations is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required; sessions are planned to be interactive with focus on examples, case-studies and hands-on practice.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**AI in Business & Analytics Landscape**: Evolution from BI to AI-assisted analytics; AI in decision-making; Prompt curation for forecasting models – Descriptive, Diagnostic, Predictive, Prescriptive; AI tools for data analytics; AI technologies in business; Data-driven culture.	**8 Hours**
Module-2	**Sectoral Applications of AI-Assisted Analytics**: Finance – Fraud detection, Credit scoring, Risk analytics, Algorithmic trading basics; Retail – Demand forecasting, Customer segmentation, Recommendation systems, Inventory optimization; Healthcare – Disease prediction models, Patient risk stratification, Medical imaging analytics (conceptual); Automobile – Predictive maintenance, Autonomous systems (conceptual), Supply chain optimization; Manufacturing – Quality control using AI, Production optimization, Smart factory analytics; Sectoral case study analysis.	**12 Hours**
Module-3	**Big Data Concepts**: 5Vs of Big Data – Volume, Velocity, Variety, Veracity, Value; Structured, semi-structured, and unstructured data; Data lakes vs data warehouses; Distributed computing basics; Hadoop & Spark basics (conceptual); Batch vs stream processing.	**8 Hours**
Module-4	**Cloud Platforms for Analytics**: Role of cloud computing in analytics; Google Colab for ML projects; AWS basics – EC2, S3 storage, Overview of analytics services; Cloud deployment basics; Cost awareness in cloud computing; Running ML model in Google Colab; Uploading dataset to cloud storage; Platforms – Google Colab, Amazon Web Services.	**8 Hours**
Module-5	**AI-Assisted Analytics Project**: Problem identification, Data collection, Data cleaning & preprocessing, Feature engineering, Model selection, Evaluation metrics, Business interpretation, Deployment-ready presentation, Technical report, Dashboard or model output, Executive presentation, Ethical assessment.	**12 Hours**
Module-6	**Ethics, Governance & Data Privacy**: Algorithmic bias; Fairness in AI; Responsible AI principles; Data privacy concerns; Data protection regulations – General Data Protection Regulation, Information Technology Act; Data anonymization concepts; Transparency and Explainable AI (XAI); Case studies – AI bias incidents, Data breaches, Ethical failures in analytics projects.	**8 Hours**
	Total	**56 Hours**

Text Books:

T1. R. Sharda, D. Delen, and E. Turban, ***Business Intelligence, Analytics, Data Science, and AI***, 5th *Ed.*, Pearson Education, 2024.
T2. P. C. Bruce, et. al., ***Machine Learning for Business Analytics***, 2nd *Ed.*, Wiley, 2023.

Reference Books:

R1. S. G. Yaseen, ***Applied Artificial Intelligence in Business***, 1st *Ed.*, Springer Nature, 2025.
R2. J. Boffa, ***AI Assisted Business Analytics***, 1st *Ed.*, Springer, 2023.
R3. A. H. Gandomi, F. Chen, and L. Abualigah, ***Big Data Analytics Using Artificial Intelligence***, 1st *Ed.*, John MDPI Books, 2023.

Online Resources:

1. https://www.youtube.com/watch?v=J5WnKMIOQuY: Google Data Analytics
2. https://www.youtube.com/watch?v=JhjpC2tbFxs: by Simplilearn
3. https://www.youtube.com/watch?v=yuIMWWMWN4A: by TechCanvas

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Identify and formulate real-world business problems suitable for AI-assisted analytics solutions.
CO2	Apply analytics techniques across key sectoral domains such as Finance, Retail, and Healthcare.
CO3	Apply big data concepts and tools in handling large-scale structured & semi-structured datasets.
CO4	Explore & utilize popular cloud-based platforms for scalable analytics implementation.
CO5	Develop end-to-end AI-assisted analytics solutions for real-world business problems.
CO6	Evaluate ethical, legal, and privacy implications in AI-driven business analytics applications.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	2	2	2						1	2	1	1
CO2	2	3	3	3	2						1	2	2	2
CO3	2	2	2	2	3						1	3	3	3
CO4	2	3	3	3	3						1	3	3	3
CO5	2	3	3	3	3						2	2	2	2
CO6	1	2	2	1	1						1	2	2	2

Category	Code	Skill Lab & Project-I	L-T-P	Credits	Marks
PRJ	IP4010		0-0-4	2	100

Objectives	This laboratory course focuses on overall skill development of through problem formulation, designing, development and implementation of models as a solution for the identified problem. Students will be introduced to different open source tools to carry out the assigned project, finishing with project demonstration, report, presentation, viva, and evaluation.
Pre-Requisites	Knowledge of electrical engineering, software, circuit theory, control systems, power electronics, and renewable energy systems is required.
Teaching Scheme	Regular laboratory sessions to design, develop, and test hardware & software systems, culminating in a project-based application of concepts.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1-2	Interfacing of circuits using microcontrollers.
3-4	Design of Power Electronics gate driver circuits.
5-6	Design of controller circuits.
7-8	Design of IOT hardware platforms using Arduino and Raspberry Pi.
9-10	Study of Python-based control programming for IOT applications.
11-12	Problem identification and formulation of project.
13-16	Development of mathematical model/ hardware architecture.
17-20	Simulation/programming/hardware setup.
21-24	Result analysis/ validation of hardware/system integration and testing.
25-26	Project demonstration, presentation, viva-voce and evaluation.

Text Books:

T1. S. Attaway, ***MATLAB: A Practical Introduction to Programming and Problem Solving***, 6th *Ed.*, Butterworth-Heinemann, 2022.
T2. P. Desai, ***Python Programming for Arduino: Develop Practical IoT Applications***, 1st *Ed.*, Packt Publishing, 2015.
T3. S. Monk, ***Programming the Raspberry Pi: Getting Started with Python***, —edn3, McGraw-Hill Education, 2020.
T4. A. N. Kani, ***Microprocessors and Microcontrollers***, 3rd *Ed.*, McGraw-Hill Education, 2017.

Reference Books:

R1. A. K. Tyagi, ***MATLAB and Simulink for Engineers***, 1st *Ed.*, Oxford University Press, 2012.
R2. J. Blum, ***Exploring Arduino: Tools and Techniques for Engineering Wizardry***, 2nd *Ed.*, Wiley, 2019.
R3. Selected research articles from various scientific journals.
R4. Any other book(s) and/or study material(s) as advised by the teacher.

Online Resources:

1. https://nptel.ac.in/courses/106105166: by Prof. D. V. Gadre, IIT Delhi
2. https://nptel.ac.in/courses/106106182: by Prof. S. Iyengar, IIT Ropar
3. https://nptel.ac.in/courses/108102045: by Prof. A. Basu, IIT Kharagpur

Note: Additional course/reference materials, research publications, manuals/API, tools, libraries, or other software may be suggested by the teacher as per requirement of the skills needed for the project.

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Analyze and implement microcontroller interfacing with sensors, actuators, and modules.
CO2	Design and evaluate gate driver circuits for MOSFETs/IGBTs with isolation and protection.
CO3	Design and develop analog and digital control circuits to regulate voltage, current, and speed.
CO4	Develop IoT hardware using Arduino/Raspberry Pi with sensors, cloud, and Python.
CO5	Apply simulation, programming, and hardware tools for project modelling and prototyping.

Program Outcomes Relevant to the Course:

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PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

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CO1	3	2	2	2	3		1	2		2	2	3	2	1
CO2	3	3	3	2	3		2	1		2	2	3	2	1
CO3	3	3	3	2	2		2	1		2	2	3	2	2
CO4	2	2	3	2	3		2	1		2	3	2	3	2
CO5	2	2	2	2	3		1	2		2	3	2	3	3

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