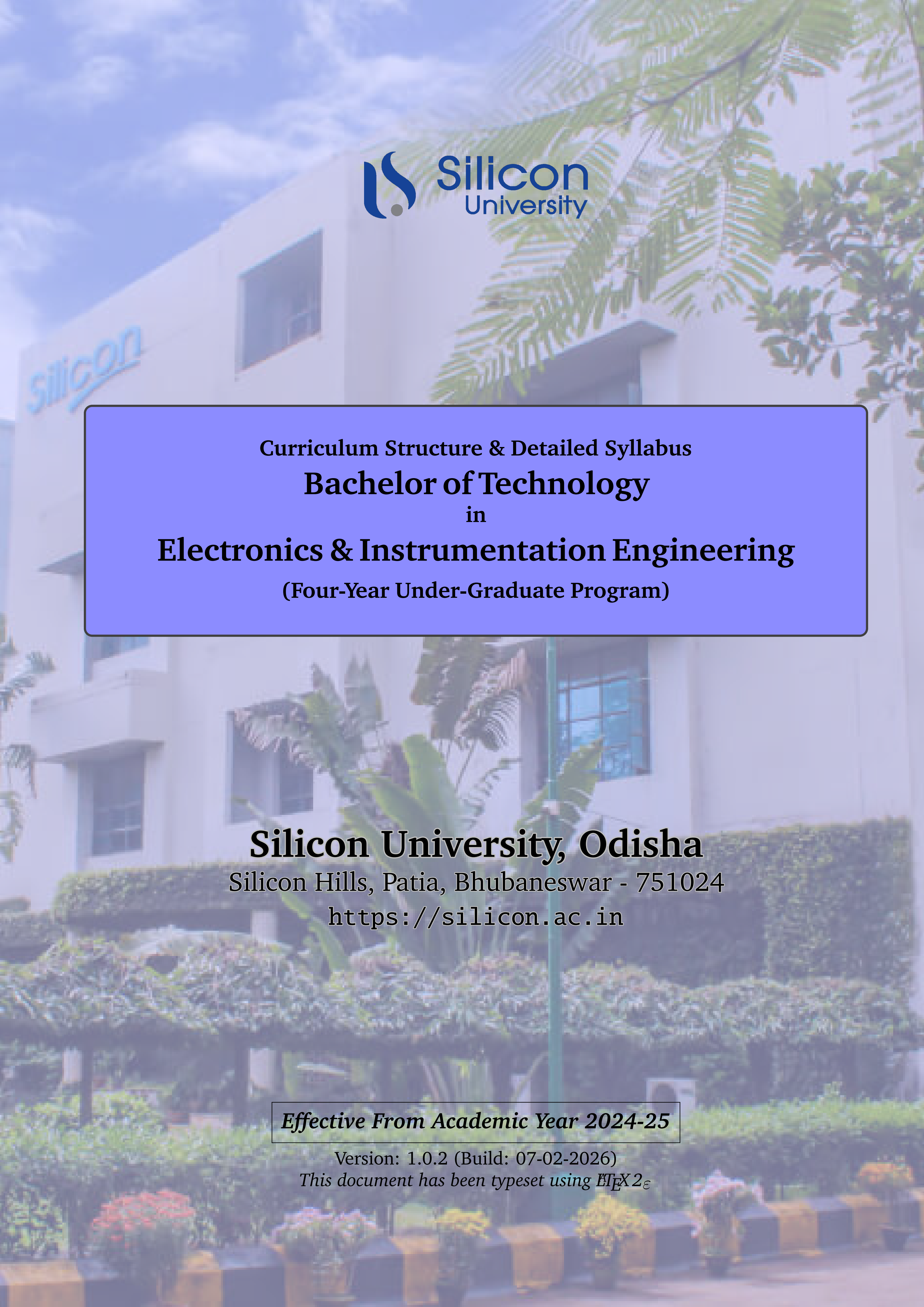

Curriculum Structure & Detailed Syllabus

Bachelor of Technology

in

Electronics & Instrumentation Engineering

(Four-Year Under-Graduate Program)

Silicon University, Odisha

Silicon Hills, Patia, Bhubaneswar - 751024

https://silicon.ac.in

Effective From Academic Year 2024-25

Version: 1.0.2 (Build: 07-02-2026)

This document has been typeset using LaTeX 2ε

Approval History

ACM#	Date	Resolutions
SU-1	27/04/2024	The curriculum structure of B. Tech. (EIE) was approved in principle by the Academic Council.
SU-2	17/08/2024	The curriculum structure of B. Tech. (EIE) 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. (EIE) 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. (EIE) 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 various complex engineering problems related to sensors, process instrumentation, VLSI, Biomedical and Real-time Embedded Systems by applying fundamental concepts of electronics and instrumentation.

PSO2. Imbibe the skills in modern technologies, tools & 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. Appreciate and adapt to emerging technologies in electronics and related domains to design and create efficient systems for process automation in the real world using appropriate sensors, instruments, tools, and platforms to meet the challenges of the future.

Program Educational Objectives (PEOs)

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

PEO2. *Proficiency for the Real World*: To inculcate the skills required to analyze, formulate, design, develop, test and optimize efficient and cost-effective electronics and instrumentation systems useful in various real world scenarios.

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.(EIE)

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	EC2019	Basics of Instrumentation	3	0	0	3	0	0
PCR	EE2010	Circuit Theory	3	0	0	3	0	0
PCR	EC2004	Analog Electronic Circuits	3	1	0	3	1	0
PRACTICAL								
UCR	CS2004	OOP Using Java Lab	0	0	2	0	0	1
PCR	EC2023	Basics of Instrumentation Lab	0	0	2	0	0	1
PCR	EC2005	Analog Electronic Circuits 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	EC2020	Transducers & Measurement Systems	3	0	0	3	0	0
PCR	EC2007	Digital Electronic Circuits	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	EC2021	Transducers & Measurement Systems Lab	0	0	2	0	0	1
PCR	EC2008	Digital Electronic Circuits Lab	0	0	4	0	0	2
PCR	EC2022	Simulation & Design Lab	0	0	2	0	0	1
		TOTAL	**29**			**24**		
		TOTAL (with Honours/Minor)	**32**			**27**		

3rd Year B.Tech.(EIE)

Semester V								
Category	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
PCR	EC3009	Introduction to Digital Signal Processing	3	0	0	3	0	0
PCR	EC3002	Digital VLSI Design	3	1	0	3	1	0
PCR	EC3047	Instrumentation Devices & Systems	3	1	0	3	1	0
PCR	EC3045	Communication Systems Engineering	3	0	0	3	0	0
PEL		Program Elective - I	3	0	0	3	0	0
PEL		Program Elective - II	3	0	0	3	0	0
HNS/MNR		Honours / Minor - II	3	0	0	3	0	0
PRACTICAL								
PCR	EC3048	Introduction to Digital Signal Processing Lab	0	0	2	0	0	1
PCR	EC3005	Digital VLSI Design Lab	0	0	2	0	0	1
PCR	EC3049	Instrumentation Devices & Systems Lab	0	0	2	0	0	1
SEC	HS3001	Soft Skills for Professionals	0	0	2	0	0	1
INT	IP3003	Summer Internship - II	0	0	0	0	0	1
		TOTAL	**28**			**25**		
		TOTAL (with Honours/Minor)	**31**			**28**		

Semester VI								
Category	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
PCR	EC3050	Industrial Automation & Control	3	0	0	3	0	0
PCR	EC3009	Microprocessors & Microcontrollers	3	0	0	3	0	0
PCR	EE3001	Control Systems Engineering	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	EC3051	Industrial Automation & Control Lab	0	0	2	0	0	1
PCR	EC3011	Microprocessors & Microcontrollers Lab	0	0	2	0	0	1
SEC	IP3007 / 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	**30**			**23**		
		TOTAL (with Honours/Minor)	**34**			**27**		

*__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.(EIE)

(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	IP4012	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. MOOC - Massive Open Online Course (on NPTEL / Swayam / Other).
4. 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.
5. The Value Addition Course (Yoga / NSS / NCC) may be assigned in a different semester depending on available capacity.

4th Year B.Tech.(EIE)

(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	IP4012	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. MOOC - Massive Open Online Course (on NPTEL / Swayam / Other).
4. 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.
5. The Value Addition Course (Yoga / NSS / NCC) may be assigned in a different semester depending on available capacity.

4th Year B.Tech.(EIE)

(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	IP4012	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. MOOC - Massive Open Online Course (on NPTEL / Swayam / Other).
4. 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.
5. 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
EC2010	Solid State Devices
EC2011	Embedded C Programming
EE2007	Soft Computing Techniques
	Program Elective - II
EC3013	IC Fabrication Technology
EC3014	IoT & Applications
EC3052	PLC, SCADA & Distributed Control Systems
	Program Elective - III
EC3054	VLSI System Design & Verification
EC3017	Embedded System Design
EC3018	Introduction to Machine Learning
	Program Elective - IV
EC3020	Analog VLSI Design
EC3021	Real Time Embedded Systems
EC3055	Virtual Instrumentation & DAQ
	Program Elective - V
EC3024	Low Power VLSI Design
EC3025	Smart Sensors for IoT
EC3056	Industrial Instrumentation
	Program Elective - VI
EC3028	Design of Semiconductor Memories
EC3029	Industrial IoT
EC3019	MEMS & Sensor Design
	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 Electronics & Instrumentation Engineering
EC2018	Advanced Electronic Circuits
EC3057	Mechatronics in Manufacturing
EC3058	Biomedical Instrumentation & Signal Processing
EC4007	Advanced Sensor Technology
EC4008	Analytical Instrumentation
	Minor in "Sustainable Energy & E-Mobility"
EC2024	Power Electronic Devices
EE2008	Renewable Energy Systems
EE3022	Basics of Power Systems
EE3024	Smart Power Systems
EE4002	Electric & Hybrid Vehicles
	Minor in "Information Technology"
CS2003	Operating Systems
CS2008	Computer Organization & Architecture
CS2002	Design & Analysis of Algorithms
CS2009	Database Management Systems
CS4001	Internet Technology & Applications
	Minor in "Artificial Intelligence & Machine Learning"
CS3013	Data Mining & Data Warehousing
CS2014	Artificial Intelligence
CS3002	Machine Learning
CS4003	Human Language Processing
CS4004	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	Fundamentals of 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***, 16^{th} *Ed.*, Dhanpat Rai Publishing Company, 2015.
T2. Wiley-India Editorial Team, ***Engineering Chemistry***, 2^{nd} *Ed.*, Wiley India, 2011.
T3. C. N. Banwell, ***Fundamentals of Molecular Spectroscopy***, 4^{th} *Ed.*, McGraw-Hill Education, 2017.

Reference Books:

R1. S. S. Dara, ***Engineering Chemistry***, 12^{th} *Ed.*, S. Chand Publisher, 2014.
R2. G. A. Ozin & A. C Arsenault, ***Nanochemistry - A Chemical Approach to Nanomaterials***, 2^{nd} *Ed.*, RSC Publishing, 2008.
R3. J. M. Lehn, L. Cademartiri, ***Concepts of Nanochemistry***, 1^{st} *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	1	1
CO2	2	2	2	1	1	1	1	1			1	2	1	1
CO3	2	2	1	2	1	1	1	1			1	2	1	1
CO4	2	2	2	1	1	1	1	1			1	1	2	2
CO5	2	2	1	1	1	1	1				1	2	1	2

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 $\lvert\psi\rvert^2$, 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.

P.T.O

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***, 11^{th} *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							1	2	1
CO2	3	2	1	2	3							1	2	1
CO3	2	2	1	2	3							1	2	1
CO4	2	2	1	2	3							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	
CO3	2	2	3	2	1	3	1	1		1	2		1	
CO4	2	2	3	2	1	3	2	2		1	2		1	
CO5	2	2	3	2	1	3	3	2		1	2		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***, 2^{nd} *Ed.*, Pearson Education, 2002.
T2. E. Horowitz, S. Sahni, S. A-Freed, ***Fundamentals of Data Structures in C***, 2^{nd} *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***, 11^{th} *Ed.*, Pearson Education.
T2. A. S. Sedra and K. C. Smith, ***Microelectronic Circuits***, 7^{th} *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***, 2^{nd} *Ed.*, Universities Press, 2008.
T2. M. A. Weiss, ***Data Structures and Algorithm Analysis in C***, 2^{nd} *Ed.*, Pearson Education, 2002.

Reference Books:

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

R2. Y. Kanetkar, ***Data Structures Through C***, 2^{nd} *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***, 1^{st} *Ed.*, White Falcon Publishing, 2021.
T2. M. A. Rizvi, ***Effective Technical Communication***, 2^{nd} *Ed.*, Tata McGraw-Hill, 2017.
T3. M. Raman and S. Sharma, ***Technical Communication: Principles and Practice***, 3^{rd} *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***, 1^{st} *Ed.*, Tata McGraw-Hill, 2003.
R2. J. Seely, ***The Oxford Guide to Writing and Speaking***, 3^{rd} *Ed.*, Oxford University Press, 2013.
R3. B. K. Mitra, ***Effective Technical Communication - A Guide for Scientists and Engineers***, 1^{st} *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***, 8^{th} *Ed.*, Wiley India, 2015.

Reference Books:

R1. S. Pal and S. C. Bhunia, ***Engineering Mathematics***, 1^{st} *Ed.*, Oxford University Press, 2015.
R2. B. V. Ramana, ***Higher Engineering Mathematics***, 1^{st} *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

P.T.O

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	Basics of Instrumentation	L-T-P	Credits	Marks
PCR	EC2019		3-0-0	3	100

Objectives	The objective of this course is to introduce the basic principles & uses of different electrical & electronic measuring instruments including 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	Qualities of Measurement: Significance of measurement, Significant figure, Functional elements of generalized measurement systems, Deflection & null type instruments; Static & Dynamic Characteristics: Systematic statistical characteristics, Calibration; Errors in measurement, Concept of calibration and loading effects of series and shunt connected instruments.	**9 Hours**
Module-2	Bridge Circuits: DC and AC Bridges, Errors in bridge circuits, Quality factor (Q) and dissipation factor(D), General equations for Bridge Balance; Application of DC and AC bridges: Resistance measurement, Insulation resistance measurement, Inductance measurement (Maxwell's, Hay's and Anderson bridge) and Capacitance measurement (Wien's, Owens's and Schering Bridge).	**9 Hours**
Module-3	Measuring Instruments: DC Galvanometer, DC Potentiometer, PMMC and MI instruments, Voltmeters, Ammeters, Ohmmeters, Extension of the range of instruments; AC Indicating Instruments: EDM Wattmeter (1-phase & 3-phase), Energy meter; Basics of instrument transformer, Digital CRO, DVM, Digital frequency meter and spectrum analyzer.	**9 Hours**
Module-4	Basic Sensing Elements: Sensors, Transducers, Classification & selection of transducers; Resistive Sensing Elements: Resistive potentiometers, strain gauges, RTD and Thermistor; Inductive Sensing Elements: Principle, inductive displacement sensor, push-pull type, LVDT, RVDT, Hall effect sensors.	**8 Hours**
Module-5	Capacitive Transducers: Variable separation, Area dielectric displacement transducer, Push-pull type capacitive sensor, Pressure, Humidity and Level measurement.	**7 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. Ghosh, ***Introduction to Measurement and Instrumentation***, 3rd *Ed.*, PHI Learning, 2009.
T3. H. S. Kalsi, ***Electronic Instrumentation and Measurements***, 4th *Ed.*, McGraw-Hill Education, 2019.
T4. A. K. Sawhney, ***A Course in Electrical and Electronics Measurements & Instrumentation***, Dhanpat Rai & Co, 2015.

Reference Books:
R1. J. J. Carr, ***Elements of Electronics Instrumentation Measurement***, 3rd *Ed.*, Pearson Education, 2003.
R2. D. A. Bell, ***Electronic Instrumentation and Measurements***, 3rd *Ed.*, Oxford University Press, 2013.
R3. J. P. Bentley, ***Principles of Measurement Systems***, 4th *Ed.*, Pearson Education, 2005.
R4. D. V. S. Murthy, ***Transducers and Instrumentation***, 2nd *Ed.*, PHI Learning, 2008.

Online Resources:
1. https://nptel.ac.in/courses/108105153: by Prof. A. Chatterjee, 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 the characteristics, errors, and calibration concepts of different measuring instruments.
CO2	Evaluate the values of R, L, and C using suitable bridges and their applications.
CO3	Analyze the construction, characteristics, and working principles of various measuring instruments.
CO4	Explain the construction, characteristics, and working principles of different sensing elements used in different measuring instruments.
CO5	Explore the concepts of capacitive transducers and their applications in modern industrial instrumentation.

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	2	2							2	3	2	3
CO2	3	3	3	2							2	3	3	2
CO3	3	3	3	3							3	2	2	1
CO4	2	3	2	3							3	3	2	1
CO5	2	3	3	3							3	3	2	2

Category	Code	Circuit Theory	L-T-P	Credits	Marks
PCR	EE2010		3-0-0	3	100

Objectives	The objective of this course is that the student should be able to analyze any circuit configuration, synthesize circuits with any given specification of network functions, and test and improve the design as required.
Pre-Requisites	Basics of Circuit analysis, Laplace transform, Fourier transform, 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 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 Theorems: Thevenin's theorem, Norton's theorem, Superposition theorem, Reciprocity theorem, Maximum power transfer theorem, Millman's theorem (AC & DC Networks); Coupled Circuits: Introduction, Dot Convention, Coefficient of coupling, Electrical equivalent of magnetically coupled coils, Series and parallel connection of coupled coils, Transformer as a magnetically coupled circuit; Resonance: Introduction, Series Resonance, Parallel Resonance, Quality factor, Bandwidth and Selectivity for series and parallel resonant circuits, Frequency Response Curve.	**11 Hours**
Module-2	Laplace Transform & its Application: Fundamentals of Laplace & Inverse Laplace Transform, initial and final value theorem; Fundamentals of Switching behavior of RL, RC & RLC circuits. Application Of Laplace Transform to Transient Analysis: Response of RL, RC & RLC network with step, sinusoidal, impulse, and ramp input.	**8 Hours**
Module-3	Fourier Series and Fourier Transform: Periodic and Aperiodic functions, Fourier Series Analysis of Continuous Time Signals, Fourier Transform, Properties, Circuit analysis with Fourier Series and Fourier Transform; Filters: Introduction to Filters, Frequency Response Curve, Filter Transfer functions and cut-off frequencies.	**7 Hours**
Module-4	Two-Port Networks: Introduction, z, y, ABCD and h-parameters, Reciprocity and Symmetry, Interrelation of two-port parameters, Interconnection of two-port networks; Network Functions & Response: Transfer function and driving point function for one & two-port networks, Concept of poles and zeros, Significance & Restriction on location of Poles and Zeros.	**9 Hours**
Module-5	Network Synthesis: Hurwitz polynomial and its Properties, Positive real functions and their properties, Concepts of network synthesis, Realization of R-L, R-C, and L-C functions in Cauer-I, Cauer-II, Foster-I and Foster-II forms.	**7 Hours**
	Total	**42 Hours**

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. W. H. Hayt, J. Kemmerly, J. D. Phillips, and S. M. Durbin, ***Engineering Circuit Analysis***, 9th *Ed.*, McGraw-Hill Education, 2020.

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. A. Chakrabarti, ***Circuit Theory: Analysis and Synthesis***, 7th *Ed.*, Dhanpat Rai & Co., 2013.
R4. J. D. Irwin and R. M. Nelms, ***Basic Engineering Circuit Analysis***, 11th *Ed.*, Wiley, 2015.

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://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	Describe network theorems, coupled circuits, and resonant circuits and apply them to solve complex network problems.
CO2	Explain the switching phenomena of electrical circuits and evaluate transient and steady-state performance using Laplace Transformation.
CO3	Analyze filter circuits and sinusoidal, and non-sinusoidal signals using the Fourier series and Fourier transform and its application in electrical & electronics circuit analysis.
CO4	Determine two-port network parameters and their practical application to electrical and electronic circuits.
CO5	Identify Network Functions and synthesize one port network using Foster and Cauer forms.

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).
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.
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		2	2			1	1		2	2	1	1
CO2	2	2		2	3			1	1		3	2	1	1
CO3	2	2		2	3			1	1		3	2	1	1
CO4	2	2		1	2			1	1		2	2	1	1
CO5	2	2		1	2			1	1		1	2	1	1

Category	Code	Analog Electronic Circuits	L-T-P	Credits	Marks
PCR	EC2004		3-1-0	4	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	Knowledge of semiconductor diodes and bipolar junction 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.	**11 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.	**11 Hours**
Module-3	Compound Configurations: CMOS and its circuit realization, Darlington pair, Current Mirror, Cascade & Cascode configuration. Frequency Response Analysis: Low Frequency Response of BJT, High Frequency Response of BJT, Low Frequency Response of FET, Miller's Effect, Multistage Frequency Effects, Gain-Bandwidth Relation.	**11 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.	**11 Hours**
Module-5	Feedback Amplifiers: Introduction, Feedback Topologies, Derivation of different parameters (Z_i, Z_o, A_v, A_i), Practical feedback circuits, Standard ICs; Oscillators: Introduction to Oscillators, High Frequency Oscillators: Hartley and Crystal Oscillators, Standard ICs; Power Amplifiers: Introduction to Power Amplifiers, Classification of Power Amplifiers: Class A, Class B, Class C, Push-Pull Amplifiers.	**12 Hours**
	Total	**56 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. V. Wait, L. P. Huelsman, and G. A. Korn, ***Introduction to Operational Amplifier Theory and Applications***, McGraw-Hill USA, 1992.
T4. 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.electrical4u.com/circuit-analysis.htm
4. http://www.allaboutcircuits.com
5. https://www.electronics-tutorials.ws/

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

CO1	Design different biasing methods and small signal models of BJT and estimate the performance parameters of different amplifier configurations.
CO2	Analyze the structural behavior, characteristics and different biasing configurations of JFET and MOSFET.
CO3	Understand and analyze the structural configuration of multi-stage amplifier and plot its frequency response.
CO4	Study the construction and characteristics of an Op-Amp and design circuits for various linear applications using Op-Amp.
CO5	Design various industrial circuits such as oscillators & negative feedback amplifiers using transistors 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).

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	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	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 Electronic Circuits Lab	L-T-P	Credits	Marks
PCR	EC2005		0-0-4	2	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	Basic analytical and logical understanding including knowledge of basic electronics is required.
Teaching Scheme	Regular laboratory experiments to be conducted under supervision of the teacher with focus on implementation in 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	Design and simulate BJT bias circuit and compare the results..
2	Design and simulate JFET bias circuit and compare the results.
3	Design and simulate MOSFET bias circuit and compare the results.
4	Design and simulate BJT common-emitter circuit and compare DC and AC performance.
5	Design and simulate JFET common-source circuit and compare DC and AC performance
6	Design and simulate MOSFET common-source circuit and compare DC and AC performance
7, 8	Determining the frequency response of a common-emitter amplifier: low frequency, high frequency and mid frequency response and compare with simulated results.
9, 10	Differential amplifier circuits: DC bias & AC operation with & without current source.
11	Analysis of RC Coupled Multi Stage Amplifier. (2 Stages).
12, 13	Study of Darlington Circuit and Current Mirror Circuits.
14	OP-Amp Frequency Response and Compensation.
15	Application of Op-Amp as differentiator, integrator, square wave generator.
16	Obtain the band width of FET/BJT using Square wave testing of an amplifier.
17, 18	Study of Feedback Amplifier (Voltage series, Voltage shunt, Current series, and Current shunt configurations).
19, 20	RC phase shift oscillator/Wien-Bridge Oscillator using Op-Amp, Crystal Oscillator
21, 22	Class A and Class B Power Amplifiers.

Text Books:

T1. R. L. Boylestad and L. Nashelsky, ***Electronic Devices and Circuit Theory***, 10^{th} *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/
2. https://wiki.analog.com/university/courses/alm1k/alm_circuits_lab_outline
3. https://wiki.analog.com/university/courses/electronics/labs

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	2	3	2						2	3	2	3
CO6	3	2	3	3	3						1	3	3	2

Category	Code	Basics of Instrumentation Lab	L-T-P	Credits	Marks
PCR	EC2023		0-0-2	1	100

Objectives	The objective of this laboratory course is to practically understand the concepts of static characteristics, dynamic characteristics, error analysis tools, principles, testing & calibration of different measuring instruments.
Pre-Requisites	Basic knowledge of different electrical and magnetic circuits. Topics taught in Basics of Instrumentation 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 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 static and dynamic characteristics of a Measuring Instrument.
2	Statistical analysis of errors in measurement (using standard dataset).
3	Measurement of Low Resistance using Kelvin's Double Bridge.
4	Design & testing of Sinusoidal Oscillator.
5	Measurement of Self Inductance using Anderson's Bridge.
6	Calibration of capacitance sensor using Schering Bridge.
7	Measurement of frequency using Wien's Bridge.
8	Measurement of R, L, and C using Q-meter (bandwidth of a resonance circuit and Q-meter).
9	Study and testing of energy meter and clamp meter.
10	Study of Lissajous pattern and measurement of unknown frequency.
11	Temperature measurement by RTD and Thermistor.
12	Measurement of force using strain gauge.
13	Displacement measurement using LVDT.
14	Level measurement using capacitive transducer & its calibration.

Text Books:

T1. A. K. Sawhney, ***A Course in Electrical and Electronics Measurements & Instrumentation***, Dhanpat Rai & Co, 2015.
T2. A. K. Ghosh, ***Introduction to Measurement and Instrumentation***, 4th *Ed.*, PHI Learning, 2009.

Reference Books:

R1. D. A. Bell, ***Electronic Instrumentation and Measurements***, 3rd *Ed.*, Oxford University Press, 2013.
R2. D. V. S. Murthy, ***Transducers and Instrumentation***, 2nd *Ed.*, PHI Learning, 2008.
R3. E. W. Golding and F. C. Widdis, ***Electrical Measurements and Measuring Instruments***, 5th *Ed.*, Reem Publication, 2015.

P.T.O

Online Resources:

1. https://nptel.ac.in/courses/108105153: by Prof. A. Chatterjee
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	Investigate performance characteristics and evaluate errors of a measuring instrument.
CO2	Accurately measure various electrical parameters using appropriate instruments.
CO3	Measure physical parameters using relevant sensors and measuring instruments.
CO4	Perform analysis on time domain signals to measure unknown parameters.
CO5	Investigate the response of measuring 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).
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	1	1
CO2	3	3	3	2							2	3	1	2
CO3	2	2	3	3							3	3	3	2
CO4	3	3	2	3							3	3	1	1
CO5	3	3	2	3							3	3	2	3

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	Transducers & Measurement Systems	L-T-P	Credits	Marks
PCR	EC2020		3-0-0	3	100

Objectives	The objective of this course is to study the characteristics of different types of measurement systems and industrial applications of various transducers & sensors for design & 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	Dynamic Characteristics: Transfer functions of typical sensing elements, Step & frequency response of first & second-order elements, Dynamic errors, Dynamic compensation; Temperature Measurement: Thermal expansion methods - Bimetallic, Liquid in glass, Thermocouples (Laws, Characteristics, Installation), RTDs (3-wire & 4-wire type), Thermistor, IC type Temperation Sensor, Thermal Radiation Pyrometer (narrowband & broadband), Optical pyrometer.	**9 Hours**
Module-2	Force Measurement: Bourdon tube, bellows, diaphragm, load cell; Torque Measurement: Torsion Bar; Pressure Measurement: Manometers, Mc-Leodgauge, Thermal conductivity, and Ionization gauge; Flow Measurement: Variable Head (Orifice, Venturi, Pitot static), Variable area (Rotameter), Turbine flow meter, Electromagnetic flow meter, Ultrasonic flow meter, Doppler velocity meter.	**9 Hours**
Module-3	Translational & Rotational Velocity Measurement: Moving coil moving magnet pickups, Eddy current magnetic & photoelectric pulse counting; Seismic Measurement: Seismic displacement, velocity & acceleration pickups. Miscellaneous Sensors: Optical sensors, Principle, intensity and phase-modulated sensors, FBG sensor.	**8 Hours**
Module-4	Acceleration Measurement: Piezoelectric transducers - Basic principle, Equivalent circuit, Frequency response, Charge amplifier; Accelerometers: Basic principle & frequency response, MEMS Accelerometer; Miscellaneous Measurements: Level measurements using floats; pH and Liquid Conductivity Measurement: Basic principles, Viscosity Measurement, Chemical Sensors: ISFET, Electro-chemical.	**8 Hours**
Module-5	Signal Conditioning Elements: Deflection bridges - design of resistive & reactive bridges, push-pull configuration for improvement of linearity & sensitivity; Application of Operational Amplifiers: Instrumentation amplifier, Isolation amplifier, Analog filters, Charge amplifier design, AC carrier systems, Phase-sensitive demodulators and its applications.	**8 Hours**
	Total	**42 Hours**

P.T.O

Text Books:

T1. J. P. Bentley, ***Principles of Measurement Systems***, 4^{th} *Ed.*, Pearson Education, 2005.
T2. A. K. Ghosh, ***Introduction to Measurement and Instrumentation***, 3^{rd} *Ed.*, PHI Learning, 2009.

Reference Books:

R1. D. Patranabis, ***Sensors and Transducers***, 2^{nd} *Ed.*, PHI Learning, 2013.
R2. D. V. S. Murthy, ***Transducers and Instrumentation***, 2^{nd} *Ed.*, PHI Learning, 2008.
R3. E. O. Doeblin, ***Measurement Systems - Applications and Design***, 6^{th} *Ed.*, McGraw Hill, 2007.
R4. C. Rangan, G. Sarma, and V. S. V. Mani, ***Instrumentation : Devices and Systems***, 2^{nd} *Ed.*, McGraw Hill, 2017.
R5. B. G. Liptak, ***Instrument Engineers' Hand Book (Process Measurement & Analysis)***, 4^{th} *Ed.*, CRC Press, 2006.

Online Resources:

1. https://nptel.ac.in/courses/108/105/108105088/: by Prof. S. Mukhopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/108/105/108105062/: by Prof. Mukhopadhyay and Sen, IIT Kharagpur
3. https://nptel.ac.in/courses/108/105/108105064/: by Prof. A. Barua, IIT Kharagpur
4. https://nptel.ac.in/courses/108/108/108108147/: By Prof. H. J. Pandya, IISc Bangalore

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

CO1	Explain various measuring instruments and use temperature sensors in industrial applications.
CO2	Articulate the principles and uses of different force, torque, pressure sensors, and flow meters.
CO3	Utilize the concepts of velocity measurement and specialized optical sensors.
CO4	Determine special measuring principles of different physical parameters using various sensors.
CO5	Analyze the design of signal conditioning circuits and evaluate their performance.

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	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	Digital Electronic Circuits	L-T-P	Credits	Marks
PCR	EC2007		3-1-0	4	100

Objectives	The objective of this course is to understand the concepts & techniques associated with digital systems and their design & implementations in VLSI technology.
Pre-Requisites	Knowledge of basic eectronics 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	Introduction: Review of Boolean Algebra and Logic gates; Codes: Binary codes and their application: BCD Code, Excess-3 Code, 2-4-2-1 Code, 8-4-(-2)-(-1) code and Gray code, Code converters; Combinational Logic Design: Boolean Algebra and Identities, Algebraic Reduction using Boolean algebra; Standard Representation for Logic Functions: Sum-of-Products (SOP)and Product-of-Sums (POS) forms, Canonical SOP and POS forms; K-map representation and simplification of logic functions using K-map, Minimization of 2, 3, 4 variable logical functions; Don't care conditions.	**11 Hours**
Module-2	Combinational Logic Components: Adders, Subtractors, Carry-Look-Ahead Adder, Binary Multiplier, Equality Detector and Comparator, BCD to 7-Segment Display, Multiplexer, De-Multiplexer, Decoders, Encoder (Priority Encoder), Design of Combinational Circuits using Multiplexer and Decoder.	**11 Hours**
Module-3	Sequential Logic Design: Latches & Flip flops: S-R, D, JK & T Flip Flops. Master-Slave JK FF, Flip Flop Conversion; Finite State Machines: Mealy and Moore models: FSM Design using Melay and Moore based model, Sequence detector; Synchronous Counters: Up counter, Down Counter, Up-Down Counter, Mod-N Counters & Random Sequence Counter.	**12 Hours**
Module-4	Asynchronous Counter: Up & Down using positive and negative edge trigger Flip Flop, Up-Down Counter, Mod-N Asynchronous counter; Shift Registers: SISO, SIPO, PIPO & PISO, Bi-directional shift register, Universal Shift Register, Ring Counter, Johnson Counter; Data Converters: ADCs and DACs; Basic Operational Characteristics and Parameters: Noise margin, Propagation delay, Fan-in, Fan-out; Semiconductor Memories: Basics of ROM, SRAM & DRAM.	**11 Hours**
Module-5	Verilog HDL: Introduction to Verilog HDL, Verilog design codes using different modeling styles: Data flow, Behavioral, Gate level and Structural Modeling, Data types, Synthesis and Simulation, Verilog Testbench code for design simulation, Port mapping by order, Port mapping by name; Verilog Design Codes for Combinational Circuit: Basic Logic gates - Adder, Subtractor, Mux, De-Mux, Decoder, Encoder; Verilog Design Codes for Sequential Circuit: Latches, Flip Flops & Counters.	**11 Hours**
	Total	**56 Hours**

Text Books:

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

T2. D. P. Leach, A. P. Malvino, and G. Saha, ***Digital Principles and Applications***, 8th *Ed.*, McGraw Hill Education, 2014.
T3. S. Palnitkar, ***Verilog HDL: A Guide to Digital Design and Synthesis***, 2nd *Ed.*, Prentice Hall, 2003.

Reference Books:

R1. D. V. Hall, ***Digital Circuits and Systems***, International Student Edition, McGraw-Hill Education, 1989.
R2. R. P. Jain, ***Modern Digital Electronics***, 4th *Ed.*, McGraw-Hill Education, 2009.
R3. A. A. Kumar, ***Fundamentals of Digital Circuits***, 3rd *Ed.*, PHI Learning, 2014.
R4. W. H. Gothmann, ***Digital Electronics - An Introduction to Theory and Practice***, 2nd *Ed.*, PHI Learning, 1982.

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	Design basic and universal boolean functions using logic gates.
CO2	Design and analyze combinational logic circuits.
CO3	Design and analyze sequential logic circuits and explain finite state machine.
CO4	Design, analyze and implement memory array using sequential network for digital logic and investigate performance of CMOS based logic circuits in modern VLSI technology.
CO5	Simulate and synthesize various digital circuits using HDL in 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).
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	3	2	3	2	1						3	1	
CO2	2	3	2	3	3	1						3	1	
CO3	2	3	2	3	3	1						3	1	
CO4	2	3	2	3	2	1					2	3	1	
CO5	2	3	2	3	2	1					2	3	1	

Category	Code	Solid State Devices	L-T-P	Credits	Marks
PEL	EC2010		3-0-0	3	100

Objectives	The objective of this course is to study the underlying physics of semiconductor devices and designing different semiconductor devices for applications in industry and various other domains.
Pre-Requisites	Knowledge of solid state physics including quantum physics of electrons in isolated atom and group of atoms 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: Review of quantum mechanics, Electrons in periodic lattices, E-K diagrams, Energy bands in solids; Electrons and holes in semiconductors: Silicon crystal structure, Donors and acceptors in the band model, Effective mass, Density of states(D(E)), Thermal equilibrium, Fermi-Dirac distribution function(f(E)) for electrons and holes, Fermi energy, Derivation of equilibrium concentration of electrons (n) and holes (p) from D(E) and f(E), Fermi level and carrier concentrations, np product and intrinsic carrier concentration.	**10 Hours**
Module-2	Electrons, holes and their transport phenomena in semiconductors: Carrier concentrations at extremely high and low temperatures - complete ionization, partial ionization and freeze-out, Energy-band diagram and Fermi-level, Variation of Ef with doping concentration and temperature; Carrier drift: Electron and hole mobilities, Drift current and conductivity and resistivity; Carrier diffusion: diffusion current, Total current density, Thermal generation, Electron-hole recombination.	**9 Hours**
Module-3	PN Junction & Schottky diodes: P-N junction characteristics; Building blocks of the pn junction theory, Energy band diagram and depletion layer of a pn junction, Built-in potential, Carrier injection under forward bias-Quasi-equilibrium boundary condition; current continuity equation, I-V characteristics, Reverse biased P-N junction: Avalanche breakdown, Zener diode, Schottky diode: I-V characteristics, Comparison between Schottky barrier diode and pn-junction diode.	**8 Hours**
Module-4	MOS Capacitor and MOSFET: The MOS structure, Energy band diagrams, Surface accumulation, Surface depletion, Flat-band condition and flat-band voltage, Threshold condition and threshold voltage, C-V characteristics of ideal MOS capacitor, Basic structure of MOSFET, MOSFET Vt, Qinv and I-V Characteristics.	**8 Hours**
Module-5	IC Fabrication Process: Oxidation, Diffusion, Ion implantation, Photolithography, Etching, Chemical vapor deposition, Sputtering and twin tube CMOS process.	**7 Hours**
	Total	**42 Hours**

P.T.O

Text Books:

T1. D. A. Neamen, ***Semiconductor Physics and Devices***, 4^{th} *Ed.*, McGraw-Hill, 2012.
T2. G. Streetman and S. K. Banerjee, ***Solid State Electronic Devices***, 7^{th} *Ed.*, Pearson, 2014.

Reference Books:

R1. S. M. Sze and K. N. Kwok, ***Physics of Semiconductor Devices***, 3^{rd} *Ed.*, John Wiley & Sons, 2006.
R2. C. T.Sah, ***Fundamentals of Solid State Electronics***, 1^{st} *Ed.*, World Scientific Publishing Co., 1991.
R3. D. A. Neamen and D. Biswas, ***Semiconductor Physics and Devices***, 4^{th} *Ed.*, Tata McGraw-Hill Education, 2012.

Online Resources:

1. https://nptel.ac.in/courses/115102103/: by Prof. M. R. Shenoy, IIT Delhi
2. https://nptel.ac.in/courses/113104012/: by Prof. D. Gupta, IIT Kanpur

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

CO1	Analyze charge carrier statistics and calculate various parameters of semiconductor devices.
CO2	Investigate carrier transport phenomena to calculate the conductivity of semiconductor devices.
CO3	Apply the concepts to investigate the electronic properties of diodes under different conditions.
CO4	Investigate the V I characteristics of MOS capacitor and MOSFET.
CO5	Describe and explain the basic fabrication steps in CMOS technology.

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	2	2							1	2	1	1
CO2	3	3	2	2							2	2	2	2
CO3	3	3	3	1							2	2	1	2
CO4	3	1	2	2							2	3	1	2
CO5	3	2	3	3							1	3	1	1

Category	Code	Embedded C Programming	L-T-P	Credits	Marks
PEL	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	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	Advanced Electronic Circuits	L-T-P	Credits	Marks
HNS	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	Power Electronic Devices	L-T-P	Credits	Marks
MNR	EC2024		3-0-0	3	100

Objectives	The objective of this course is to study different types of power semiconductor devices and their switching characteristic, including the operation and characteristics of various power electronic converters.
Pre-Requisites	Knowledge of physics, 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 and parallel grouping of SCR, SCR triggering methods, SCR: Over voltage, Over Current, dv/dt, di/dt, Gate Protection, Snubber circuit.	**10 Hours**
Module-2	AC to DC Converter: Phase Controlled Converter: Principle of phase controlled converter operation, single phase full converter with R, R-L and R-L-E load, 3 phase full converter with R, R-L and R-L-E load, single phase semi converter with R, R-L and R-L-E load.	**10 Hours**
Module-3	AC to AC Converter: Single phase bi-directional controllers with R and R-L load, Single phase cycloconverters – Step up and Step down, Applications.	**6 Hours**
Module-4	DC to DC Converter: First quadrant, second quadrant, first and second quadrant, third and fourth quadrant converter; Switching Mode Regulators: Buck regulators, Boost regulators, Buck-Boost regulators; Isolated Converters: Flyback & Forward Converter, Applications.	**8 Hours**
Module-5	DC to AC Converter: Voltage Source Inverter (VSI) - Single phase Bridge Inverters, 3-Phase Inverters - 180° mode conduction, 120° mode conduction, Voltage control of 3-Phase Inverters by Sinusoidal PWM (PWM VSI), Current Source Inverter (CSI); Power Electronics Applications: UPS, SMPS, Induction Heating, AC/DC drives speed control.	**8 Hours**
	Total	**42 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.

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.

P.T.O

Online Resources:

1. https://nptel.ac.in/courses/108101038/: by Prof. Fernandes and Chatterjee, IIT Bombay.
2. https://nptel.ac.in/courses/108/102/108102145/: by Prof. G. Bhuvaneshwari, IIT Delhi.
3. https://ocw.mit.edu/courses/6-334-power-electronics-spring-2007/pages/lecture-notes/

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

CO1	Articulate the characteristics of power semiconductor devices and fundamentals of thyristors.
CO2	Analyze the operation of AC-DC converters and its application in the practical field.
CO3	Interpret the operation of AC-AC converters and analyze their performance.
CO4	Design and analyze the operation of DC-DC converters and their use in DC drives.
CO5	Investigate the operation of DC–AC converters, SPWM modulation technique and 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	2	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					2	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***, 1^{st} *Ed.*, McGraw Hill Education, 2017.

R2. P. N. Tan, M. Steinbach, A. Karpatne, and V. Kumar, ***Introduction to Data Mining***, 2^{nd} *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	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	Digital Electronic Circuits Lab	L-T-P	Credits	Marks
PCR	EC2008		0-0-4	2	100

Objectives	The objective of the course is to provide hands-on exposure on logic gates, implementation using Boolean algebra, designing digital circuits like counters, registers and apply the knowledge to formulate 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, sessions are planned to be interactive with focus on implementation in 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 & Buffer gates, use of Universal (NAND & NOR) Gates.
2	Gate-level minimization: 2-level and multilevel implementation of Boolean functions.
3	Design, implement and test a given design example with (i) NAND Gates only (ii) NOR Gates only and (iii) Using a minimum number of Gates.
4	Combinational Circuits: design, assemble and test: adders & subtractors.
5	Design, assemble & test code converters: binary code to gray code, gray code to binary and 7 segment displays.
6	Study of Multiplexer, Demultiplexer. Implement a function using multiplexer.
7	Design of Binary to Octal decoder and Implementation of Boolean function using decoder.
8	Flip-Flop: assemble, test & investigate operation of SR, D, J-K & T flip-flops.
9	Shift Registers: Design and investigate the operation of all types of shift registers.
10	Counters: Design, assemble and test various ripple & synchronous counters.
11	Binary Multiplier: design and implement a circuit that multiplies two 4-bit unsigned numbers to produce a 8-bit product.
12	Design, implement & test two bit magnitude comparator.
13	Design of a special type of counters (4-bit ring counter & Johnson counter) using JK flip-flops.
Verilog Simulation & Implementation	
14	Different types of logic gates.
15	Half adder and half subtractor using different types of modeling.
16	Full adder and full subtractor using different types of modeling.
17	Multiplexer circuits using different types of modeling.
18	Decoder circuits using different types of modeling.
19	SR-FF, D-FF, JK-FF, T-FF.
20	4-bit up counter & 4-bit down counter.

Text Books:

T1. M. M. Mano and M. D. Ciletti, ***Digital Design: With an Introduction to Verilog HDL, VHDL and System Verilog***, 6th *Ed.*, Pearson Education, 2018.

T2. S. Palnitkar, ***Verilog HDL: A Guide to Digital Design and Synthesis***, 2nd *Ed.*, Pretince Hall, 2003.

Reference Books:

R1. A. M. Michelén, ***Digital Electronics Laboratory Manual***, Pearson Education, 2000.

R2. J. W. Stewart and C. -Y. Wang, ***Digital Electronics Laboratory Experiments: Using the Xilinx XC95108 CPLD with Xilinx Foundation : Design and Simulation Software***, 2nd *Ed.*, Pearson, 2004.

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://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-111-introductory-digital-systems-laboratory-spring-2006/

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

CO1	Analyze the function of logic gates and implement of Boolean functions.
CO2	Realize universal gates and implement minimized Boolean expressions.
CO3	Design and analyze different combinational circuits.
CO4	Design various asynchronous and Synchronous Sequential Circuits.
CO5	Acquire knowledge about internal circuitry and logic behind any digital system.
CO6	Simulate various digital circuits using VHDL in industry standard tool such as Xilinx.

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	3	2	3	2	1						3	1	
CO2	2	3	3	3	3	1						3	1	
CO3	2	3	3	3	3	1					1	3	1	
CO4	2	3	2	3	2	1					1	3	1	
CO5	2	3	2	3	2	1					1	3	1	
CO6	2	3	2	3	2	1					1	3	1	

Category	Code	Transducers & Measurement Systems Lab	L-T-P	Credits	Marks
PCR	EC2021		0-0-2	1	100

Objectives	The objective of this laboratory course is to get practical exposure to transducers and measurement systems for accurately measuring temperature, weight, position/displacement, pressure, flow, level, etc.
Pre-Requisites	Basic knowledge of physics, mathematics, electrical and electronics is required. Topics taught in TMS 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 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	Analyze the response of the vibration sensor.
2	Temperature sensing using semiconductor type temperature sensor.
3	Weight measurement using strain gauge Load cell.
4	Implementation of LVDT and its signal conditioning for position/displacement measurement.
5	Pressure measurement using Bourdon tube and diaphragm type sensor.
6	Temperature measurement using a thermocouple.
7	Flow measurement using turbine-type flow sensor.
8	Time duration measurement using DAQ system and LabView.
9	Speed measurement using optical and variable reluctance type transducers.
10	Design of active 2nd order low pass filter.
11	Design of a piezoelectric accelerometer with charge amplifier configuration
12	Design of Instrumentation amplifiers.
13	Design of Phase sensitive detector.
14	Analyze the characteristics of Fiber Bragg Grating (FBG) sensor.

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.

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	Analyze the characteristics of RTD and Thermistor.
CO2	Measure temperature, weight and position using different sensors.
CO3	Explain the techniques to measure flow, level and speed using various types of sensors.
CO4	Conceptualize and design different types of active filters.
CO5	Design instrumentation amplifiers and phase sensitive detectors.

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	3	3	2
CO2	3	3	3	2	3						2	3	2	2
CO3	3	3	3	3	3						3	2	2	2
CO4	2	2	2	2	2						2	3	1	1
CO5	3	3	2	2	3						2	2	2	3

Category	Code	Simulation & Design Lab	L-T-P	Credits	Marks
PCR	EC2022		0-0-2	1	100

Objectives	The objective of this laboratory course is to provide hands-on experience in simulating, designing, and analyzing systems using advanced tools. Students will gain practical insights into signal processing, data acquisition, hardware interfacing, and the integration of software with physical systems.
Pre-Requisites	Knowledge of programming, analog & digital electronics, sensors, and transducers is required to conduct the experiments.
Teaching Scheme	Regular laboratory experiments conducted under supervision of the teacher. 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	Introduction to MATLAB: Basic commands, plotting, and simulating simple mathematical models.
2	Design and simulation of RC, RL and RLC circuits in time and frequency domains.
3	Simulation and analysis of transient and steady-state responses of electrical systems.
4	Introduction to LabVIEW: Creating simple virtual instruments (VIs) for data acquisition and analysis.
5	Simulate the step response of a first-order system using LabVIEW.
6	Arduino Basics: Setting up the IDE, blinking LEDs, and interfacing simple input/output devices.
7	Temperature measurement using an LM35 sensor with Arduino and displaying data on the serial monitor.
8	Interfacing an ultrasonic sensor with Arduino for distance measurement.
9	Pulse Width Modulation (PWM) generation and motor speed control using Arduino.
10	Interfacing an LDR (Light Dependent Resistor) with Arduino for light intensity measurement.
11	Build a virtual oscilloscope for signal visualization using LabVIEW.
12	Measure voltage from a sensor or potentiometer and display it in LabVIEW.
13	Signal processing: Filtering and FFT analysis of sensor signals using LabVIEW.
14	Mini Project: Design and implementation of a simple system integrating Arduino, sensors, and LabVIEW.

Text Books:

T1. G. Johnson, ***LabVIEW Graphical Programming***, 4^{th} *Ed.*, McGraw Hill, 2006.
T2. A. K. Sawhney, ***A Course in Electrical and Electronics Measurements & Instrumentation***, Dhanpat Rai & Co, 2015.
T3. M. Schwartz, ***Internet of Things with Arduino Cookbook***, Packt Publishing, 2016.

P.T.O

Reference Books:

R1. R. Pratap, ***Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers***, South Asia Edition, Oxford University Press, 2010.

R2. D. V. S. Murthy, ***Transducers and Instrumentation***, 2nd *Ed.*, PHI Learning, 2008.

R3. G. W. Johnson and R. Jeninngs, ***LabVIEW Graphical Programming***, 4th *Ed.*, McGraw-Hill Education, 2019.

Online Resources:

1. https://nptel.ac.in/courses/108107115: by Prof. Yogesh Vijay Hote, IIT Roorkee.
2. https://nptel.ac.in/courses/103106118: by Prof. Dr. Niket S.Kaisare, IIT Madras.
3. https://nptel.ac.in/courses/108105376: by Prof. Banibrata Mukherjee, IIT Kharagpur.
4. https://nptel.ac.in/courses/106106210: by Prof. Janakiraman Viraraghavan, IIT Madras.

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

CO1	Simulate mathematical models, analyze circuits and evaluate responses of systems.
CO2	Design and create virtual instruments for data acquisition, signal processing, and visualization.
CO3	Interface various sensors for data acquisition and control using Arduino programming.
CO4	Apply signal processing techniques to interpret sensor outputs effectively.
CO5	Design, simulate, and prototype integrated systems to solve real-world 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).
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						2	3	2	2
CO2	3	3	3	3	3						2	3	2	2
CO3	3	3	3	3	3						3	3	3	2
CO4	3	3	2	3	3						3	3	2	3
CO5	3	3	3	3	3						3	3	2	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***, 2^{nd} *Ed.*, Prentice Hall India, 1992.
T2. B. P. Lathi, ***Principles of Signal Processing and Linear Systems***, 2^{nd} *Ed.*, Oxford Univ. Press, 2009.
T3. J. G. Proakis and D. G. Manolakis, ***Digital Signal Processing : Principles, Algorithms and Applications***, 4^{th} *Ed.*, Prentice Hall India, 2007.
T4. S. K. Mitra, ***Digital Signal Processing : A Computer Based Approach***, 4^{th} *Ed.*, McGraw-Hill, 2013.

Reference Books:
R1. A. Ambardar, ***Analog and Digital Signal Processing***, 2^{nd} *Ed.*, Brooks/Cole Publishing Company (an International Thomson Publishing Company), 1999.
R2. M. J. Roberts, ***Signals and Systems - Analysis using Transform Methods and MATLAB***, 2^{nd} *Ed.*, McGraw-Hill, 2003.
R3. A. N. Kani, ***Signals and Systems***, 2^{nd} *Ed.*, McGraw-Hill Education, 2010.
R4. A. N. Kani, ***Digital Signal Processing***, 2^{nd} *Ed.*, McGraw-Hill Education, 2012.
R5. P. R. Babu, ***Digital Signal Processing***, 4^{th} *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	Digital VLSI Design	L-T-P	Credits	Marks
PCR	EC3002		3-1-0	4	100

Objectives	The objective of this course is to study the design, fabrication & testing of devices, circuits & systems using integrated micro fabrication technologies providing an in-depth coverage of the state of the art in 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**: Historical Perspective, 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 and Layout of complex CMOS Logic Gates (Euler Method).	**11 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.	**11 Hours**
Module-3	**MOS Inverter Circuits**: 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, Schematic of sequential circuit.	**12 Hours**
Module-4	**Switching Characteristics & Interconnect Effects**: Introduction, Switching Time Analysis, Design with delay constraints, Calculation of Interconnect Parasitics, Calculation of Interconnect Delay (Elmore Delay), Power Dissipation in CMOS Gates, Power and Delay product.	**11 Hours**
Module-5	**Transfer Gate & Dynamic Logic Design**: Introduction, Pass Transistor concepts, CPL, CMOS Transmission Gate, Dynamic & Domino logic, NORA; Basics of Semiconductor Memory - DRAM, SRAM Cell Design & Operation, Memory Architecture.	**11 Hours**
	Total	**56 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	Explain 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				2	1	2		2
CO2	3	3	1	2	2	1						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	Instrumentation Devices & Systems	L-T-P	Credits	Marks
PCR	EC3047		3-0-0	3	100

Objectives	The objective of this course is to learn the principles, working and industrial applications of various types of sensors used in process instrumentation.
Pre-Requisites	Knowledge of electrical and electronics measurement, sensor fundamentals, signal processing with basic understanding of physics and industrial processes 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	**Level Measurement**: Mechanical level sensors - Displacers, Diaphragm level indicators, Differential pressure level indicators, Air, Bubblers; Optical level sensors- Laser sensors, IR and visible light sensors; Electrical level sensors- Resistive, Inductive and capacitive level Indicators; Ultrasonic level indicators, Gamma-ray level indicators.	**9 Hours**
Module-2	**Humidity Measurement**: Capacitive and resistive types, pH and liquid conductivity measurement - Basic principles; Viscosity measurement - Basic principles, Problems based on level, Hydrostatic pressure measurement; Chemical sensors - For gas and humidity measurements, Electronic (resistive, capacitive, FET), Electro-chemical, Intelligent (smart) sensor systems and their structure, Properties and applications, Primarily data processing, Diagnostics and auto-calibration.	**8 Hours**
Module-3	**Consistency Measurement**: Definition, Methods of measurement, Turbidity measurement - Turbidity and scattering of light, Isotropic scattering and turbidity, Units of turbidity, Methods of measurement, Opacity measurement, Units and definition and methods of measurement.	**9 Hours**
Module-4	**Density Measurement**: Hydrometers, Differential bubblers, Differential pressure cells, Coriolis densitometer, displacer and float-type densitometers, Vibrating U-tube densitometers, Weight-based U-tube densitometer, Ultrasonic densitometer, Gamma-ray densitometers; Industrial gas analysis - Methods based on thermal properties, Oxygen & Carbon monoxide analysis.	**9 Hours**
Module-5	**Infrared Analyzer**: Analyzer types, IR source, IR detectors, Fourier transform infrared analysis, Sample handling systems, Removing particulate matter, Removing aerosol and water vapour, Keeping the sample above its dew point, Signal conditioning - Recovery of signals, Lock-in amplifier, PLL.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. A. K. Ghosh, ***Introduction to Measurements and Instrumentation***, 3rd *Ed.*, PHI Learning, 2009.
T2. J. P. Bentley, ***Principles of Measurement Systems***, 4th *Ed.*, Pearson Education, 2005.

Reference Books:

R1. D. Patranabis, ***Sensors and Transducers***, 2nd *Ed.*, PHI Learning, 2010.

R2. B. G. Liptak, ***Instrument Engineers' Hand Book (Process Measurement & Analysis)***, 4th *Ed.*, CRC Press, 2006.
R3. E. O. Doebelin, ***Measurement Systems Application and Design***, 4th *Ed.*, McGraw-Hill, 1990.

Online Resources:
1. https://nptel.ac.in/courses/108105062: by Prof. S. Sen and Prof. S. Mukhopadhyay, IIT Kharagpur
2. 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 principles of different types of level sensors and their industrial applications.
CO2	Describe humidity, pH, viscosity and smart sensor measurement principles and applications.
CO3	Analyze industrial techniques for measuring consistency, turbidity, and opacity.
CO4	Apply industrial techniques for density measurement and gas analysis methods.
CO5	Explain IR analyzers, FTIR techniques, sample handling, and signal conditioning 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).
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	2	2	1	1	2	1				2	3	2	3
CO2	2	2	1	2	2	1	1				2	3	2	3
CO3	2	2	2	2	2	2	1				2	3	2	3
CO4	2	2	2	3	2	2	1				3	3	2	3
CO5	2	2	3	2	3	2	1				2	3	2	2

Category	Code	Communication Systems Engineering	L-T-P	Credits	Marks
PCR	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***, 4^{th} *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	IC Fabrication Technology	L-T-P	Credits	Marks
PEL	EC3013		3-0-0	3	100

Objectives	The objective of this course is to learn the fabrication flow and IC integration process of semiconductor devices and semiconductor ICs.
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.	**9 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.	**8 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.	**9 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.	**8 Hours**
Module-5	**IC Process Integration**: Bipolar transistor fabrication, Isolation techniques, P-MOS, N-MOS and C-MOS processes.	**8 Hours**
	Total	**42 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***, 2^{nd} *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	IoT & Applications	L-T-P	Credits	Marks
XXX	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	PLC, SCADA & Distributed Control Systems	L-T-P	Credits	Marks
PEL	EC3052		3-0-0	3	100

Objectives	The objective of this course is to learn programmable logic controllers, distributed control systems and SCADA to design and develop an instrumentation system for automation of large-scale process industries.
Pre-Requisites	Knowledge of electrical, electronics and computer programming 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 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	**Programmable Logic Controller (PLC)**: Definition, Historical background, Parts of a PLC, Principles of operation, PLCs vs. other types of controllers, PLC size and application, Advantages of PLCs, Developing fundamental PLC wiring diagrams and ladder logic programs, Electromagnetic control relays, Contactors, Motor starters, Manually and Mechanically operated switches, Sensors, Output control devices, Seal-in circuits, Electrical interlocking circuits, Converting relay schematics into PLC ladder programs, Ladder logic program from a narrative description.	**8 Hours**
Module-2	**PLC Programming**: Introduction, Types of PLC languages, Ladder diagram format, Ladder relay instructions, Ladder relay programming, Fundamentals of logic, Timers and counters, Program/Flow control instructions, Arithmetic instructions, Data manipulation, Data transfer instructions and special function instructions, Math instructions; PLC Installation Practices; Editing and Troubleshooting - PLC enclosures, Electrical noise, Leaky inputs and outputs, Grounding, Voltage variations and surges, Program editing and commissioning, Programming and monitoring, Preventive maintenance, Trouble shooting, PLC programming software.	**9 Hours**
Module-3	**Introduction to SCADA**: Data acquisition systems, Evolution of SCADA, Communication technologies, Monitoring & supervisory functions, SCADA applications in utility automation, Industries; SCADA System Components –Schemes, Remote terminal unit, Master terminal units, Intelligent electronic devices, Communication network, SCADA server, Operator interface, SCADA applications in utility industry.	**8 Hours**
Module-4	**Distributed Control Systems (DCS)**: Introduction, History of DCS, Distributed vs Centralized control, DCS concept, Communication in DCS, Modes of DCS, DCS hardware & software, DCS structure, Architectural feature of DCS, DCS design considerations, DCS Subsystem, Advantages & disadvantages, Presentation and monitoring devices, Communication options in DCS, Configuration, Some popular DCS and Field bus systems.	**9 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	**System Integration with PLC & Computer**: Supervisory computer functions, Supervisory control and optimization; Computer interface with DCS hardware - Gateway, Interface with PLC, Interface with direct I/O, Network linkages, Links between networks, Industrial network system, Data communication, Star topology, Bus topology, Peer-to-peer network, Serial communication protocols.	8 Hours
	Total	**42 Hours**

Text Books:

T1. F. D. Petruzella, ***Programmable Logic Controllers***, 5th *Ed.*, McGraw-Hill Education, 2017.
T2. S. A. Boyer, ***SCADA - Supervisory Control and Data Acquisition***, 3rd *Ed.*, Instrument Society of America, 2004.
T3. K. Kant, ***Computer Based Industrial Control***, 2nd *Ed.*, PHI Learning, 2010.

Reference Books:

R1. S. Bhanot, ***Process Control: Principles and Applications***, 1st *Ed.*, Oxford University Press, 2008.
R2. L. A. Bryan and E. A Bryan, ***Programmable Controller: Theory and Implementation***, 3rd *Ed.*, Industrial Text Company Publication, 2003.
R3. D. H. Hanssen, ***Programmable Logic Controller: A Practical Approach to IEC61131-3 using CoDeSys***, 1st *Ed.*, John Wiley & Sons, 2015.
R4. K. P. Raju and Y. J. Reddy, ***Instrumentation and Control System***, McGraw-Hill Education, 2017.
R5. B. G. Liptak, ***Process Control: Instrument Engineers Handbook***, 4th *Ed.*, The Instrumentation Systems and Automation Society, 2006.

Online Resources:

1. https://nptel.ac.in/courses/108105063: by Prof. S. Mukhopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/108105088: by Prof. S. Mukhopadhyay, IIT Kharagpur
3. https://nptel.ac.in/courses/108105062: by Prof. S. Sen and Prof. S. Mukhopadhyay, IIT Kharagpur

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

CO1	: Design and develop PLC wiring and ladder logic programs for industrial control systems.
CO2	Develop, edit, and troubleshoot PLC programs using ladder logic and software tools.
CO3	Describe SCADA architecture and applications in industrial monitoring and automation.
CO4	Explain DCS architecture and configure hardware, software and communication systems.
CO5	Integrate PLCs with computers and networks for supervisory control and data exchange.

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)
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	2	2				2	3	2	3
CO2	3	3	2	2	3	2	2				2	3	3	2
CO3	3	3	3	2	2	2	2				3	2	2	1
CO4	2	2	3	3	3	3	3				3	3	2	1
CO5	2	2	2	3	2	2	3				3	3	2	2

Category	Code	VLSI System Design & Verification	L-T-P	Credits	Marks
PEL	EC3054		3-0-0	3	100

Objectives	The objective of this course is to learn the Verilog HDL techniques for the design and analysis of digital circuits and systems.
Pre-Requisites	Fundamental knowledge on digital electronics circuits and MOSFET 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 and Ports modules, Port declaration, Port connection rules, Connecting ports to external signals.	**7 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, Turn-off delays, Min/Typical/Max values; Switch-level modeling - Switch-modeling elements, MOS switches, CMOS switches.	**9 Hours**
Module-3	**Combinational Circuit Design-II**: Behavioral modeling - Initial and Always statements, Adders, Subtractors, Comparator, MUX & DeMUX (Using if...else and case construct); Loops – While, For, Repeat & Forever loops (with relevant examples); Structural modeling - 4-Bit adders, 2-Bit multiplier, 4-Bit comparator, 8:1-MUX & 1:8-DeMUX.	**9 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 & 2:4 Decoders, Test Bench of Decoder, Priority encoders, Test bench of priority encoder; Latches and Flip-Flops - D Latch, Flip-flop, Positive & negative edge-triggered D flip-flop.	**9 Hours**
Module-5	**Sequential Circuit Design**: Synchronous & asynchronous reset, Counter design using synthesizable constructs – Synchronous & Asynchronous counters, BCD up–down counter; Finite state machine (FSM) - Melay & Moore machines, Verilog implementation of Sequence detector (Overlapping Permitted & Non-overlapping), Vending machine.	**8 Hours**
	Total	**42 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

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

CO1	Explain the basic concepts and syntax of Verilog HDL.
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	2	2	1	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	2	1
CO4	1	3	3	3	2	1					2	1	3	2
CO5	1	3	3	3	2	1					1	1	3	1

Category	Code	Embedded System Design	L-T-P	Credits	Marks
PEL	EC3017		3-0-0	3	100

Objectives	The objective of this course is to learn the components, program, integrate and manage hardware and firmware to design and develop embedded systems for real-world applications.
Pre-Requisites	Knowledge of microprocessor and microcontrollers, basic electronics, digital electronic 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 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 Embedded Systems and EDLC - Definition, Characteristics, Types of embedded systems, Design metrics components: processor, memory, I/O, sensors, SoC Embedded Product Development Life Cycle (EDLC), EDLC Models - Waterfall, V-model. Design metrics - Power, Performance, Reliability.	**9 Hours**
Module-2	Embedded Processors - Processor taxonomy - RISC & CISC, Processor performance, General processor architecture, Basic RISC architecture, Concept of pipelining, Pipelining stages, Load store architecture, Data and control instructions, Branching instructions, Control flow, Memory map and addressing modes, Basic Assembly language programs.	**10 Hours**
Module-3	Embedded Hardware Design, Development, Testing, Introduction to RTOS, Digital/Analog components, Interfacing, Timers, ADC/DAC, System bus architectures, Communication interfaces: USB, SPI, I2C, CAN Integration of hardware and firmware techniques, Board bring-up, Product eclosure development tools and techniques; Introduction to RTOS: Real time tasks, Types, Task periodicity- periodic, Sporadic, Aperiodic, Concept of task utilization.	**9 Hours**
Module-4	Hardware-Software co-simulation and program modeling - Introduction to Hardware-Software co-simulation, Co-simulation approaches, Specification techniques and Program Modeling - Basic computational models in embedded systems - DFG, CDFG, State machine model, State chart, Petri nets, Unified Modeling Language (UML) - Design examples, Hardware-Software tradeoffs.	**8 Hours**
Module-5	Application Trends and Case Studies - Design process and examples, Design of ACVM, Smart card, Digital camera, Model train controller, Automotive design and relevant examples.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. R. Kamal, ***Embedded Systems – Architecture, Programming and Design***, 12th *Ed.*, Tata McGraw-Hill, 2007.
T2. K. V. Shibu, ***Introduction to Embedded Systems***, 2nd *Ed.*, Tata McGraw-Hill, 2017.
T3. W. Wolf, ***Computers as Components - Principles of Embedded Computing System Design***, 2nd *Ed.*, Morgan Kauffman, 2008.

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/106105159: by Prof. A. Basu, IIT Kharagpur
2. https://nptel.ac.in/courses/108102045: by Prof. S. Chaudhary, IIT Delhi

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

CO1	Describe embedded system concepts, components, design metrics and product life cycle models.
CO2	Explain processor architectures, instruction types, pipelining and basic assembly programming.
CO3	Apply hardware design, interfacing, communication protocols and RTOS concepts in systems.
CO4	Analyze hardware-software co-design methods and perform testing, debugging and validation.
CO5	Explore embedded design processes by case studies in consumer and 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).
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)
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	3	3	3	2			1				2	1		3
CO2	3	3	1	2			1				2	2	1	2
CO3	3	3	2	3	1		1				2	2	1	2
CO4	3	3	3	2	2	1	2			1	2	1	2	2
CO5	3	3	3	1	1	1	2			1	2	3	1	2

Category	Code	Introduction to Machine Learning	L-T-P	Credits	Marks
PEL	EC3018		3-0-0	3	100

Objectives	The objective of this course is to study various supervised, unsupervised, and reinforcement learning techniques & algorithms to discover patterns in data and make predictions based on the patterns for solving business problems.
Pre-Requisites	Knowledge of engineering 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	**Supervised Learning**: Overview of supervised learning; Simple linear regression - Estimation, Interpretation and Assumptions. Multiple linear regressions - Model building, Interpretation of coefficients, Interaction terms and Diagnostics, Evaluation metrics for regression, Model selection techniques - Best subset selection, Forward & backward stepwise selection, Regularization techniques - Ridge and Lasso Regressions, Discussion on bias-variance tradeoff and overfitting in linear models.	**9 Hours**
Module-2	**Classification**: Classification problems, Logistic regression, K-Nearest Neighbors (KNN) for classification – Algorithm, Distance metrics and Sensitivity to k; Evaluation metrics - Confusion matrix, Accuracy, Precision, Recall, F1-score, ROC curve and AUC; Comparative discussion between parametric & non-parametric classifiers, Limitations and use-cases of classification models.	**8 Hours**
Module-3	**Generative Models & SVM**: Generative models for discrete data - Bayesian concept learning and Naïve Bayes classifier; Support Vector Machines (SVM) for classification; Concept of kernel functions & trick; Reproducing Kernel Hilbert Space (RKHS), Non-linear classification using kernelized SVMs, Support Vector Regression (SVR).	**9 Hours**
Module-4	**Unsupervised Learning**: Clustering methods (K-Means, Hierarchical Clustering), Dimensionality reduction (PCA, LDA) and their use in preprocessing and visualization, Model evaluation techniques (validation set, LOOCV, k-fold CV, bootstrap), Decision trees and Ensemble methods (Bagging, Random Forest, AdaBoost, Gradient Boosting).	**8 Hours**
Module-5	**Reinforcement Learning**: Distinction from supervised & unsupervised learning, Key components - Agent, Environment, State, Action, Reward, and Return, The single-state case - K-armed bandit problem, Exploration vs. exploitation trade-off, ε-greedy strategy and Upper-confidence bound methods; Elements of reinforcement learning – Markov Decision Process (MDP), Policy, Value function, Reward signal, and Transition models, Model-based learning approaches - Value iteration, Policy iteration, Update rules & convergence behavior.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. T. Hastie, R. Tibshirani, and J. Friedman, ***The Elements of Statistical Learning - Data Mining, Inference, and Prediction***, 2^{nd} *Ed.*, Second Edition, 2009.
T2. S. Haykin, ***Neural Networks and Learning Machines***, 3^{rd} *Ed.*, Pearson Education, 2009.
T3. E. Alpaydın, ***Introduction to Machine Learning***, 2^{nd} *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***, 2^{nd} *Ed.*, Springer, 2013.
R2. T. M. Mitchell, ***Machine Learning***, 1^{st} *Ed.*, McGrow-Hill Education, 2013.
R3. C. M. Bishop, ***Pattern Recognition and Machine Learning***, 1^{st} *Ed.*, Springer, 2006.

Online Resources:

1. https://nptel.ac.in/courses/106106139: by Dr. B. Ravindran, IIT Madras
2. https://nptel.ac.in/courses/106106143: by Dr. B. Ravindran, IIT Madras
3. https://nptel.ac.in/courses/106105152: by Prof. S. Sarkar, IIT Kharagpur

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

CO1	Apply supervised learning and linear regression models with evaluation and regularization.
CO2	Analyze & select suitable classification models using metrics to address real-world problems.
CO3	Implement generative, SVM, and SVR models for effective classification and regression tasks.
CO4	Apply clustering, dimensionality reduction, and ensemble methods for data analysis.
CO5	Apply reinforcement learning concepts and models to solve dynamic real-world 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).
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	3	1	1						1	3	1	2
CO2	3	2	3	1	1						1	3	1	3
CO3	3	3	3	2	1						1	3	1	2
CO4	3	2	2	2	1						1	3	1	2
CO5	2	2	2	2	1						1	3	1	3

Category	Code	Mechatronics in Manufacturing	L-T-P	Credits	Marks
HNS	EC3057		3-0-0	3	100

Objectives	The objective of this course is to study various aspects of mechatronics such as programmable logic devices, hydraulic and pneumatic systems, drives and mechanisms, and applications of mechatronics in the manufacturing industry.
Pre-Requisites	Knowledge of electronics and electrical engineering is required.
Teaching Scheme	Regular classroom lectures with the use of ICT as required; sessions are planned to be interactive with a focus on examples, case studies, and the 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	**Mechatronics**: Introduction, Examples of mechatronic systems, Embedded systems, The design process, Traditional and mechatronic designs, Systems – Modelling of systems, Connected systems, Measurement systems, Control systems, Feedback, Basic elements of a closed-loop system, Analog and digital control systems, Sequential controllers.	**8 Hours**
Module-2	**Hydraulic & Pneumatic Systems**: Actuation systems, Hydraulic systems, Pneumatic systems - Flapper nozzle system, I/P converter, Valves, Directional control valves, Directional valves, Pressure control valves, Cylinders, Cylinder sequencing, Servo and proportional control valves, Valve bodies and plugs, Control valve sizing.	**8 Hours**
Module-3	**Electrical Drives**: Electrical Systems, Mechanical Switches, Relays, Solid-state switches, Solenoids, DC motors, AC motors, Stepper motors, Stepper motor specifications, Stepper motor control and selection, DC Servo motors, Use of Diodes, Thyristors, TRIACs, Bipolar Transistors and MOSFETs in motor drives.	**9 Hours**
Module-4	**Mechanisms**: Mechanical systems, Types of motion, Freedom and constraints, Loading, Kinematic chains(Four bar, slider-crank), Cams, Gears, Gear trains, Rotational to translational motion, Ratchet and pawl, Belt and chain drives, Bearings, Electromechanical linear actuators.	**8 Hours**
Module-5	**System Models**: Mathematical models, Mechanical system building blocks, Rotational systems, Building up a mechanical system, Electrical system building blocks, Electrical and mechanical analogies, Fluid system building blocks, Building up a model for a fluid system, Thermal system building blocks, Building up a model for a thermal system.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. W. Bolton, ***Mechatronics***, 4^{th} *Ed.*, Pearson Education, 2010.
T2. C. W. De Silva, ***Mechatronics: An Integrated Approach***, 1^{st} *Ed.*, CRC Press,2005.

Reference Books:

R1. D. Shetty, ***Mechatronics: Systems Design***, 2^{nd} *Ed.*, CI-Engineering, 2010.
R2. C. D. Johnson, ***Process Control Instrumentation Technology***, 8^{th} *Ed.*, Pearson Education, 2015.

Online Resources:

1. https://nptel.ac.in/courses/112107298: by Prof. P. M. Pathak, IIT Roorkee
2. https://nptel.ac.in/courses/112101304: by Prof. P. Gandhi, IIT Bombay
3. https://nptel.ac.in/courses/112103174: by Dr. S. N. Joshi, IIT Guwahati

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

CO1	Explain the fundamentals of mechatronic system design and modeling with control concepts.
CO2	Analyze hydraulic and pneumatic actuation systems and their control valve mechanisms.
CO3	Explain the operation and control of electrical drives and solid-state motor systems.
CO4	Analyze mechanical systems and mechanisms used for motion and power transmission.
CO5	Develop mathematical models for mechanical, electrical, fluid and thermal 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).
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	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	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	Renewable Energy Systems	L-T-P	Credits	Marks
MNR	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	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	Introduction to Digital Signal Processing Lab	L-T-P	Credits	Marks
PCR	EC3048		0-0-2	1	100

Objectives	The objective of the lab course is to perform basic signal processing operations such as linear & circular convolution, auto & cross correlation, frequency analysis, and implementation of FIR & IIR filters using MATLAB.
Pre-Requisites	Knowledge of signals & systems and MATLAB programming are required.
Teaching Scheme	Regular laboratory experiments to be conducted under the supervision of the teacher. Demonstration will be given for each experiment using ICT.

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	Generation of various types of waveforms (sine, cosine, square & triangular) using MATLAB.
2	Linear convolution of sequences (without using the inbuilt convolution function in MATLAB).
3	Computation of autocorrelation of a sequence, cross correlation of two sequences using MATLAB.
4	Finding the convolution of a periodic sequence using DFT & IDFT in MATLAB.
5	Circular convolution of two sequences and comparison of the result with the result obtained from linear convolution using MATLAB.
6	Convolutions of long duration sequences using overlap add & overlap save using MATLAB.
7	Implementation of FFT algorithm by decimation in time (DIT) using MATLAB.
8	Implementation of FFT algorithm by decimation in frequency (DIF) using MATLAB.
9	Design and implementation of FIR (lowpass and high pass) filters using windowing techniques (rectangular, triangular & kaiser) in MATLAB.
10	Design and implementation of HR (lowpass and high pass) filters (Butterworth and Chebyshev) in MATLAB.

Text Books:

T1. J. G. Proakis and D. G. Manolakis, ***Digital Signal Processing : Principles, Algorithms and Applications***, 4^{th} *Ed.*, Prentice Hall India, 2007.
T2. A. V. Oppenheim, A. S. Willsky, and S. H. Nawab, ***Signals and Systems***, 2^{nd} *Ed.*, Prentice Hall India, 1992.
T3. S. K. Mitra, ***Digital Signal Processing : A Computer Based Approach***, 4^{th} *Ed.*, McGraw Hill, 2013.

Reference Books:

R1. P. R. Babu, ***Digital Signal Processing***, 4^{th} *Ed.*, SciTech Publication, 2011.
R2. R. Pratap, ***Getting Started with MATLAB : A Quick Introduction for Scientists & Engineers***, 1^{st} *South Asia Ed.*, Oxford University Press, 2010.
R3. A. N. Kani, ***Signals and Systems***, 2^{nd} *Ed.*, McGraw Hill Education, 2010.
R4. S. S. Kumar and S. V. B. Lenina, ***MATLAB: Easy Way Of Learning***, 1^{st} *Ed.*, PHI Learning, 2016.

Online Resources:

1. https://nptel.ac.in/courses/108107115: by Prof. Y. V. Hote, IIT Roorkee
2. https://nptel.ac.in/courses/103106118: by Prof. N. Kaisare, IIT Madras

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

CO1	Generate and analyze various continuous and discrete-time waveforms using MATLAB.
CO2	Analyze basic signal processing operations like convolution, correlation etc.
CO3	Implement convolution of long duration sequences using overlap save and add methods.
CO4	Implement various efficient computation technique using FFT-DIT and FFT-DIF algorithm.
CO5	Design FIR & IIR filters using windowing and classical filter techniques in MATLAB.

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	1						1	2	1	1
CO2	2	1	2	2	1						2	2	2	1
CO3	3	2	1	1	3						2	2	1	2
CO4	2	1	3	3	2						3	3	2	1
CO5	3	2	1	1	2						2	2	1	2

Category	Code	Digital VLSI Design Lab	L-T-P	Credits	Marks
PCR	EC3005		0-0-2	1	100

Objectives	The aim of this course is to enable students to design, simulate and implement digital circuits using VLSI design tools and to develop skills in logic synthesis, timing analysis and layout design, integrated circuit design for semiconductor industry applications.
Pre-Requisites	Basic knowledge on semiconductors physics and digital electronics is required.
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	Design a schematic and simple layout for CMOS inverter, Parasitic extraction and simulation.
2	Design a schematic and simple layout for CMOS NAND & NOR gate, Parasitic extraction and simulation.
3	Design and simulation of full adder.
4	Design and simulation of MUX, De-MUX.
5	Design and simulation of the D flip-flop.
6	Design, Test bench creation and simulation of full adder and its FPGA implementation.
7	Design, Test bench creation and simulation of full subtractor and its FPGA implementation.
8	Design, Test bench creation and simulation of 4:1 MUX & 1:4 De-MUX and its FPGA implementation.
9	Design, Test bench creation and simulation of 4-bit binary up/down counter and its FPGA implementation.
10	Design, Test bench creation and simulation of 4-bit shift register and its FPGA implementation.

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. 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	Design a combinational logic circuit using CAD tools.
CO2	Implement sequential logic circuits using CAD tools.
CO3	Realize combinational logic circuits using hardware description language.
CO4	Implement sequential logic circuits using HDL.

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								1	1	1	1
CO2	3	3	2	1								2	2	2
CO3	2	2	2	1							1	2	2	2
CO4	2	2	3									2	2	1

Category	Code	Instrumentation Devices & Systems Lab	L-T-P	Credits	Marks
PCR	EC3049		0-0-2	1	100

Objectives	The objective of this course is to provide a hands-on exposure to LabVIEW programming and design different measurement systems using appropriate types of sensors used in industrial applications.
Pre-Requisites	Knowledge of transducers and sensors is required. Topics taught in the theory class are essential to conduct the experiments.
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	Design of a temperature measurement system with a thermocouple providing cold junction compensation using LabVIEW and DAQ.
2	Design of a microcontroller-based storage and display device.
3	Design of LVDT and its signal conditioning circuit using LabVIEW and DAQ.
4	Design of load cell using stain gauge, LabVIEW and DAQ.
5	Design of an orifice type flow meter with diaphragm type differential pressure transducer with capacitive sensing scheme.
6	Design of a piezoelectric accelerometer with charge amplifier configuration.
7	Design of active low pass, high pass & band pass filters.
8	Design of a stepper motor drive.
9	Design of regulated power supply unit.
10	Design of embedded real-time system using ARM controller.
11	Design of PID controller using LabVIEW and hardware design.
12	Design of pressure sensor using LabVIEW and DAQ.
13	Design of sound measurement using LabVIEW and DAQ.

Text Books:

T1. J. P. Bentley, ***Principles of Measurement Systems***, 4th *Ed.*, PHI Learning, 2005.
T2. A. K. Ghosh, ***Introduction to Instrumentation and Control***, 4th *Ed.*, PHI Learning, 2012.
T3. C. D. Johnson, ***Process Control Instrumentation Technology***, 8th *Ed.*, Pearson Education, 2014.
T4. J. Travis and J. Kring, ***LabVIEW for Everyone: Programming Made Easy and Fun***, 3rd *Ed.*, Prentice Hall, 2006.

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.

P.T.O

Online Resources:

1. https://nptel.ac.in/courses/108105062: by Prof. S. Sen and Prof. S. Mukhopadhyay, IIT Kharagpur
2. 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	Design & test measurement systems to sense various parameters using LabVIEW and DAQ.
CO2	Design and analyze flow and acceleration sensors using capacitive and piezoelectric methods.
CO3	Design and implement analog signal conditioning circuits such as filters for sensor interfacing.
CO4	Apply PID control concepts using LabVIEW and hardware for real-time system 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).
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							2	1	1	1
CO2	3	3	3	3							2	2	2	2
CO3	2	2	3	2							3	2	2	2
CO4	2	2	3	3							2	2	2	1

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	Industrial Automation & Control	L-T-P	Credits	Marks
PCR	EC3050		3-0-0	3	100

Objectives	The objective of this course is to learn the principles, operation of process control elements including data acquisition and data presentation units for industrial applications.
Pre-Requisites	Knowledge of basic electrical engineering 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	**Process Control**: Introduction, Process Definition, Feedback Control, Controller Types - Discontinuous, Continuous and Composite, PID Controller Tuning, Zeigler-Nichols Tuning Method, Process Reaction Curve, Digital PID Controllers, Position and Velocity algorithm.	**8 Hours**
Module-2	**Final Control Elements**: Pneumatic systems, Flapper nozzle system and its characteristics, I/P converter and pneumatic actuators, Electrical actuators, Solenoids, Motors, The principle of stepper motors, Elements of power electronic devices and driver circuits, Hydraulic actuators, Control valve, Types of control valve, Control valve sizing, Cavitations and flashing.	**8 Hours**
Module-3	**Special Control Structures**: Cascade Control, Feed-forward Control, Feed-forward and Feed-back Control Configuration, Ratio Control, Selective Control and Adaptive Control Configuration.	**9 Hours**
Module-4	**Data Acquisitions & Conversion**: Introduction, Objective of DAS, Single channel DAS, Multichannel DAS, Data Loggers, Digital Transducer, Signal Processing Elements, ADC (Successive approximation, Dual-slope, Ramp, Flash type), DAC (R-R & R-2R ladder), Sensitive and resolutions of ADC & DAC; Computer and microcontroller systems, Microcontroller and computer software (Overview).	**9 Hours**
Module-5	**Data Presentation Elements**: Pointer–scale indicators, Digital display principles, Light-emitting diode (LED) displays, Liquid crystal displays (LCDs), Electroluminescence (EL) displays, Chart recorders, Paperless recorders, Laser printers.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. P. Bentley, ***Principles of Measurement Systems***, 3rd *Ed.*, Pearson Education, 2005.
T2. S. Bhanot, ***Process Control: Principles and Applications***, 1st *Ed.*, Oxford University Press, 2008.
T3. C. D. Johnson, ***Process Control Instrumentation Technology***, 8th *Ed.*, Pearson, 2014.

Reference Books:

R1. K. Kant, ***Computer-Based Industrial Control***, 2nd *Revised Ed.*, PHI Learning, 2011.
R2. C. A. Smith and A. B. Corripio, ***Principles and Practice of Automatic Process Control***, 3rd *Ed.*, John Wiley & Sons, 2006.
R3. M. Gopal, ***Digital Control and State Variable Methods***, 2nd *Ed.*, Tata McGraw-Hill, 2003.

Online Resources:
1. https://nptel.ac.in/courses/108105088/: by Prof. S. Mukhopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/108105062/: by Prof. S. Sen and Prof. S. Mukhopadhyay, IIT Kharagpur

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

CO1	Describe process control, feedback, and PID tuning methods for industrial systems.
CO2	Explain the concepts of actuators, solenoids, stepper motors, and control valves.
CO3	Implement cascade, feed-forward, ratio, selective and adaptive control strategies.
CO4	Apply concepts of DAS, ADC/DAC, signal processing, and microcontroller systems.
CO5	Illustrate data presentation techniques using indicators, displays, recorders, and printers.

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	2	1	3	2	2				1	3	2	1
CO2	2	2	3	1	2	2	2				1	2	2	1
CO3	3	3	3	3	3	3	2				3	2	2	1
CO4	3	3	2	3	3	2	3				3	1	2	3
CO5	2	2	2	2	2	2	3				2	1	2	2

Category	Code	Microprocessors & Microcontrollers	L-T-P	Credits	Marks
PCR	EC3009		3-0-0	3	100

Objectives	The objective of this course is to learn various microprocessors & microcontrollers, develop assembly-level programs and interface with other external devices as per the application requirements.
Pre-Requisites	Basic knowledge of Digital Electronic 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**: 8085 microprocessor & its organization, General architecture, Bus organization, Memory concepts, Pins and signals, Timing diagram, Instruction set & programming, Addressing modes, Memory interfacing, Interrupts.	**10 Hours**
Module-2	**Intel 8086 Microprocessor**: Bus interface unit, Execution unit, Register organization, Memory segmentation, Pin architecture, Minimum and maximum mode, Physical memory organization, Memory interfacing, Interrupts, Addressing Modes, Instructions, Advanced co-processor architectures – Intel 80386, Pentium.	**8 Hours**
Module-3	**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**
Module-4	**Microcontrollers**: Introduction to 8051 Microcontrollers, Architecture, Memory organization, Special function register, Port operation, Memory interfacing, I/O interfacing, Serial data transfer scheme, On board communication interfaces-I2C Bus, SPI Bus, USART, External communication interfaces-RS232, USB.	**8 Hours**
Module-5	**Microcontroller Programming**: 8051 Instruction set, Interrupts, Programming and applications - Servo motor, Stepper motor control, High performance RISC architecture - Introduction to RISC processors, ARM - arcon RISC machine, Core and architecture, Registers, ARM processor family.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. R. S. Gaonkar, ***Microprocessor Architecture, Programming, and Applications with the 8085***, 6th *Ed.*, Penram International Publishing, 2013.
T2. A. K. Ray and K. M. Bhurchandani, ***Advanced Microprocessors and Peripherals***, 2nd *Ed.*, McGraw Hill Education, 2006.
T3. M. A. Mazidi, J. G. Mazidi, R. McKinlay, ***The 8051 Microcontroller and Embedded Systems: Using Assembly and C***, 2nd *Ed.*, Pearson Education, 2011.
T4. A. N. Sloss, D. Symes, C. Wright, ***ARM System Developer's Guide: Designing and Optimizing System Software***, Elsevier, 2012.

Reference Books:

R1. K. Kant, ***Microprocessors and Microcontrollers: Architecture, Programming and System Design 8085, 8086, 8051, 8096***, 2nd *Ed.*, Prentice Hall India, 2013.
R2. D. Hall, ***Microprocessors and Interfacing***, 3rd *Ed.*, McGraw-Hill Education, 2017.
R3. K. J. Ayala, ***The 8051 Microcontroller***, 3rd *Ed.*, Cengage Learning, 2007.

Online Resources:

1. https://nptel.ac.in/courses/108107029: by Dr. P.Agarwal, IIT Roorkee
2. https://nptel.ac.in/courses/106108100: by Prof. Krishna Kumar, IISc Bangalore

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

CO1	Explain 8085 architecture, operations, memory management, and develop related programs.
CO2	Explain 8086 architecture, programming, memory interfacing, and advanced processor features.
CO3	Design & implement interfacing of 8255, 8251, 8279, and related ICs for various applications.
CO4	Differentiate microprocessors and microcontrollers and program 8051 for specific tasks.
CO5	Design and implement microcontroller-based systems using ARM architecture and 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).
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	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***, 5^{th} *Ed.*, New Age Intl., 2010.
T2. K. Ogata, ***Modern Control Engineering***, 5^{th} *Ed.*, PHI Learning, 2010.

Reference Books:

R1. B. C. Kuo, ***Automatic Control Systems***, 7^{th} *Ed.*, Prentice Hall India, 2010.
R2. R. C. Dorf and R. H. Bishop, ***Modern Control Systems***, 8^{th} *Ed.*, Addison Wesley, 2003.
R3. U. A. Bakshi and V. U. Bakshi, ***Control System Engineering***, 1^{st} *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	Analog VLSI Design	L-T-P	Credits	Marks
PEL	EC3020		3-0-0	3	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.	**8 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.	**9 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.	**9 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.	**9 Hours**
Module-5	**Bandgap References and LNA**: Low power band gap reference design. Low Noise Amplifier (LNA) - Design of low noise amplifier.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. T. C. Carusone, D. A. Johns, and K. A. Martin, ***Analog Integrated Circuit Design***, 2^{nd} *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***, 3^{rd} *Ed.*, Oxford University Press, 2013.

Reference Books:

R1. P. Gray, P. Hurst, S. Lewis, and R. Meyer, ***Analysis and Design of Analog Integrated Circuits***, 4^{th} *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***, 1^{st} *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	Real Time Embedded Systems	L-T-P	Credits	Marks
PEL	EC3021		3-0-0	3	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.	**9 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.	**9 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.	**9 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.	**8 Hours**
Module-5	**Application & Case Studies**: Design process and design examples, Automatic chocolate vending machine, Digital camera, Adaptive Cruise control, Smart card.	**7 Hours**
	Total	**42 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	Virtual Instrumentation & DAQ	L-T-P	Credits	Marks
PEL	EC3055		3-0-0	3	100

Objectives	The objective of this course to learn the virtual instrumentation concepts, LabVIEW programming, Data acquisition, Machine vision and motion control for designing modern measurement and automation systems.
Pre-Requisites	Knowledge of sensors, transducers, actuators, analog & digital electronics, and computer 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 & 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**: Historical perspectives, advantages, block diagram & architecture of a virtual instrument, Conventional instruments vs. Traditional instruments, Data-flow techniques, Graphical programming in data-flow, Comparison with conventional programming, Distributed system using LabVIEW.	**7 Hours**
Module-2	**VI Programming**: Structures in LabVIEW, Loop behavior & inter-loop communication, Local & Global variables, Shift registers, Feedback, Auto-indexing, Loop timing, Timed loop; Other Structures: Sequence structures, Case structures, Formula node, Event structure; Arrays & Clusters, Graphs & Charts, File Input/Output, String Handling: String functions, LabVIEW string formats, Parsing of strings.	**10 Hours**
Module-3	**Data Acquisition**: Introduction, Classification of Signals, Analog interfacing: Sampling Theorem, Over-sampling, and Inter-channel Delay, ADCs, DACs Connecting signals to the DAQ: DI, RSE, NRSE, Practical vs. Ideal interfacing, Bridge Signal Sources; PC Buses: Local busses - PCI, RS232, RS422, RS485; Interface Buses: USB, PCMCIA, VXI, SCXI, PXI.	**10 Hours**
Module-4	**Machine Vision**: Basics of IMAQ vision: Digital Images, Display; Image analysis, Image processing techniques, Particle Analysis: Thresholding, Binary Morphology, Particle Measurement; Machine Vision: Edge Detection, Pattern Matching, Geometric Matching, Dimensional Measurement, Color Inspection, OCR; Machine Vision Hardware and Software.	**7 Hours**
Module-5	**Motion Control**: Motors: Servomotors, Brushless Servomotors, Stepper Motors, Linear Stepper Motors; Calculation of trajectory, Selecting the right motion controller; Move Types: Single-Axis, Point-to-Point Motion, Coordinated Multi-Axis Motion, Electronic Gearing; Motor Amplifiers and Drivers: Simple Servo Amplifiers, Stepper Motor Amplifiers, AC Servo Amplifiers, DC Servo Amplifiers.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. G. Johnson, ***LabVIEW Graphical Programming***, 4th *Ed.*, McGraw Hill, 2006.
T2. S. Gupta and J. John, ***Virtual Instrumentation using LabVIEW***, 2nd *Ed.*, McGraw-Hill, 2010.

T3. J. Jerome, ***Virtual Instrumentation using LabVIEW***, 1st *Ed.*, PHI Learning, 2010.

Reference Books:

R1. K. James, ***PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control***, 1st *Ed.*, Newnes, 2000.
R2. G. W. Johnson and R. Jeninngs, ***LabVIEW Graphical Programming***, 4th *Ed.*, McGraw-Hill, 2019.
R3. P. A. Blume, ***The LabVIEW Style Book***, 1st *Ed.*, Prentice Hall, 2017.

Online Resources:

1. https://nptel.ac.in/courses/108105376: by Prof. B. Mukherjee, IIT Kharagpur
2. https://www.ni.com/docs/en-US/bundle/labview/page/user-manual-welcome.html
3. https://forums.ni.com/t5/Example-Programs/ct-p/code-documents
4. https://www.ni.com/docs/en-US/bundle/usb-6008-6009-feature/page/introduction.html
5. https://www.ni.com/en/support/documentation/supplemental/16/simple-state-machine-template-documentation.html

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

CO1	Explain virtual instrumentation concepts, architecture, and data-flow programming.
CO2	Implement LabVIEW programming using loops, structures, arrays, and file operations.
CO3	Explain data acquisition concepts, signal interfacing, and bus communication systems.
CO4	Apply machine vision techniques for image analysis, processing, and measurement.
CO5	Analyze and design motion control systems using motors, drivers, and controllers.

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	2	1	2	1	2	2				2	3	2	2
CO2	2	2	3	2	3	2	2				2	3	3	2
CO3	3	2	2	2	2	2	2				2	2	2	1
CO4	2	2	3	3	3	3	3				2	3	2	1
CO5	2	2	3	3	2	2	3				3	2	3	2

Category	Code	Low Power VLSI Design	L-T-P	Credits	Marks
PEL	EC3024		3-0-0	3	100

Objectives	The objective of this course is to model power consumption and study the techniques to design low power digital VLSI circuits and systems.
Pre-Requisites	Knowledge of Digital Electronic Circuits 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 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**: Need for low power VLSI chips, Sources of dissipation in digital integrated circuits, Degrees of freedom, Emerging low power approaches - an overview; Device and technology impact on low power electronics - Introduction, Dynamic power dissipation in CMOS, Effects of low power on speed, Constraints on power reduction, Transistor sizing and optimal gate oxide thickness, Impact of technology scaling, Technology and device innovations.	**8 Hours**
Module-2	**Low Power Circuit Techniques**: Introduction, Power consumption in circuits, Flip-flops and latches, Logic, High capacitance nodes; Energy recovery CMOS - A simple example, A look at some practical details, Retractile logic, Reversible pipelines, High-performance approaches.	**8 Hours**
Module-3	**Low Power Clock Distribution**: Power dissipation in clock distribution, Single driver vs. Distributed buffers, Buffer and device sizing under process variations, Zero skew vs. tolerable skew, Chip and package co-design of clock network.	**9 Hours**
Module-4	**Logic Synthesis for Low Power**: Introduction, Power estimation techniques, Power minimization techniques; Low power arithmetic components - Introduction, Circuit design style, Adders, Multipliers, Division.	**9 Hours**
Module-5	**Low Power Memory Design**: Introduction, Sources and reductions of Power Dissipation in Memory Subsystem, Sources of Power Dissipation in DRAM and SRAM, Low Power DRAM Circuits, Low Power SRAM Circuits.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. M. Rabaey and M. Pedram, ***Low Power Design Methodologies***, Springer India, 2009.
T2. K. Roy and S. C. Prasad, ***Low-Power CMOS VLSI Circuit Design***, Wiley India, 2009.

Reference Books:

R1. G. K. Yeap, ***Practical Low Power Digital VLSI Design***, Kluwer Academic Publishers, 1998.
R2. A. P. Chandrakasan and R. W. Brodersen, ***Low Power Digital CMOS Design***, Kluwer Academic Publishers, 2012.
R3. A. Bellaouar and M. Elmasry, ***Low-Power Digital VLSI Design: Circuits and Systems***, Kluwer Academic Publishers, 1995.

R4. K. S. Yeo, S. S. Rofail, and W. -L. Goh, ***CMOS/BiCMOS ULSI: Low Voltage, Low Power***, 1st Indian Reprint, Pearson Education, 2002.

Online Resources:
1. https://nptel.ac.in/courses/106105034: by Prof. A. Pal, IIT Kharagpur
2. https://nptel.ac.in/courses/108103108: by Prof. C. Karfa and Dr. S. Biswas, IIT Guwahati

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

CO1	Describe the need of low power VLSI design and impact on low power electronics.
CO2	Explain low power circuit design techniques and energy recovery CMOS circuit methods.
CO3	Analyze and design low power clock distribution network for VLSI chips.
CO4	Perform logic synthesis for low power systems and design low power arithmetic components.
CO5	Design low power memory circuits like DRAM and SRAM.

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	1	1		1						1	1	1	1
CO2	3	2	1	1	2	1					2	2	2	2
CO3	2	3	2	1							2	2	1	2
CO4	2	2	3	2	2	1					1	2	2	1
CO5	2	3	3	2	1	1					2	2	1	1

Category	Code	Smart Sensors for IoT	L-T-P	Credits	Marks
PEL	EC3025		3-0-0	3	100

Objectives	The objective of this course is to design various IoT based applications using smart sensors and protocols.
Pre-Requisites	Basic knowledge of sensors, transducers and its protocols 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 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	**Smart Sensors**: Introduction, Mechanical-Electronic Transitions in Sensing, Nature of Sensors, Integration of Micro-machining and Micro-electronics.	**7 Hours**
Module-2	**Sensor Outputs**: Introduction, Sensor Output Characteristics; Other Sensing Technologies - Capacitive, Piezoelectric, Hall Effect, Chemical Sensors, Improving Sensor Characteristics; Digital Output Sensors - Incremental Optical Encoders, Digital Techniques, Noise/Interference Aspects, Low-Power; Low-Voltage Sensors - Impedance, Analysis of Sensitivity Improvement, Thin Diaphragm, Increased Diaphragm Area.	**10 Hours**
Module-3	**Interfacing Mechanisms**: Introduction, Amplification and Signal Conditioning, Instrumentation Amplifiers, SLEEPMODE Operational Amplifier, Rail-to-Rail Operational Simplifiers, Switched-Capacitor Amplifier, Barometer Application Circuit, 4-20 mA Signal Transmitter, Schmitt Trigger, Inherent Power-Supply Rejection; Separate Versus Integrated Signal Conditioning - Integrated Passive Elements, Integrated Active Elements, Digital Conversion.	**9 Hours**
Module-4	**Communication for Smart Sensors**: Introduction, Standards; Automotive Protocols - SAEJ1850, CAN Protocol, Industrial Networks, Other Protocols; Protocols in Silicon - MCU With Integrated SAE J1850 and CAN, Neuronfi Chips and Lon Talk Protocol, MI-Bus, Other MCUs and Protocols; Other Aspects of Network Communications - MCU Protocols, Transition Between Protocols and Systems, Protocol as a Module.	**9 Hours**
Module-5	**Microsystems & Case Studies**: Biometic Materials and Structures for Sensor Applications; Smart Sensor Microsystems - Application-Dependent Design and Integration Approaches, Significance of IoT in the Agricultural Sector, Precision Agriculture Using Advanced Technology of IoT, Unmanned Aerial Vehicle, Augmented Reality, and Machine Learning.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. R. Frank, ***Understanding Smart Sensors***, 3rd *Ed.*, ArtechHouse, 2013.

T2. C. M. Kyung, H. Yasuura, Y. Liu, and Y-L. Lin, ***Smart Sensors and Systems: Innovations for Medical, Environmental, and IoT Applications***, Springer, 2017.

T3. D. Gupta, V. C. de Albuquerque, A. Khanna, and P. L. Mehta, ***Smart Sensors for Industrial Internet of Things: Challenges, Solutions and Applications***, Springer, 2021.

Reference Books:

R1. K. Iniewski (Ed.), ***Smart Sensors: For Industrial Applications***, 1st *Ed.*, CRC Press, 2013.
R2. V. K. Awaar, P. Jugge, and P. Nayak, ***Significance of Smart Sensors in IoT Applications***, 1st *Ed.*, CRC Press, 2021.
R3. H. Yasuura, C. M. Kyung, Y. Liu, and Y. L. S. Lin, ***Smart Sensors at the IoT Frontier***, Springer, 2017.

Online Resources:

1. https://nptel.ac.in/courses/108106165: by Prof. S. Talukder, IISER, Bhopal.
2. 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	Describe the fundamentals of smart sensors and their micro-machining integration mechanisms.
CO2	Explain principles, characteristics, and digital output features of various smart sensors.
CO3	Apply sensor interfacing and signal conditioning techniques for designing smart applications.
CO4	Explore various communication protocols for smart sensors and their MCU implementations.
CO5	Design and implement smart sensor microsystems and IoT-based 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).
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	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	3				3	3	2	3
CO5	2	2	2	3	2	2	3				3	2	2	3

Category	Code	Industrial Instrumentation	L-T-P	Credits	Marks
PEL	EC3056		3-0-0	3	100

Objectives	The objective of the course is to learn the process, characteristics, functionalities, instrument analysis, telemetry systems and power plant instrumentation along with industrial hazards and safety considerations.
Pre-Requisites	Knowledge of electronics, electrical engineering, communication engineering and basic internet technology is required.
Teaching Scheme	Regular class room lectures with use of ICT as and when required; sessions are planned to be interactive with a 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**: Functional Units, Classification, Performance characteristics, Dynamic calibration; Errors - An overview, Statistical error analysis, Reliability and related topics; Transducers - Pressure transducers, Electrical and vacuum type, Pirani gauge, Thermocouple gauge, Ionization gauge; Flow meter – Turbo-magnetic, Electro-magnetic, Ultrasonic type; Level sensor – Electrical type (contact & non-contact).	**10 Hours**
Module-2	**Instruments for Analysis**: Introduction, Gas analyzers, Liquid analyzers, X-ray methods, Chromatography – Gas & Liquid, Nuclear magnetic resonance spectroscopy, Electron spin resonance spectroscopy, Mass spectroscopy, Sampling techniques.	**9 Hours**
Module-3	**Telemetry**: Introduction, Pneumatic means, Electrical means - Voltage, Position and Synchro transmitters & receivers, Frequency telemetry, Multiplexing, Modulation, Modulation of digital data, Types of transmission channels and characteristics, Briefing of a telemetry system in operation, Wireless I/O.	**8 Hours**
Module-4	**Power Plant Instruments**: Introduction, The Power plant scheme, Pressure, Temperature, Flow, Level, Vibration and Expansion, Analysis – Conductivity, Silica, Sodium, pH, DO, Turbidity and Hydrazine, Flue gas analysis.	**8 Hours**
Module-5	**Hazards & Safety**: Initial consideration, Enclosures – NEMA type, IP type, Intrinsic safety, Prevention of ignition, Methods of production, Analysis; Evaluation and construction – Intrinsically safe installation, Unbalanced and balanced schemes.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. D. Patranabis, ***Principle of Industrial Instrumentation***, 3rd *Ed.*, McGraw-Hill, 2012.
T2. R. S. Khandpur, ***Handbook of Analytical Instruments***, 3rd *Ed.*, Tata McGraw-Hill, 2015.

Reference Books:

R1. B. G. Liptak, ***Process Measurement and Analysis***, 3rd *Ed.*, Chilton Book Company, 1995.
R2. J. P. Bentley, ***Principles of Measurement Systems***, 4th *Ed.*, Pearson Education, 2005.
R3. A. K. Ghosh, ***Introduction to Measurement and Instrumentation***, 3rd *Ed.*, PHI Learning, 2009.

R4. D. Patranabis, ***Sensors and Transducers***, 2nd *Ed.*, PHI Learning, 2010.
R5. D. V. S Murthy, ***Transducers and Instrumentation***, 4th *Ed.*, PHI Learning, 2000.

Online Resources:

1. https://nptel.ac.in/courses/10810506/: by Dr.A. Barua, IIT Kharagpur
2. https://nptel.ac.in/courses/108105062/: by Prof. S. Mukhopadhyay and Prof. S. Sen, IIT Kharagpur
3. https://nptel.ac.in/courses/108105088/: by Prof. S. Mukhopadhyay, IIT Kharagpur

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

CO1	Explain functional units, transducers, and performance analysis of industrial instruments.
CO2	Describe principles and applications of analytical instruments and sampling methods.
CO3	Explain telemetry principles, transmission methods, and wireless I/O systems in industry.
CO4	Describe instrumentation for measurement and analysis in power plant operations.
CO5	Realize safety standards, intrinsic safety, and ignition prevention in industries.

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	2	2	2	3	2	1				2	3	2	3
CO2	2	2	2	2	2	2	1				2	3	2	3
CO3	2	2	2	2	3	2	1				3	3	2	3
CO4	2	2	3	1	2	2	1				2	3	2	2
CO5	2	1	2	2	2	2	3				3	3	2	2

Category	Code	Design of Semiconductor Memories	L-T-P	Credits	Marks
XXX	EC3028		3-0-0	3	100

Objectives	The objective of this course is to learn the design, architecture, operation and testing of different types of semiconductor memory systems.
Pre-Requisites	Knowledge of MOSFET and CMOS device operation, combinational & sequential logic circuits, and basics of VLSI design 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	**Static Random-Access Memory (SRAM)**: SRAM in the computer memory hierarchy, SRAM array block structure, SRAM cell design, Six-transistor (6T) CMOS SRAM cell, Read and write operation, Cell layout considerations, Peripheral circuit operation - Sense amplifier and bit line pre-charge equalization, Write driver, Row address decoder and column MUX, Address transition detector.	**9 Hours**
Module-2	**SRAM Cell Stability**: Definition, Modelling and Testing, Static noise margin (SNM) of SRAM cells, SNM Definitions - Noise margins NM_H and NM_L with V_{OL} and V_{OH} defined as stable logic points, Noise margins NM_H and NM_L with V_{OL} and V_{OH} defined as -1 slope points, SNM as a side of the maximum square drawn between the inverter characteristics, Analytical SNM expression for a 6T SRAM cell, Inference of SNM analytical expressions, Hold SNM and read SNM of 6T SRAM cell, Destructive read nature of SRAM.	**8 Hours**
Module-3	**SRAM Fault Models & Testing**: Faults involving one cell - Stuck-at fault (SAF), Stuck-open fault (SOF), Transition fault (TF), Faults involving two cells - Coupling fault (CF), Faults involving n cells - n-coupling fault, Bridging fault (BF), State coupling fault (SCF), Neighborhood pattern sensitive fault (NPSF), Stability faults - Data retention fault (DRF), Stability fault (SF); SRAM Test Practices - March tests, IDDQ test, Limitations of IDDQ testing in scaled technologies, Design for test techniques - Built-in self test.	**9 Hours**
Module-4	**Dynamic Random-Access Memories (DRAMs)**: DRAM technology development, CMOS DRAMs, DRAMs cell theory and advanced structures, Advanced DRAM design & architecture, Application specific DRAMs.	**7 Hours**
Module-5	**Nonvolatile Memories**: Masked read only memories (ROMs) - High density ROMs, Programmable read-only memories (PROMs) - Bipolar PROMs, CMOS PROMs, Erasable (UV) programmable read-only memories (EPROMs); Floating Gate EPROM cell – One time programmable (OTP) EPROMs, Electrically erasable PROMs (EEPROMs), EPROM technologies and applications, Non-volatile flash memories (NAND and NOR topologies), Advanced flash memory architecture (3D Flash).	**9 Hours**
	Total	**42 Hours**

P.T.O

Text Books:

T1. A. Pavlov, ***CMOS SRAM : Circuit Design and Parametric Test in Nano Scaled Technologies***, Springer, 2008.

T2. S. Yu, ***Semiconductor Memory Devices and Circuits***, 1st *Ed.*, CRC Press, 2022.

Reference Books:

R1. B. Prince, ***Semiconductor Memories: A Handbook of Design, Manufacture and Application***, 2nd *Ed.*, Wiley–Blackwell, 1996.

R2. A. K. Sharma, ***Advanced Semiconductor Memories: Architecture, Design and Applications***, 1st *Ed.*, Wiley-IEEE Press, 2002.

Online Resources:

1. https://nptel.ac.in/courses/117106092: by Prof. S. Srinivasan, IIT Madras
2. https://nptel.ac.in/courses/108106069: by Prof. A. Dasgupta, IIT Madras

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

CO1	Design and analyze SRAM circuits including cell design, read/write operations and peripherals.
CO2	Analyze and evaluate SRAM cell stability using SNM definitions, models, and testing methods.
CO3	Apply SRAM testing techniques to detect cell faults using fault models and test practices.
CO4	Analyze the operation and architecture of DRAM circuits, cells, and advanced structures.
CO5	Compare the operation among different types of ROMs and Flash memories.

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).
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	2	2			1				2	3	2	3
CO2	3	3	2	2			1				2	2	1	2
CO3	3	3	3	2			1				2	2	1	2
CO4	3	2	1	2			1				2	3	2	3
CO5	3	2	2	1			1				2	3	2	3

Category	Code	Industrial IoT	L-T-P	Credits	Marks
PEL	EC3029		3-0-0	3	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.	**8 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.	**7 Hours**
Module-3	**The IIoT Data Flow**: IIoT data flow in the factory, Measurements and the actuator chain, Controllers, Industrial Protocols, SCADA, ERP & MES.	**8 Hours**
Module-4	**Implementing Industrial IoT**: IoT Data Flow, Discovering OPC, OPC Classic, OPC UA, Understanding the IIoT edge, Implementing the IIoT data flow.	**9 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.	**10 Hours**
	Total	**42 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	MEMS & Sensor Design	L-T-P	Credits	Marks
PE	EC3019		3-0-0	3	100

Objectives	The objective of this course is to learn the underlying principles of microsystems, advantages of miniaturization, fundamentals of micro-machining and micro-fabrication techniques for designing right type of miniaturized sensors and instruments in different applications.
Pre-Requisites	Fundamental knowledge of sensors and transducers 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 & 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	**Overview of MEMS & Microsystems**: Introduction, MEMS products, Difference between Microsystems and Microelectronics, Multidisciplinary approach of MEMS, automotive and other industrial applications, Markets of Microsystems; Materials for MEMS: Substrate and Wafers, Active substrate materials, Silicon as substrate, compound, and piezoresistive materials, GaAs, Quartz, PZT, Polymers, Packaging materials.	**8 Hours**
Module-2	**Microsystem Fabrication Process**: Introduction, Photolithography, Ion implantation, Diffusion, Oxidation, CVD, PVD, Sputtering, deposition by Epitaxy, Wet etching of silicon: Isotropic etching, Anisotropic etching, TMAH, EDP; Micromanufacturing: Bulk Micromachining, Surface Micromachining, LIGA.	**8 Hours**
Module-3	**MEMS for Sensing & Actuation**: Microsensors: Acoustic wave, Biosensors, Chemical, Optical, Pressure, Thermal sensors; Microactuation: Thermal forces, SMA, Piezoelectric crystals and Electrostatic forces; Concepts of Microgrippers, Micromotors, Microvalves and Micropumps, Microaccelerometers, Microfluidics.	**10 Hours**
Module-4	**Microsystems Design**: Introduction, Design Considerations, Process Design, Mechanical Design, Finite Element Method, Design of a Micropressure Sensor, Design of Microfluidics Network Systems, Computer-Aided Design; Design Considerations of Piezoresistive Pressure Sensor, Inertial Sensor, Tactile Sensor, Flow Sensor.	**9 Hours**
Module-5	**Selected MEMS Products**: Blood Pressure (BP) Sensor, Microphone, Acceleration Sensors, Gyro and its design considerations; Top Concerns of MEMS Products: Performance, Accuracy, Repeatability, Reliability, Cost and Market Uncertainties.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. T. -R. Hsu, ***MEMS & Microsystems - Design and Manufacture***, 1st *Ed.*, McGraw-Hill Education, 2017.
T2. C. Liu, ***Foundations of MEMS***, 2nd *Ed.*, Pearson Education, 2012.

P.T.O

Reference Books:

R1. S. E. Lyshevski, ***Nano- and Micro-Electromechanical Systems : Fundamentals of Nano- and Microengineering (Vol. 8)***, CRC Press, 2005.
R2. D. A. Bell, ***Electronic Instrumentation and Measurements***, 2^{nd} *Ed.*, Oxford University Press, 2007.
R3. G. K. Ananthasuresh, K. J. Vinoy, S. Gopalkrishnan, K. N. Bhat, and V. K. Aatre, ***Micro and Smart Systems***, 1^{st} *Ed.*, Wiley India, 2012.
R4. E. Gaura and R. M. Newman, ***Smart MEMS and & Sensor Systems***, 1^{st} *Ed.*, Imperial College Press, 2006.

Online Resources:

1. https://nptel.ac.in/courses/108108113/: by Prof. H. J. Pandya, IISc Bangalore
2. https://nptel.ac.in/courses/117105082/: by Prof. S. Kal, IIT Kharagpur
3. https://nptel.ac.in/courses/112104181/: by Dr. S. Bhattacharya, IIT Kanpur

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

CO1	Describe MEMS concepts, materials, applications, and differences between microsystems.
CO2	Explain microsystem fabrication processes, micromachining techniques, and etching methods.
CO3	Articulate MEMS-based sensors and actuators, including microdevices for sensing and actuation.
CO4	Apply microsystem design principles and CAD tools for sensors and microfluidic systems.
CO5	Analyze MEMS products and evaluate their performance, reliability, and design concerns.

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).
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	2			1				2	2	1	1
CO2	3	3	2	2			1				2	2	1	1
CO3	3	3	2	2			1				2	3	2	3
CO4	3	3	2	3			1				2	3	3	3
CO5	3	3	2	3			1				2	3	3	3

Category	Code	Biomedical Instrumentation & Signal Processing	L-T-P	Credits	Marks
HNS	EC3058		3-1-0	4	100

Objectives	The objective of this course is to learn different biomedical instruments, sensors, signal processing techniques and their application in diagnosis, therapeutic and surgical procedures.
Pre-Requisites	Knowledge of basic electronics, signal processing, sensors and transducers are required.
Teaching Scheme	Regular classroom lectures with use of ICT, audio & video tools as 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 Bio-Engineering**: Bio-medical signals sources and relevant examples, Basic medical instrumentation system, Bio-electric potentials - Sources, Resting & action potentials; Biomedical signals - Anatomy of heart, ECG, PCG, EEG, EMG.	**11 Hours**
Module-2	**Biosensors & Biomedical Recorders**: Electrode theory, Bio-potential electrodes and recorders for ECG, EEG & EMG, Transducers for Biomedical applications, Glucose sensors, Immune sensors, MOSFET biosensors.	**11 Hours**
Module-3	**X-Ray & Radio-isotope Instrumentation**: Generation of ionizing radiation, Nature and production of X-Rays, Computed Tomography, Magnetic resonance imaging system, Ultrasonic imaging systems.	**11 Hours**
Module-4	**Removal of Noise & Artifacts**: Random and structured noise, Physiological interference, Stationary and non-stationary processes, Noises and artifacts present in ECG, Time and Frequency domain filtering.	**11 Hours**
Module-5	**Signal Processing & Event Detection**: Detection of P, Q, R, S and T Waves in ECG, EEG signal and its characteristics, EEG analysis, Sleep EEG, EEG Rhythms, Waves and transients, Detection of waves and transients.	**12 Hours**
	Total	**56 Hours**

Text Books:

T1. R. S. Khandpur, ***Handbook of Biomedical Instrumentation***, 3rd *Ed.*, McGraw-Hill, 2014.
T2. D. C. Reddy, ***Biomedical Signal processing - Principles & Techniques***, 1st *Ed.*, McGraw-Hill, 2005.
T3. W. J. Tompkins, ***Biomedical Digital Signal Processing***, Editorial Prentice Hall, 1993.
T4. R. M. Rangayyan, ***Biomedical Signal Analysis - A Case Study Approach***, 2nd *Ed.*, John Willey & Sons, 2002.

Reference Books:

R1. J. L. Cromwell, F. J. Weibell, and E. A. Pfeiffer, ***Biomedical Instrumentation and Measurement***, 2nd *Ed.*, Prentice Hall of India, 2017.
R2. J. J. Carr and J. M. Brown, ***Introduction to Biomedical Equipment Technology***, 4th *Ed.*, Pearson Education, 2000.
R3. H. E. Thomas, ***Handbook of Biomedical Instrumentation and Measurement***, 1st *Ed.*, Reston Publishing Company, 1975.

Online Resources:

1. https://nptel.ac.in/courses/102101068: by Prof. S. Srivastava, IIT Bombay
2. https://nptel.ac.in/courses/108105101: by Prof. S. Mukhopadhya, IIT Kharagpur
3. https://nptel.ac.in/courses/108105091: by Prof. D. Sheet, IIT Kharagpur
4. https://ocw.mit.edu/courses/biological-engineering/

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

CO1	Explain bio-signal sources, bio-potentials and basic biomedical instrumentation systems.
CO2	Describe biosensors, bio-potential electrodes and biomedical recording systems.
CO3	Explain principles and instrumentation of X-ray, CT, MRI and ultrasonic imaging systems.
CO4	Apply filtering techniques to remove noise and artifacts from biomedical signals.
CO5	Analyze and detect key events and waveforms in ECG and EEG biomedical signals.

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	3	1		1					2	2	1	1
CO2	1	1	2	3							2	2	1	1
CO3	2	2	1	2		2					2	1	2	2
CO4	2	1	2	2		1					3	2	2	2
CO5	3	2	2	1		2					1	1	2	1

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***, 4^{th} *Ed.*, PHI Learning, 2021.

T2. E. Horowitz, S.Sahni, and S. Rajasekaran, ***Fundamentals of Computer Algorithms***, 2^{nd} *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).

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	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***, 9^{th} *Ed.*, Springer, 2017.
T2. S. Haykin, ***Neural Networks and Learning Machines***, 3^{rd} *Ed.*, Pearson Education, 2009.
T3. E. Alpaydın, ***Introduction to Machine Learning***, 2^{nd} *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***, 2^{nd} *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	Basics of Power Systems	L-T-P	Credits	Marks
MNR	EE3022		3-1-0	4	100

Objectives	The objective of this course is to study different aspects of power systems, the complete path of electrical energy from generation up to the consumers, and various components used in operation & control of modern power systems.
Pre-Requisites	Knowledge of Basic Electrical 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 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	**Generation of Electrical Energy**: Basics of electrical generation sources - Thermal, Hydro, Nuclear; Layout, Basic components, Advantages & Disadvantages; **Renewable Energy**: Wind, Solar; Layout, Basic components; Grid connected renewable sources, operational issues.	**11 Hours**
Module-2	**Transmission Lines**: Components of transmission lines - Conductors & Supporting structures, Insulators, Air gaps, Shielding; DC & AC transmission lines, Comparison, Underground cables, Design Parameters, Benefits of high-voltage transmission; **Substation Equipment**: Transformers, Regulators, Circuit breakers, Isolators, Their relationship to system protection, Maintenance & System control; Digital substation equipment for modernization and Reliability.	**11 Hours**
Module-3	**Distribution System**: Primary & Secondary, Overhead & Underground, Consumers - Residential, Commercial, Industrial; Voltage classifications, Common equipment; Modernization & Automation, Intelligent Electronic Devices, Outage management, Customer information systems; **Consumption**: Wiring to the consumer's load, Emergency generators, Uninterruptible Power Supply (UPS), Systems to enhance reliable power service and Their operating issues, Smart meters, Service reliability indicators, Common problems and Solutions for large power consumers.	**12 Hours**
Module-4	**System Protection**: System vs. Personal protection, Protection against equipment failures, Faults on power lines, Lightning strikes, Inadvertent operations, Causes of system disturbances, Protective relays, Protection against faults, Lightning strikes, Minimization of system disturbances; Personal protection and Safe working procedures in & around high-voltage power systems; Common safety procedures & methods; Equipotential grounding, Ground potential rise, Touch potential, Step potential; Precautions around high-voltage power lines, Substations and around home.	**12 Hours**
Module-5	**Interconnected Power Systems**: Concept of Interconnection, Hierarchical Grid arrangements, Cascade Tripping, Islanding, Load dispatch center, use of SCADA (Supervisory Control and Data Acquisition) and EMS (Energy Management Systems) for reliable operation of large power systems.	**10 Hours**
	Total	**56 Hours**

Text Books:

T1. S. W. Blume, ***Electric Power System Basics for the Nonelectrical Professional***, 2nd *Ed.*, John Wiley & Sons, 2017.

Reference Books:

R1. V. K. Mehta and R. Mehta, ***Principles of Power Systems***, 4th *Ed.*, S. Chand, 2005.
R2. D. P. Kothari and I. J. Nagrath, ***Power System Engineering***, 2nd *Ed.*, McGraw-Hill, 2007.
R3. A. v'Meier, ***Electric Power Systems - A Conceptual Introduction***, John Wiley & Sons, 2006.

Online Resources:

1. https://nptel.ac.in/courses/108104052: by Dr. S. N. Singh, IIT Kanpur
2. https://nptel.ac.in/courses/108101040: by Dr. A. M. Kulkarni, IIT Bombay

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

CO1	Describe various renewable & nonrenewable sources for generation of electrical power.
CO2	Explain fundamental aspects of transmission systems and substation equipment.
CO3	Elaborate the components of a distribution system & transmission of electricity to consumers.
CO4	Explain the basics of electrical protection systems in terms of system and personal safety.
CO5	Articulate the concepts, benefits, challenges of large power systems and reliable 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				3						2		
CO2	3	3	1		2	2					1	3	1	
CO3	3	3			2	2					2	2		
CO4	3	3			3						2	3	2	2
CO5	3	2	2		2	1						2	1	3

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	Industrial Automation & Control Lab	L-T-P	Credits	Marks
PCR	EC3051		0-0-2	1	100

Objectives	The objective of this course is to learn applications of sensors, controller and final control elements for testing, calibration of measuring Instruments and various measuring techniques used in the automation industry.
Pre-Requisites	Basic knowledge on fundamentals of semiconductor physics is required.
Teaching Scheme	Regular laboratory experiments are to be conducted under the supervision of the teacher. Demonstrations along with associated safety measures will be explained.

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	Performance analysis on ON-OFF/P/PI/PD/PID controllers of 1st order processes using LABVIEW/SIMULINK.
2	Performance analysis on ON-OFF/P/PI/PD/PID controllers of 2nd order processes using LABVIEW/SIMULINK.
3	Design of Feedback, Feed-forward and Cascade controller by MATLAB or SIMULINK.
4	PID Control Tuning by Process reaction Curve (PRC) method.
5	PID Control Tuning by Ziegler-Nichols techniques.
6	Measurement and study of the characteristics of P/I & I/P converter.
7	Experiments on air velocity sensor and its associated signal conditioner circuit.
8	Determination of the different types of valve characteristics and gain under various conditions.
9	Measurement of displacement by IR motion sensor.
10	Experiment with flow measurement by using a flow sensor.
11	Measurement of position control by DC motor drives.
12	Experiments and study of the characteristics of the level control system.
13	Experiments and study of the characteristics of a pressure control system.
14	Experiments on phase-plane analysis of relay control system.

Text Books:

T1. S. Bhanot, ***Process Control: Principles and Applications***, 1st *Ed.*, Oxford University Press, 2008.
T2. M. Gopal, ***Digital Control and State Variable Methods***, 2nd *Ed.*, Tata McGraw-Hill, 2003.

Reference Books:

R1. J. Stenerson, ***Industrial Automation and Process Control***, 3rd *Ed.*, Prentice Hall of India, 2003.
R2. C. D. Johnson, ***Process Control Instrumentation Technology***, 8th *Ed.*, Pearson Education, 2014.

Online Resources:

1. https://nptel.ac.in/courses/108105064: by Prof. A. Barua, IIT Khargpur
2. https://nptel.ac.in/courses/103106148: by Prof. R. Rangaswamy, IIT Madras

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

CO1	Design and analyze various processes and their time-response performance.
CO2	Investigate and design various controller structures and their configurations.
CO3	Design PID controller tuning methods and investigate the effect on industrial processes.
CO4	Explain the principle, operations and characteristics of the final control element.

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	2	2							2	1	1	1
CO2	3	3	2	3							2	2	2	2
CO3	3	2	3	3							3	2	2	2
CO4	2	2	2	2							2	2	2	1

Category	Code	Microprocessors & Microcontrollers Lab	L-T-P	Credits	Marks
PCR	EC3011		0-0-2	1	100

Objectives	The objective of the course is to provide hands-on practice on programming of different microprocessors & microcontrollers along with their interfacing with external devices for real-world applications.
Pre-Requisites	Basic analytical & logical understanding including basic 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	Programs for 16 bit arithmetic operations using 8086.
2	Programs for Sorting and Searching (using 8086).
3	Programs for String manipulation operations (using 8086).
4	Programs for Digital clock and Stopwatch (using 8086).
5	Interfacing ADC and DAC.
6	Parallel Communication between two MP Kits using Mode1 & Mode2 of 8255.
7	Interfacing and Programming 8279, 8259 & 8253.
8	Serial Communication between two MP Kits using 8251.
9	Interfacing and Programming of Stepper Motor and DC Motor Speed control.
10	Programming using Arithmetic, Logical and Bit Manipulation instructions of 8051 microcontroller.
11	Programming and verifying Timer, Interrupts and UART operations in 8051 microcontroller.
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/108105102: by Prof. S. Chattopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/108107029: by Prof. P. Agarwal, IIT Roorkee
3. https://nptel.ac.in/courses/108103157: by Prof. S. R. Ahamed, IIT Guwahati

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

CO1	Describe the evolution, operation, assembly programming and 8086 instruction set.
CO2	Develop and apply assembly programs using loop, branch, arithmetic, logic, shift and arrays.
CO3	Analyze 8255 PPI modes and interface peripherals like ADC, DAC, stepper motor and 8279 PIC.
CO4	Develop programs like finding largest/smallest numbers and check the existence of data.
CO5	Experiment with 8051 assembly programming and functions for implementing 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	1	1	1	1							2	1	
CO2	3	2	3	2	2						1	3		
CO3	3	2	3	2	3							3		
CO4	3	2	3	3	3						1	3		
CO5	3	2	2	2	2						1	2		

Category	Code	Emerging Technologies Lab	L-T-P	Credits	Marks
SEC	IP3007		0-0-4	2	100

Objectives	The objective of this course is to learn the creation of IoT-based embedded applications, integrating sensing, communication and data processing using modern development tools for solving real-time engineering problems.
Pre-Requisites	Knowledge of microprocessors & microcontrollers, digital electronic circuits and programming skills in C or Python is required.
Teaching Scheme	The lab will follow a hands-on, experiment-driven approach supported by short demonstrations and guided coding sessions. Students will perform individual and group experiments, integrate hardware & software, and document results through lab records and viva discussions.

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
Embedded Systems Fundamentals and Interfacing (All Compulsory)	
1	Configure the embedded development environment and perform basic digital input/output operations and analog sensor interfacing.
2	Establish serial communication between an embedded system and a computing device using the UART protocol for data transmission and reception.
3	Generate PWM signals and control output power for applications such as motor speed or LED brightness control.
4	Interface Analog-to-Digital and Digital-to-Analog converters for acquisition and generation of analog signals.
5	Design a system that monitors and displays real-time environmental parameters such as temperature, humidity, and light intensity.
6	Implement a system that activates devices or generates alerts automatically when sensor readings cross pre-defined threshold levels.
IoT, Communication, and Cloud Integration (All Compulsory)	
7	Enable wireless data transmission between embedded systems and user interfaces for IoT applications.
8	Implement IoT data exchange between client and server using RESTful web services with HTTP GET and POST operations.
9	Establish MQTT-based communication between IoT devices through a broker for real-time data transmission.
10	Develop a system that enables two IoT nodes to exchange data and coordinate actions directly.
11	Design a system that generates and transmits notifications via online platforms such as email, messaging, or cloud-based services upon event occurrence.
12	Use Node-RED as a visual programming environment for creating and managing IoT workflows and automation processes.

Cont'd. . .

Experiment-#	Assignment/Experiment
13	Design graphical user interfaces in Node-RED for monitoring real-time IoT data using gauges, charts, and indicators.
14	Collect, store, and visualize sensor data on a cloud platform with real-time graphical representation.
	Smart IoT, Analytics, and Visualization (Any Six)
15	Perform preprocessing, filtering, and extraction of significant features from raw IoT data for analysis.
16	Apply machine learning models to IoT data for predictive or classification-based decision-making.
17	Explore the basic tools and techniques used for developing AR/VR environments integrated with sensor-based data.
18	Design an AR system that overlays digital content onto the real-world environment using marker-based detection.
19	Develop a navigation application that provides directional assistance within indoor environments using augmented reality.
20	Visualize and interpret IoT data through graphical plots using data analytics or visualization tools.
21	Analyze sensor data and identify patterns for predicting equipment maintenance requirements.
22	Integrate sensing, data transmission, cloud storage, analytics, and visualization into a complete IoT solution.

Text Books:
T1. R. Kamal, ***Embedded Systems – Architecture, Programming and Design***, 12th Reprint, Tata McGraw-Hill, 2007.
T2. H. W. Huang, ***The Atmel AVR Microcontroller: Using C***, 2nd *Ed.*, Cengage Learning, 2017.
T3. A. Bahga and V. Madisetti, ***Internet of Things : A Hands-On Approach***, 1st *Ed.*, Universities Press, 2014.
T4. B. B. Brey, ***The Intel Microprocessors: Architecture, Programming and Interfacing***, 9th *Ed.*, Pearson Education, 2020.
T5. E. Upton and G. Halfacree, ***Raspberry Pi User Guide***, 5th *Ed.*, Wiley India, 2022.

Reference Books:
R1. A. McEwen and H. Cassimally, ***Designing the Internet of Things***, 1st *Ed.*, Wiley India, 2014.
R2. S. Raschka and V. Mirjalili, ***Python Machine Learning***, 3rd *Ed.*, Packt Publishing, 2022.
R3. S. Singh, ***Data Analytics using Python***, 1st *Ed.*, McGraw-Hill Education, 2021.
R4. A. B. Craig, ***Understanding Augmented Reality: Concepts and Applications***, 1st *Ed.*, Morgan Kaufmann, 2013.

Online Resources:
1. https://nptel.ac.in/courses/106105159: by Prof. A. Basu, IIT Kharagpur
2. https://nptel.ac.in/courses/106105166: by Prof. S. Misra, IIT Kharagpur
3. https://nptel.ac.in/courses/106106139: by Prof. B. Ravindran, IIT Madras
4. https://nptel.ac.in/courses/108102045: by Prof. S. Chaudhury, IIT Delhi
5. https://nptel.ac.in/courses/108104113: by Prof. K. P. Kumar, IIT Kanpur
6. https://nptel.ac.in/courses/106106212: by Prof. R. Selvaraju, IIT Roorkee
7. https://nptel.ac.in/courses/106105152: by Prof. S. Sarkar, IIT Kharagpur
8. https://nptel.ac.in/courses/106107222: by Prof. D. J. Reji, IIT Roorkee

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

CO1	Integrate sensors & peripheral devices using embedded platforms for IoT applications.
CO2	Implement IoT communication protocols for reliable data exchange between nodes and servers.
CO3	Design & deploy IoT data visualization dashboards using Node-RED and cloud integration.
CO4	Apply machine learning techniques & augmented reality tools for intelligent IoT systems.
CO5	Analyze & interpret IoT-generated data to build end-to-end smart 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	3	2	2	1					2	3	2	1
CO2	3	2	3	3	2	1					2	3	2	2
CO3	2	1	3	3	3						2	3	3	2
CO4	2	2	3	3	2	1					2	3	3	1
CO5	3	3	3	3	2	1					3	3	3	2

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

Department of Electronics Engineering
SiliconTech, Bhubaneswar

This document has been typeset using $\LaTeX 2_\varepsilon$