



Curriculum Structure & Detailed Syllabus
Bachelor of Technology
in
Computer Science & Engineering
(Four-Year Under-Graduate Program)

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Approval History

ACM#	Date	Resolutions
SU-1	27/04/2024	The curriculum structure of B. Tech. (CSE) was approved in principle by the Academic Council.
SU-2	17/08/2024	The curriculum structure of B. Tech. (CSE) and the 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. (CSE) and the detailed syllabus up to 2nd Year 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, and develop efficient software solutions to problems of varying complexity related to algorithms, system software, multimedia, web applications, data processing, and networking by applying fundamental concepts of computer science.
- PSO2. Develop the skills in different computer languages, environments, tools & platforms to become a successful software professional or entrepreneur, develop a zest for innovation & higher studies, and contribute as a responsible citizen with effective communication, strong moral values and professional ethics.
- PSO3. Adapt to the evolutionary changes in computing and embrace modern practices of software development to deliver user-friendly expert systems with for business success in the real world to meet the challenges of the future.

Program Educational Objectives (PEOs)

- PEO1. *Fundamental Knowledge & Core Competence:* To apply fundamental knowledge of mathematics, science and engineering required for a successful computer professional and inculcate competent problem solving ability using efficient algorithms.
- PEO2. *Proficiency for the Real World:* To foster the skills and creative ability to analyze, design, test and implement cost effective software applications and digital support systems for the changing needs of the real world.
- PEO3. *Leadership & Social Responsibility:* To exhibit leadership capability with professional, ethical, interpersonal skills, social & economic commitment with a sense of responsibility towards public policies, community services, humanity and environment.
- PEO4. *Life-long Learning:* To grow professionally through continued education & training of technical and management skills, pursue higher studies, and engage in life-long learning.

Course Categories & Definitions

L	Lecture
T	Tutorial
P	Practical / Laboratory / Sessional
WCH	Weekly Contact Hours
UCR	University Core Course
UMC	University Mandatory Course (0-Credit)
PCR	Program Core Course
PEL	Program Elective Course
OEL	Open Elective Course
HNS	Honours (Choice-based) Course
MNR	Minor (Choice-based) Course
OOO	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

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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.(CSE)

Semester III								
Category	Code	Course Title	WCH L-T-P			Credits L-T-P		
THEORY								
PCR	MT2001	Discrete Mathematics	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	CS2002	Design & Analysis of Algorithms	3	1	0	3	1	0
PCR	CS2003	Operating Systems	3	0	0	3	0	0
PCR	EC2001	Digital Electronics	3	0	0	3	0	0
PRACTICAL								
UCR	CS2004	OOP Using Java Lab	0	0	2	0	0	1
PCR	CS2005	Design & Analysis of Algorithms Lab	0	0	2	0	0	1
PCR	EC2002	Operating Systems Lab	0	0	2	0	0	1
PCR	CS2006	Digital Electronics Lab	0	0	2	0	0	1
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	MT2002	Optimization Techniques	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	CS2008	Computer Organization & Architecture	3	0	0	3	0	0
PCR	CS2009	Database Management Systems	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	CS2011	Database Management Systems Lab	0	0	4	0	0	2
PCR	CS2012	Computer Organization & Architecture Lab	0	0	2	0	0	1
PCR	CS2013	Internet & Web Technology Lab	0	0	4	0	0	2
		TOTAL	31			25		
		TOTAL (with Honours/Minor)	32			27		

3rd Year B.Tech.(CSE)

Semester V								
Category	Code	Course Title	WCH L-T-P			Credits L-T-P		
THEORY								
PCR		Computer Networks	3	0	0	3	0	0
PCR		Machine Learning	3	1	0	3	1	0
PCR		Software Engineering	3	0	0	3	0	0
PCR		Formal Languages & Automata Theory	3	0	0	3	0	0
PEL		Program Elective - II	3	0	0	3	0	0
PEL		Program Elective - III	3	0	0	3	0	0
HNS/MNR		Honours / Minor - II	3	0	0	3	0	0
PRACTICAL								
PCR		Computer Networks Lab	0	0	2	0	0	1
PCR		Machine Learning Lab	0	0	2	0	0	1
PCR		Software Engineering Lab	0	0	2	0	0	1
SEC		Soft Skills & Inter-Personal Skills	0	0	2	0	0	1
INT		Summer Internship - II	0	0	0	0	0	1
		TOTAL	27			24		
		TOTAL (with Honours/Minor)	30			27		

Semester VI								
Category	Code	Course Title	WCH L-T-P			Credits L-T-P		
THEORY								
PCR		Internet of Things	3	0	0	3	0	0
PCR		Soft Computing	3	0	0	3	0	0
PCR		Compiler Design	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		Internet of Things Lab	0	0	2	0	0	1
PCR		Soft Computing Lab	0	0	2	0	0	1
SEC	/	Emerging Technologies Lab / Entrepreneurship & Innovation	0	0	4	0	0	2
SEC		Professional & Technical Writing	0	0	2	0	0	1
VAC		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.(CSE)
(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
OOO		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		Skill Lab & Project - I	0	0	4	0	0	2
INT		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
OOO		MOOC - II	0	0	0	3	0	0
PRACTICAL								
UCR		Presentation Skills & Technical Seminar	0	0	2	0	0	1
PRJ		Project - II	0	0	16	0	0	8
		TOTAL	21			15		

		GRAND TOTAL	201			160		
		GRAND TOTAL (with Honours/Minor)	221			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.(CSE)
(With Practice School Option in 7th Semester)

Semester VII								
Category	Code	Course Title	WCH L-T-P			Credits L-T-P		
PRACTICAL								
PSI		Practice School / Industry Internship	0	0	0	0	0	15
INT		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		Skill Lab & Project - I	0	0	4	0	0	2
		TOTAL	7			8		
		TOTAL (with Honours/Minor)	15			16		

		GRAND TOTAL	180			160		
		GRAND TOTAL (with Honours/Minor)	198			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.(CSE)
(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		Skill Lab & Project - I	0	0	4	0	0	2
INT		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		Practice School / Industry Internship	0	0	0	0	0	15
		TOTAL	0			15		

		GRAND TOTAL	180			160		
		GRAND TOTAL (with Honours/Minor)	198			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	
CS2014	Artificial Intelligence
CS2015	Computer Graphics
CS2016	Advanced Java Programming
Program Elective - II	
	Data Mining & Data Warehousing
	Cloud Computing
	System Programming
Program Elective - III	
	Big Data Analytics
	Realtime Systems
	Distributed Databases
Program Elective - IV	
	Natural Language Processing
	Wireless Sensor Networks
	Mobile Application Development
Program Elective - V	
	Data Visualization & Reporting
	Mobile Computing
	Cryptography & Network Security
Program Elective - VI	
	Bioinformatics Algorithms
	Embedded Systems
	Blockchain Technology
Open Elective - I & II (Basket)	
	Applied Linear Algebra
	Stochastic Processes
	Numerical Optimization
	Simulation & Modelling
	Fluid Mechanics
	Power Plant Engineering
	Project Management
	Organizational Behaviour
	Entrepreneurship Development
	Securities Analysis, Investment & Trading
	Circular Economy

List of Tracks for Honours / Minor

Code	Honours / Minor # and Subjects
<i>Honours in Computer Science & Engineering</i>	
MT2003	Statistical Inference
	Time Series Analysis
	Deep Learning
	Generative AI
	Nature Inspired Computing
<i>Minor in “VLSI System Design & Verification”</i>	
EC2013	Semiconductor Devices
	Digital VLSI Design
	IC Fabrication Technology
	Digital IC Design & Verification
	Analog VLSI Design
<i>Minor in “Smart Energy Systems”</i>	
EE2010	Circuit Theory
	Renewable Energy Systems
	Basics of Power Systems
	Smart Power Systems
	Electric & Hybrid Vehicles
<i>Minor in “Embedded & IoT System Design”</i>	
EC2011	Embedded C Programming
	Sensors & Transducers
	Embedded System Design
	Real Time Embedded Systems
	Industrial IoT
<i>Minor in “Business Management”</i>	
MG2002	Marketing Management
	Human Resources Management
	Production and Operation Management
	Financial Management
	Business & Corporate Law
<i>Minor in “Business Analytics”</i>	
MG2005	Introduction to Business Analytics
	Data Analytics with Python
	Applied Business Statistics & Predictive Modelling
	Business Intelligence & Visualization
	Business Analytics using Power of AI

Note:

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

Part II

Detailed Syllabus

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

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

Program Outcomes Relevant to the Course:

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

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

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

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

Cont'd...

PO11	Life-Long Learning: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)
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Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

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*, 11th Ed., Pearson Education, 2015.

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

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

P.T.O

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

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

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

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

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

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

Reference Books:

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

Online Resources:

- <https://nptel.ac.in/courses/122104015/>: by Prof. M. Harbola, IIT Kanpur.
- <https://nptel.ac.in/courses/105105108/>: by Prof. S. Bhattacharya, IIT Kharagpur)

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

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

Program Outcomes Relevant to the Course:

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

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

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

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

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

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction, Basic concepts, System, Control volume, Surrounding, Boundaries, Universe, Types of systems, Macroscopic and microscopic viewpoints, Concept of continuum, Thermodynamic equilibrium, State, Property, Process, Exact & inexact differentials, Point & path functions, Cycle, Quasi-static process, Reversibility and irreversibility, Pressure measurement, Zeroth law of thermodynamics, Temperature, Principles of thermometry, Constant volume gas thermometer, Temperature scale.	7 Hours
Module-2	Pure Substances, p-v, T-v, T-s and h-s diagrams, Phase Transformations, Triple point and critical state, properties during change of phase, Dryness Fraction, Property tables. Brief discussion on 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. Kanetkar, *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	3
CO2	3	3	3	2							2	3	2	3
CO3	3	3	1	2							2	3	2	3
CO4	3	3	1	2							2	3	2	3
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*, 2nd Ed., Pearson Education, 2002.
 T2. E. Horowitz, S. Sahni, S. A-Freed, *Fundamentals of Data Structures in C*, 2nd Ed., Univ. Press, 2008.

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

P.T.O

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

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

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

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

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:

- <https://nptel.ac.in/courses/108/105/108105053/>: by Prof. G. D. Roy, Prof. N. K. De, and Prof. T. K. Bhattacharya, IIT Kharagpur
- <https://nptel.ac.in/courses/108/108/108108076/>: By Prof. L. Umanand, IISc Bangalore
- <https://www.electrical4u.com/>
- 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	2			2		1		1	1	1	1		1	1
CO2	3			2		1		2	1	1	2	1	1	1
CO3	1			3		2		2	1	1	1		1	2
CO4	1			2		2		1	1	2	2		1	1
CO5	1			1		1		1	1	1	1	1	1	1

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	3	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	3	2	2

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 Skills*, Oxford University Press, 2011.
 R3. T. Panigrahi, *Communicative Competence*, 1st Ed., Notion Press, 2024.

Online Resources:

- <https://nptel.ac.in/courses/109/106/109106094/>: by Prof. A. Iqbal, IIT Madras
- <https://nptel.ac.in/courses/109/104/109104031/>: by Dr. T. Ravichandran, IIT Kanpur
- <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. Halder, *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 proper 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
CO2	2	2	2	1	2				2	1	1			1
CO3	2	2	3	1	2				2	1	1			1
CO4	2	2	3	1	2				2	1	1	2		1
CO5	2	2	3	1	2				2	1	1	2		2

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

Reference Books:

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

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

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

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

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Cont'd...

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

Text Books:

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

Reference Books:

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

Online Resources:

- <https://archive.nptel.ac.in/courses/109/105/109105144/>: by Prof. S. Singh, IIT Kharagpur
- <https://archive.nptel.ac.in/courses/109/106/109106129/>: by Dr. Ay. I. Viswamohan, IIT Madras
- <https://archive.nptel.ac.in/courses/109/104/109104030/>: by Dr. T. Ravichandran, IIT Kanpur
- <https://www.ef.com/wwen/english-resources/>
- https://owl.purdue.edu/owl/purdue_owl.html
- <https://www.usingenglish.com/>
- <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	Discrete Mathematics	L-T-P	Credits	Marks
PCR	MT2001		3-0-0	3	100

Objectives	The objective of this course is to gain mathematical maturity to handle logical & abstract processes, discrete structures including graph which are essential for solving various problems in computer science.
Pre-Requisites	Knowledge of Sets, basics of number systems, 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	Propositional Logic, Propositional Equivalences, Predicates and Quantifiers, Nested Quantifiers, Rules of Inference, Proof Strategies.	9 Hours
Module-2	Mathematical induction, basics of counting, Pigeonhole principle, Relations and their properties, N-ary Relations & their applications, Representing relations, Closure of relations, Equivalence relations, Partial ordering and Lattice.	9 Hours
Module-3	Introduction to Graphs, Graph terminology, Representation of graphs & graph isomorphism, Connectivity, Euler & Hamilton paths, Planar graph & Graph colouring, Trees, Spanning trees.	9 Hours
Module-4	Generalized permutation and combinations, Recurrence Relations, solving linear Recurrence Relations, Generating functions, Inclusion and Exclusion with applications.	7 Hours
Module-5	Semigroup, Monoid, Groups, Subgroups, Cosets and Lagrange's theorem, Codes and group codes, Rings, Integral Domains & Fields.	8 Hours
Total		42 Hours

Text Books:

- T1. K. H. Rosen, *Discrete Mathematics and Its Applications*, 6th Ed., Tata McGraw-Hill, 2008.
 T2. C. L. Liu, *Elements of Discrete Mathematics*, 2nd Ed., Tata McGraw-Hill, 2008.

Reference Books:

- R1. J. P. Tremblay and R. Manohar, *Discrete Mathematical Structures with Applications to Computer Science*, 1st Ed., McGraw-Hill Education, 2017.
 R2. J. R. Mott, A. Kandel, and T. P. Baker, *Discrete Mathematics for Computer Scientists and Mathematicians*, 2nd Ed., Pearson Education, 2015.

Online Resources:

- <https://nptel.ac.in/courses/106104573>: by Prof. N. Saxena, IIT Kanpur
- <https://nptel.ac.in/courses/106106183>: by Dr. A. Shukla and Prof. S. Iyengar, IIT Ropar
- <https://nptel.ac.in/courses/106108227>: by Prof. A. Choudhury, IIIT Bangalore
- <https://nptel.ac.in/courses/106103205>: by Prof. B. George and Prof. S. Gopalan, IIT Guwahati
- <https://nptel.ac.in/courses/106106094>: by Prof. K. Krithivasan, IIT Madras
- <https://nptel.ac.in/courses/111106086>: by Prof. S. Chakraborty, Chennai Mathematical Institute

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

CO1	Apply logic for logical inferences in real life problems.
CO2	Understand and apply the concepts of relation and lattice.
CO3	Apply graph theory to real-life problems of computer science & engineering.
CO4	Apply principle of inclusion & exclusion, generating functions and recurrence relations to solve counting problems.
CO5	Differentiate the discrete algebraic structures and apply them to study group codes.

Program Outcomes Relevant to the Course:

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

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2					1	1	2	1	1
CO2	3	2	2	2	1							2	1	1
CO3	3	3	3	3	3					3	1	2	1	1
CO4	3	2	3	2	2					2		2	1	1
CO5	2	2	2	2	2							2	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	Design & Analysis of Algorithms	L-T-P	Credits	Marks
PCR	CS2002		3-1-0	4	100

Objectives	The objectives of this course is to introduce the techniques for designing efficient algorithms, apply them to solve problems, and analyze their complexities for application in different domains of computer science.
Pre-Requisites	Knowledge of Discrete Mathematics and Data Structures is essential.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction, Definition, Characteristics of algorithm, Growth of functions, Asymptotic analysis, Standard asymptotic notations and common functions, Recurrences, Solution of recurrences by iterative, Recursion tree, Substitution and Master method; Algorithm design techniques, Divide and conquer strategy for designing algorithms, Obtaining best, average, and worst-case running time of merge sort, quick sort and randomized quick sort.	12 Hours
Module-2	Heaps, Building a Heap, The heap sort algorithm, Priority Queue with their analysis; Lower bound of sorting algorithms; Dynamic Programming, Elements of dynamic programming, Matrix chain multiplication, Longest Common Subsequence, String matching algorithms (Naive, Rabin-Karp, Knuth Morris-Pratt algorithm).	10 Hours
Module-3	Greedy algorithms, Elements of Greedy strategy, Activity selection problem, Fractional Knapsack problem along with correctness proof, Huffman codes; Backtracking and Branch & Bound techniques (n-Queen, Knapsack, and Travelling Salesman problem); Data structure for disjoint sets, Disjoint set operations, Linked list representation, Path compression, Disjoint set forest.	12 Hours
Module-4	Graph algorithms and their characteristics, Breadth-first and Depth-first search, Minimum spanning trees, Kruskal and Prim's algorithms, Single source shortest path algorithms(Bellman-Ford, Dijkstra), All-pair shortest path algorithm (Floyd-Warshall) with their analysis.	10 Hours
Module-5	Maximum flow problem, Ford-Fulkerson algorithm and its analysis; NP completeness (Polynomial time, Polynomial time verification, NP completeness and reducibility), Cook's Theorem (without proof), Examples of NP complete problems (without proof)- Circuit satisfiability, 3-CNF satisfiability, Clique, Vertex cover, Ham-cycle, TSP (without proof); Approximation algorithm characteristics, Travelling Salesman Problem, Randomized algorithms (Max 3-CNF satisfiability).	12 Hours
Total		56 Hours

Text Books:

- T1. T. H.Cormen, C.E.Leiserson, R. L. Rivest, and C. Stein, *Introduction to Algorithms*, 4th Ed., PHI Learning, 2021.
- T2. E. Horowitz, S.Sahni, and S. Rajasekaran, *Fundamentals of Computer Algorithms*, 2nd Ed., University Press, 2015.

T3. J. Kleinberg and É. Tardos, *Algorithm Design*, 1st Ed., Pearson Education, 2013.

Reference Books:

- R1. M. T. Goodrich and R. Tamassia, *Algorithm Design: Foundations, Analysis, and Internet Examples*, 1st Ed., John Wiley & Sons, 2001.
- R2. U. Manber, *Introduction to Algorithms: A Creative Approach*, 1st Ed., Addison-Wesley, 1989.
- R3. S. Sridhar, *Design and Analysis of Algorithms*, 1st Ed., Oxford University Press, 2014.
- R4. G. Sharma, *Design & Analysis of Algorithms*, 4th Ed., Khanna Publishers, 2019.

Online Resources:

1. <https://nptel.ac.in/courses/106106131>: by Prof. M. Mukund, Chennai Mathematical Institute
2. <https://nptel.ac.in/courses/106101060>: by Prof. Ranade, Diwan, and Viswanathan, IIT Bombay
3. <https://nptel.ac.in/courses/106105164>: by Prof. S. Mukhopadhyay, IIT Kharagpur
4. <https://web.stanford.edu/class/archive/cs/cs161/cs161.1138/>
5. <https://ocw.mit.edu/courses/6-046j-design-and-analysis-of-algorithms-spring-2015/>

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

CO1	Design algorithms, analyze their running time for best, worst, and average-cases, and understand divide & conquer strategy considering quick sort and merge sort as examples.
CO2	Compare Heapsort with other comparison based sorting algorithms and develop dynamic programming algorithms.
CO3	Apply disjoint-set data structure and various algorithm design techniques such as greedy, backtracking, and branch-and-bound in real life problems.
CO4	Model a given engineering problem using graphs and design the corresponding algorithms to solve the problem.
CO5	Compare various pattern matching algorithms, understand NP-Completeness and the need of approximation & randomized algorithms.

Program Outcomes Relevant to the Course:

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

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	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	Operating Systems	L-T-P	Credits	Marks
PCR	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	Digital Electronics	L-T-P	Credits	Marks
PCR	EC2001		3-0-0	3	100

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

- T1. M. M. Mano and M. D. Ciletti, *Digital Design: With an Introduction to Verilog HDL*, 5th Ed., Pearson Education, 2013.
- T2. L. K. John and C. H. Roth Jr., *Digital System Design using VHDL*, 2nd Ed., Cengage Learning, 2012.

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Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	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 robust 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	Design & Analysis of Algorithms Lab	L-T-P	Credits	Marks
PCR	CS2005		0-0-2	1	100

Objectives	The objective of this course is to design and implement efficient algorithms for a specified application.
Pre-Requisites	Knowledge of Discrete Mathematics and Data Structures are essential.
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	Linear & Binary Search.
2	Conversion of infix to postfix expression using Stack.
3	Sorting: Selection, Bubble and Insertion Sort.
4	Sorting: Quick Sort and Merge Sort.
5	Sorting: Heap Sort.
6	Matrix Chain Multiplication.
7	Longest Common Subsequence.
8	Fractional and 0/1 Knapsack problem.
9	n-Queen problem.
10	Graph Traversal using BFS/DFS.
11	Dijkstra's single source shortest path algorithm.
12	Warshall's all pair shortest path algorithm.
13	Kruskal's/Prim's algorithm for Minimum Spanning Tree.
14	Naïve and Rabin-Karp string matching algorithm.

Text Books:

- T1. T. H.Cormen, C.E.Leiserson, R. L.Rivest, and C. Stein, *Introduction to Algorithms*, 4th Ed., PHI Learning, 2021.
- T2. E. Horowitz, S.Sahni, and S.Rajasekaran, *Fundamentals of Computer Algorithms*, 2nd Ed., University Press, 2015.
- T3. J. Kleinberg and É. Tardos, *Algorithm Design*, 1st Ed., Pearson Education, 2013.

Reference Books:

- R1. M. T. Goodrich and R. Tamassia, *Algorithm Design: Foundations, Analysis, and Internet Examples*, 1st Ed., John Wiley & Sons, 2001.
- R2. U. Manber, *Introduction to Algorithms: A Creative Approach*, 1st Ed., Addison-Wesley, 1989.
- R3. S. Sridhar, *Design and Analysis of Algorithms*, 1st Ed., Oxford University Press, 2014.
- R4. G. Sharma, *Design & Analysis of Algorithms*, 4th Ed., Khanna Publishers, 2019.

Online Resources:

1. <https://nptel.ac.in/courses/106106131>: by Prof. M. Mukund, Chennai Mathematical Institute
2. <https://nptel.ac.in/courses/106101060>: by Prof. Ranade, Diwan, and Viswanathan, IIT Bombay
3. <https://nptel.ac.in/courses/106105164>: by Prof. S. Mukhopadhyay, IIT Kharagpur

4. <https://web.stanford.edu/class/archive/cs/cs161/cs161.1138/>
5. <https://ocw.mit.edu/courses/6-046j-design-and-analysis-of-algorithms-spring-2015/>

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

CO1	Implement various searching and sorting algorithms and compare their execution time.
CO2	Understand and develop skill to solve problems using divide and conquer strategy.
CO3	Apply greedy, dynamic programming, backtracking and branch and bound paradigms to solve real life problems.
CO4	Formulate engineering problems and solve them using graph algorithms.
CO5	Implement and compare various pattern matching algorithms such as Naïve, Rabin-Karp 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).
PO6	The Engineer and The World: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO11	Life-Long Learning: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

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

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

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Operating Systems Lab	L-T-P	Credits	Marks
PCR	CS2006		0-0-2	1	100

Objectives	The objective of this laboratory course is to learn operating system level programming and provide a hands-on exposure on implementation of various algorithms of the operating system.
Pre-Requisites	Knowledge of programming, data structures, and concepts of operating systems taught in the theory class 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	Introduction to Linux OS and basic VI editor commands.
2	Linux File Structure and advance Linux commands like grep , pipe , cut , etc.
3	Introduction to UNIX Shell Script: Arithmetic Expressions, Relational and Conditional Operators.
4	UNIX Shell Script: Looping, Switch Cases.
5	Process Creation, process handing, process signaling through fork() , exec() .
6	CPU Scheduling (Non-Pre-emptive) FCFS, SJF, Priority.
7	CPU Scheduling (Pre-emptive) SRTF, RR, Priority-based preemptive.
8	Multi-Threaded application using POSIX threads.
9	Synchronization using Semaphore (Producer- Consumer, Reader-Writer).
10	Message passing : Pipe and Signals.
11	Inter-process communication using shared memory.
12	Deadlock implementation: Banker's Algorithm.
13	Implementing Page Replacement Algorithms.
14	Implementing Disk scheduling Algorithms.

Text Books:

- T1. V. Mukhi, *The C Odyssey: UNIX*, 1st Ed., BPB Publications, 1992.
 T2. A. Silberschatz, P. B. Galvin, and G. Gagne, *Operating System Concepts*, 8th Ed., Wiley, 2009.

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:

- https://www.technicalsposium.com/sharelabcodings_os.html
- https://www.cse.iitb.ac.in/~mythili/teaching/cs347_autumn2016/index.html

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

CO1	Become conversant with various Linux commands and their specific uses.
CO2	Write, debug, and execute UNIX shell scripts for a given problem.
CO3	Implement various scheduling algorithms used at the operating system level.
CO4	Write programs for creation of child processes and communication among them.
CO5	Develop and implement deadlock avoidance and detection 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).
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		1					2			1
CO2	3	2	3	2		1					2	2		
CO3	2	2	3	2		1					2	2		1
CO4	2	2	2	3		1					2	2		
CO5	2	3	3	3		1					2	2		1

Category	Code	Optimization Techniques	L-T-P	Credits	Marks
PCR	MT2002		3-0-0	3	100

Objectives	The objective of this course is to provide a good exposure to linear and non-linear programming with several standard numerical methods, and the right kind of tools to solve large scale optimization problems in engineering.
Pre-Requisites	Knowledge of calculus of several variables, coordinate geometry of two and 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	Linear Programming: Graphical Method, Simplex Method, Big-M Method, Alternate Optima, Redundancy & Degeneracy.	8 Hours
Module-2	Simplex Method Algorithm, Dual Problem, Construction of Dual, Duality Theorem (without proof), Dual Simplex method, Post Optimal analysis.	8 Hours
Module-3	Integer Linear Programming: Branch & Bound Method, Gradient of a Function, Matrix differentiation, Multi Variable Unconstrained Optimization and its relationship to Taylor's Series, Convex Function, Convex Programming Problem.	9 Hours
Module-4	Quadratic Programming, Wolfe's method for QPP, Optimality Conditions, Lagrangian & Lagrange Multipliers, KKT Necessary/sufficient optimality conditions, Unconstrained optimization - Line search methods for uni-modal functions, Steepest Descent method, Newton's method.	9 Hours
Module-5	Constrained Optimization: Frank Wolfe's Method, Rosen's Gradient Projection Method, Penalty Function Method.	8 Hours
Total		42 Hours

Text Books:

- T1. S. Chandra, Jayadeva, and A. Mehera, *Numerical Optimization with Applications*, 1st Ed., Narosa Publishing House, 2013.
- T2. A. Ravindran, D. Phillips, and J. J. Solberg, *Operations Research: Principle and Practice*, 2nd Ed., Wiley India, 2010.

Reference Books:

- R1. D. G. Luenberger and Y. Ye, *Linear & Nonlinear Programming*, 3rd Ed., Springer, 2008.
- R2. S. S. Rao, *Engineering Optimization*, 4th Ed., New Age Publishers, 2009.
- R3. K. Dev, *Optimization for Engineering Design*, 2nd Ed., Prentice Hall India, 2012.

Online Resources:

1. <https://nptel.ac.in/courses/106108056>: by Dr. S. K. Shevade, IISc Bangalore
2. <https://nptel.ac.in/courses/111105100>: by Prof. Goswami and Chakraborty, IIT Kharagpur
3. <https://nptel.ac.in/courses/112101298>: by Prof. A. A. Kulkarni, IIT Bombay
4. <https://nptel.ac.in/courses/106106245>: by Prof. P. Biyani, IIT Delhi

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

CO1	Solve linear programming problems using graphical and simplex methods.
CO2	Apply duality concepts solve optimization problems and perform post-optimal analysis.
CO3	Solve integer programming and quadratic programming problems.
CO4	Explain and solve non-linear programming and unconstrained optimization problems.
CO5	Solve constrained optimization problems in engineering using appropriate 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).
PO10	Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	Life-Long Learning: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

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

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

Category	Code	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. Gutttag, *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	Computer Organization & Architecture	L-T-P	Credits	Marks
PCR	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 architectural concepts of a digital computer, identify various functional units and describe their functionality.
CO2	Understand various instruction formats, represent instructions in different formats, and solve problems using different addressing modes.
CO3	Explore circuit arrangements for binary arithmetic, perform diverse arithmetic operations using various techniques, and work with floating-point representations and operations.
CO4	Explain the working principle of Main memory, Cache memory and Virtual memory and solve numerical problems based on memory management.
CO5	Describe the working mechanism of the control unit and compare the performance of hardwired and software approaches.

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

Category	Code	Database Management Systems	L-T-P	Credits	Marks
PCR	CS2009		3-1-0	4	100

Objectives	The objective of the course is to understand the aspects of design, implementation, and operation of relational database systems, transaction processing, concurrency control, recovery, and some advanced database concepts.
Pre-Requisites	Basic knowledge of data structures and algorithms 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 and definitions, three-schema architecture, data independence, Concept of data models, types of data models, database languages, integrity, database users, Entity-Relationship model, Constraints & Keys, Extended Entity Relationship model, Relational model, Mapping of E-R model to relational schema, System structure of DBMS, Codd's 12 Rules.	12 Hours
Module-2	Query Languages: Relational Algebra, basic operations, join operations, grouping & aggregation, Relational Calculus; Query processing and optimization: Evaluation of relational algebra expressions, Heuristic-based Query optimization.	11 Hours
Module-3	Database Design: Functional dependencies, Armstrong axioms, Attribute closure, Equivalence sets of FD, Minimal cover; Normalization: Dependency & attribute preservation, lossless join; Normal Forms: 1NF, 2NF, 3NF, BCNF, Testing for lossless design, Multi-Valued Dependency (MVD), 4NF and 5NF.	11 Hours
Module-4	Transaction Processing: Basic concepts, ACID Properties, Serializability, Concurrency Control Schemes – lock-based & timestamp-based protocols, Deadlock handling, deadlock prevention, detection and recovery; Database Recovery: types of database failures, Recovery techniques - log-based recovery, checkpoints, shadow paging.	12 Hours
Module-5	Storage Strategies: Storage Architecture, File and Record Organization, Types of Indexes, B-Tree, B+ Tree, Index Files, Hashing, Data Dictionary; Distributed databases: Homogeneous vs. heterogeneous, Fragmentation & replication, Data transparency; Introduction to NoSQL: Properties, Columnar families, different NoSQL systems.	10 Hours
Total		56 Hours

Text Books:

- T1. A. Silberschatz, H. F. Korth, and S. Sudarshan, *Database System Concepts*, 6th Ed., McGraw-Hill Education, 2013.
- T2. R. Elmasri and S. B. Navathe, *Fundamentals of Database Systems*, 7th Ed., Pearson Education, 2016.
- T3. P. J. Sadalage and M. Fowler, *NoSQL Distilled*, 1st Ed., Pearson Education, 2012.

Reference Books:

- R1. R. Ramakrishnan and J. Gekhre, *Database Management Systems*, 3rd Ed., McGraw-Hill, 2003.
- R2. R. P. Mahapatra and G. Verma, *Database Management Systems*, 1st Ed., Khanna Publishing, 2013.

R3. C. J. Date, *Introduction to Database Systems*, 8th Ed., Pearson Education, 2003.

Online Resources:

1. <https://nptel.ac.in/courses/106104135/>: by Dr. A. Bhattacharya, IIT Kanpur
2. <https://nptel.ac.in/courses/106105175/>: by Prof. P. P. Das et. al., IIT Kharagpur
3. <https://cs145-fa18.github.io/>: by Prof. S. Shivakumar
4. <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-830-database-systems-fall-2010/lecture-notes/>
5. <https://docs.oracle.com/database/121/SQLRF/toc.htm>

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

CO1	Understand the components of DBMS and create E-R model for real world applications.
CO2	Construct queries using relational algebra and explain query processing & optimization.
CO3	Design relational databases and normalize the designs using different normalization techniques.
CO4	Resolve concurrency control issues and recover from database failures.
CO5	Visualize storage structures, indexing techniques and explore distributed & NoSQL databases.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Artificial Intelligence	L-T-P	Credits	Marks
PEL	CS2014		3-0-0	3	100

Objectives	The objective of the course is to provide a strong foundation of fundamental concepts and goals, methods & techniques of Artificial Intelligence (AI) to build intelligent systems with perception, 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, Foundations of AI, Intelligent Agents: Definition, Agent function & programs, Rationality, Environment types, PEAS description, Structure of Agents; Types of Agent Programs, Problem Solving: Solving Problems by Searching - Problem-Solving Agents, Example Problems, State space search, Searching for Solutions, Uninformed Search Strategies: Breadth First, Depth First, Depth Limited, Iterative Deepening DFS, Uniform Cost, Bi-directional Searches.	9 Hours
Module-2	Informed Search & Exploration: Introduction, Evaluation & Heuristic functions, Informed Search Strategies: Greedy Best First Search, A* Search, Example Problems, Local Search Algorithms: Hill Climbing Search & Simulated Annealing, Example Problems, Constraint Satisfaction Problems: Introduction & types of CSPs, Backtracking Search for CSPs, Adversarial Search: Introduction, Game playing, Minimax & Alpha-Beta Pruning; Knowledge & Reasoning: Knowledge-Based Agents, Wumpus World problem.	9 Hours
Module-3	Knowledge & Reasoning: Logic, Propositional Logic, First-Order Logic: Syntax and Semantics of First Order Logic, Using First-Order Logic, Inference in First-Order Logic: Propositional vs. First-Order Logic, Resolution, Forward & 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, Example Problems, Partial Order Planning, Planning Graphs, Hierarchical Planning, Uncertain Knowledge & Reasoning: Acting under Uncertainty, Bayes Rule & it's use; Probabilistic Reasoning: Representing Knowledge in an Uncertain Domain, Semantics of Bayesian Networks.	8 Hours
Module-5	Learning: Introduction, Learning Agent, Paradigms of learning, Learning from Observations, Inductive Learning, Information Gain approach, Learning Decision Trees; Statistical Learning, Instance Based Learning, Neural Networks: Introduction, Perceptron, Reinforcement Learning, Expert Systems: Introduction & architecture.	8 Hours
Total		42 Hours

Text Books:

- T1. S. Russell and P. Norvig, *Artificial Intelligence - A Modern Approach*, 3rd Ed., Pearson Education, 2016.

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, 2009.
- R2. G. F. Luger, *Artificial Intelligence: Structures and Strategies for Complex Problem Solving*, 6th Ed., Pearson Education, 2008.
- R3. M. Negnevitsky, *Artificial Intelligence: A Guide to Intelligent Systems*, 3rd Ed., Addison Wesley, 2.
- R4. N. J. Nilson, *Principles of Artificial Intelligence*, Narosa Publishing, 2002.

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	Use 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	Computer Graphics	L-T-P	Credits	Marks
PEL	CS2015		3-0-0	3	100

Objectives	The objective of this course is to study computer modeling of 2D & 3-D objects and efficiently generating photo-realistic renderings on color raster graphics devices.
Pre-Requisites	Knowledge of coordinate geometry and matrix operations is required.
Teaching Scheme	Regular classroom lectures with use of ICT 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, Overview of computer graphics, Basic terminologies in graphics, Lookup table, Plotters, Printers, Digitizers, Light pens, Active & passive graphics devices, Raster & random scan displays, CRT basics, Video basics.	8 Hours
Module-2	Output Primitives - Points, Lines, Circles and Ellipses as primitives, Scan conversion algorithms for primitives, Fill area primitives including scan-line polygon filling, Inside-outside test, Boundary and flood-fill, Character generation, Line attributes, Area-fill attributes, Character attributers.	10 Hours
Module-3	2D and 3D Transformations (translation, rotation, scaling), Matrix representation, Homogeneous coordinates, Composite transformations, Reflection and shearing, Viewing pipeline and coordinates system, Window-to-viewport transformation, Clipping including point clipping, Line clipping (Cohen-Sutherland, Liang-Barsky), Polygon clipping.	8 Hours
Module-4	3D display methods, Polygon surfaces, Tables, Equations, Meshes, Curved lines and surfaces, Quadric surfaces, Spline representation, Cubic spline interpolation methods, Bezier curves and surfaces, B-spline curves and surfaces, General (parallel and perspective) projection transformations, Fractal geometry.	8 Hours
Module-5	Visible surface detection concepts, Back-face detection, Depth buffer method, Illumination, Light sources, Illumination methods (ambient, diffuse reflection, specular reflection), Color models - properties of light, XYZ, RGB, YIQ and CMY color models, Animation (introduction only).	8 Hours
Total		42 Hours

Text Books:

- T1. D. Hearn and P. Baker, *Computer Graphics – C Version*, 2nd Ed., Pearson Education, 2004.
 T2. F. S. Hill, *Computer Graphics using OpenGL*, 2nd Ed., Pearson Education, 2003.

Reference Books:

- R1. J. F. Hughes, A. V. Dam, M. McGuire, D. F. Sklar, J. D. Foley, S. K. Feiner, and K. Akeley, *Computer Graphics: Principles and Practice*, 3rd Ed., Addison-Wesley Professional, 2013.
 R2. D. Hearn, M. P. Baker and W. Carithers, *Computer Graphics with OpenGL*, 4th Ed., Prentice Hall India, 2010.
 R3. S. Harrington, *Computer Graphics - A Programming Approach*, 2nd Ed., Tata McGraw-Hill, 2004.

Online Resources:

1. <http://nptel.ac.in/courses/106102065/>: by Prof. P. K Kalra, IIT Delhi
2. <https://nptel.ac.in/courses/106/106/106106090/>: by Prof. S. Das, IIT Madras

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

CO1	Describe the basics of computer graphics and its applications.
CO2	Explore the standard line, circle, and area filling algorithms.
CO3	Design various transformation models in 2D and 3D spaces.
CO4	Apply the design principles to generate curves and mapping using projection.
CO5	Explore hidden lines and surface detection techniques with color models.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Advanced Java Programming	L-T-P	Credits	Marks
PEL	CS2016		3-0-0	3	100

Objectives	The objective of the course is to learn advanced features of the Java programming language, various frameworks in J2EE for rapid development, and apply these to develop enterprise applications.
Pre-Requisites	Knowledge of object oriented programming using Java is required.
Teaching Scheme	Regular classroom 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	J2EE Environment: Overview of J2EE and J2SE, J2EE Architecture; JDBC: The Concept of JDBC, JDBC Driver Types, JDBC Packages, Database Connection, CRUD Operations using JDBC, Transaction Processing, Metadata; Web Applications and Programming: Web application architecture, Client, Server (Apache Tomcat/WebLogic), HTML5, CSS3; Client Side Programming: JavaScript, JQuery; Introduction to XML/JSON.	8 Hours
Module-2	Servlets: Introduction, Servlet Architecture, Environment Setup, Life Cycle, Form Data processing, Client HTTP Request, Server HTTP Response, HTTP Status Codes, Exception Handling; Advanced Features of Servlets: Handling Cookies, Session Tracking, URL rewriting, Database access, File uploading, Date handling, Page redirection, Sending email, Packaging, Debugging, Internationalization.	8 Hours
Module-3	Java Server Pages (JSP): Advantages of JSP over Servlet, Lifecycle of a JSP page, JSP API, Scriptlet tag, Implicit objects, Directives, Exception handling, Action tags, Expression Language (EL); Advanced Features of JSP: Session Tracking, MVC, JSTL, Custom Tags, CRUD operations; JSP Sample Code: Pagination, Registration Form, File Uploading.	9 Hours
Module-4	Maven: Introduction to Maven, Dependencies and Dependency Management, POM Structure; Spring Core: Introduction to Spring Framework, Inversion of Control and Dependency Injection, Configuring Beans in Spring, Autowiring, and Component Scanning.	8 Hours
Module-5	Spring MVC: Introduction to Spring MVC Framework, MVC Design Pattern, Configuring Spring MVC with XML and Java Configuration, Spring MVC Annotations, Form Handling and Data Binding; Spring JDBC Template: Introduction, Quieres, Parameterized Queries and Named Parameter JDBC Template, CRUD Operations.	9 Hours
Total		42 Hours

Text Books:

- T1. J. Keogh, *J2EE: The Complete Reference*, 11th Ed., McGraw Hill, 2017.
- T2. Kogent Learning Solutions, *Java Server Programming: Java EE 7 (J2EE 1.7) Black Book*, 1st Ed., DreamTech, 2014.

Reference Books:

- R1. DT Editorial Services, *J2EE 1.7 Projects Black Book*, 1st Ed., DreamTech, 2015.
 R2. Kogent Learning Solutions, *Web Technologies: HTML, Javascript, PHP, Java, JSP, XML and Ajax, Black Book*, 2nd Ed., DreamTech, 2009.
 R3. C. Walls, *Spring in Action*, 6th Ed., Manning, 2022.

Online Resources:

1. <https://docs.spring.io/spring-framework/reference/>: Spring Reference
2. <https://www.baeldung.com/spring-jdbc-jdbctemplate>: by Eugen Paraschiv
3. <https://www.javatpoint.com/spring-tutorial/>: Spring Tutorials
4. <https://www.javatpoint.com/spring-JdbcTemplate-tutorial/>: JDBC Tutorials

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

CO1	Explain concepts of J2EE and fundamentals of web application development.
CO2	Design & develop web applications using Servlet technologies.
CO3	Design & develop web applications using JSP technologies.
CO4	Understand dependency, dependency managers and set up J2EE applications.
CO5	Create enterprise J2EE applications using Spring MVC and Spring JDBC.

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

Category	Code	Statistical Inference	L-T-P	Credits	Marks
HNS	MT2003		3-0-0	3	100

Objectives	The objective of this course is inculcate statistical thinking in designing data collection, derive insights from visualizing data, obtain supporting evidence for data-based decisions, and construct models for predicting & inferring future trends from statistical properties of data.
Pre-Requisites	Basic knowledge of probability & 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	Distributions Derived from the Normal Distribution: χ^2 , t , and F distribution, Sample mean and sample variance; Survey Sampling: Population parameters, Sample random sampling - Expectation and variance of sample mean, Estimation of population variance, Normal approximation to the sampling distribution of $\bar{X}$, Estimation of a ratio.	9 Hours
Module-2	Estimation of Parameters & Fitting of Probability Distributions: Fitting the Poisson distribution, Parameter estimation (method of moments, maximum likelihood); Large sample theory for maximum likelihood estimates, Confidence intervals from maximum likelihood estimates, Bayesian approach to parameter estimation, Large sample normal approximation to the posterior, Computational aspects, Efficiency and the Camer-Rao lower bound, Negative binomial distribution, Sufficiency (Factorization & Rao-Blackwell theorem).	9 Hours
Module-3	Testing Hypotheses & Assessing Goodness of Fit: The Neyman-Person paradigm - Specification of the significance level, Concept of a p -value, Null hypothesis, Uniformly most powerful tests, Duality of confidence intervals & hypothesis tests, Generalized likelihood ratio test, Likelihood ratio tests for multinomial distribution, Probability plots, Tests for normality; Summarizing Data: Comparison of location estimates, Estimating variability by bootstrap, Measures of dispersion, Boxplots, Scatter plots, Relationship.	8 Hours
Module-4	Comparing Two Samples: Comparing two independent samples – Methods based on the normal distribution, power, A nonparametric method - the Mann Whitney test, Bayesian approach, Comparing paired samples - Methods based on the normal distribution, Signed rank test, Case studies; Analysis of Variance: One-way layout - Normal theory, F test, Problem of multiple comparisons, Kruskal Wallis test.	8 Hours
Module-5	Analysis of Categorical Data: Fisher's exact test, χ^2 test of homogeneity & independence, matched pairs designs, odds ratios; Simple Linear Regression: Statistical properties of the estimated slope & intercept, Accessing the fit, Correlation & regression.	8 Hours
Total		42 Hours

Text Books:

T1. J. A. Rice, *Mathematical Statistics and Data Analytics*, 3rd Ed., Cengage Learning, 2006.

Reference Books:

- R1. L. Wasserman, *All of Statistics : A Concise Course in Statistical Inference*, 1st Ed., Springer, 2004.
 R2. B. Efron and T. Hastie, *Computer Age Statistical Inference : Algorithms, Evidence, and Data Science*, 1st Ed., Cambridge University Press, 2016.

Online Resources:

1. <https://nptel.ac.in/courses/111105090>: by Prof. S. Kumar, IIT Kharagpur
2. <https://nptel.ac.in/courses/111102160>: by Prof. S. Dharmaraja, IIT Delhi
3. <https://nptel.ac.in/courses/111105043>: by Prof. S. Kumar, IIT Kharagpur
4. <https://nptel.ac.in/courses/111102112>: by Prof. N. Chatterjee, IIT Delhi

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

CO1	Explain sampling distributions like χ^2 , t , and F distribution and apply to real life problems.
CO2	Estimate the parameters and fitting of probability distributions.
CO3	Tests a hypothesis, assess the goodness of fit and make a decision using p -value.
CO4	Draw conclusion using two sample studies and analysis of variance.
CO5	Analyze categorical data and formulate linear regression model for the given 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).
PO10	Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	Life-Long Learning: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

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

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

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Circuit Theory	L-T-P	Credits	Marks
MNR	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. Kabisatpathy, 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	Marketing Management	L-T-P	Credits	Marks
MNR	MG2002		3-0-0	3	100

Objectives	The objective of this course is to obtain a comprehensive understanding of marketing principles and strategies, analyzing market environments, consumer behavior, and developing effective approaches to product management, pricing, promotion, distribution, and digital marketing.
Pre-Requisites	Basic knowledge on fundamentals of management and economics is desired.
Teaching Scheme	Regular classroom lectures with use of ICT as needed. Each session is planned to be interactive with focus on real-world case studies and examples.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Marketing: Meaning, scope and importance, Evolution of marketing, Understanding marketing in new perspective, Marketing environment, Information system and marketing research - Importance, scope and steps of marketing research process, Understanding consumer behaviour, Analysing business markets, Customer relationship management.	9 Hours
Module-2	Understanding consumer behaviour, Analysing business markets, Customer relationship management; Managing Mix: Product - Concept and classification, New product development, Product-mix and product line strategies, Product life cycle strategies, Branding, packaging, labelling and warranty.	8 Hours
Module-3	Promotion Programme: Advertising, Sales promotion, Public relations, Publicity and personal selling; Pricing: Price determination, Pricing policies and strategies.	8 Hours
Module-4	Channel Decision: Nature of marketing channels, Types of channel flows, Channel functions, Functions of distribution channel, Structure and design of marketing channels, Channel co-operation, Conflict and competition, Retailers and wholesalers.	9 Hours
Module-5	Distribution logistics and Supply chain management, Marketing channels, Retailing, Wholesaling and physical distribution, Marketing and information economy, Direct and online marketing.	8 Hours
Total		42 Hours

Text Books:

- T1. V. S. Ramaswamy and S. Namakumari, *Marketing Management*, 6th Ed., Sage Publications, 2018.
- T2. K. Karunakaran, *Marketing Management*, 1st Ed., Himalaya Publishing House, 2010.
- T3. T. N. Chabra and S. K. Grover, *Marketing Management*, 1st Ed., Dhanpat Rai & Co., 2016.

Reference Books:

- R1. P. Kotler and K. L. Keller, *Marketing Management*, 15th Ed., Pearson Education, 2016.
- R2. P. Baines, C. Fill, S. Rosengren, and P. Antonetti, *Marketing*, 5th Ed., Oxford University Press, 2019.
- R3. C. W. Lamb, J. F. Hair, D. Sharma, C. McDaniel, *Marketing*, 1st Ed., Cengage Learning, 2013.
- R4. J. P Mahajan and A. Mahajan, *Marketing Management*, 1st Ed., Vikas Publishing House, 2014.

Online Resources:

1. <https://nptel.ac.in/courses/110104068>: by Prof. J. Chatterjee and Dr. S. S. Mishra, IIT Kanpur
2. <https://nptel.ac.in/courses/110104070>: by Prof. J. Chatterjee and Dr. S. S. Mishra, IIT Kanpur
3. <https://nptel.ac.in/courses/110108141>: by Prof. R. Srinivasan, IISc Bangalore
4. https://ddceutkal.ac.in/Syllabus/MCOM/Marketing_Management.pdf

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

CO1	Explain marketing, marketing mix and impact of marketing on business strategies.
CO2	Conduct marketing research and understand consumer behaviour, products & their life cycle.
CO3	Design effective promotional strategies for publicity and product positioning in the market.
CO4	Determine pricing policies as per market dynamics and effectively utilize marketing channels.
CO5	Implement supply chain management and leverage digital tools for direct and online marketing.

Program Outcomes Relevant to the Course:

PO3	Design/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
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			2	3	2	2	1	1	2	2	1			
CO2			2	2	2	1	2	2	2	3	1			
CO3			2	2	2	2	2	1	2	3	2		1	
CO4			2	2	3	3	3	3	2	3	1		1	
CO5			2	2	3	3	3	3	3	3	2		1	1

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	Database Management Systems Lab	L-T-P	Credits	Marks
PCR	CS2011		0-0-4	2	100

Objectives	The objective of this course is to provide a formal foundation in database design, query, and data manipulation, and impart hand-on practice to the students to groom them into well-informed database application developers.
Pre-Requisites	Knowledge of theory of databases and programming skills is 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	Introduction to Oracle databases, simple queries for data retrieval.
2,3	Data retrieval based on conditions and sorting the query results.
4	Using single-row functions in SQL queries for data retrieval.
5	Applying grouping and aggregation functions.
6	Writing complex queries using sub-queries.
7	Create, alter, and manipulate design of tables.
8,9	Data manipulation using various DML statements.
10	Imposing various constraints on tables for maintaining data integrity.
11,12	Retrieve data from multiple tables using various types of Join operations.
13	Create, alter, and manage Views from single & multiple base tables.
14	Create and use other data base objects like sequence, indexes, and synonyms.
15	Controlling user access to database using DCL queries: Grant, Revoke.
16	Perform Set operations on tables: Union, Union All, Intersect, Minus.
17	Write SQL queries by using co-related sub-queries.
18	Introduction to PL/SQL, identifiers, literals, and keywords.
19	Write PL/SQL block by using conditional statements and expressions.
20	Using different types of Loops in a PL/SQL block.
21	Implement Exception Handling in a PL/SQL block.
22	Write PL/SQL block by using numeric, string, and other miscellaneous data types.
23	Introduction to data retrieval using Cursors by providing elementary idea.
24,25	Introduction to Stored procedures, Write PL/SQL block using procedures.
26	Develop functions with in/out parameters and using them in a PL/SQL block.
27, 28	Oracle Triggers – introduction, syntax, types and use.

Text Books:

- T1. K. Loney, *Oracle Database 11g : The Complete Reference*, 1st Ed., McGraw-Hill, 2009.
- T2. I. Bayross, *Teach Yourself SQL/PL SQL Using Oracle 8i and 9i with SQLJ*, 1st Ed., BPB Publications, 2003.

Reference Books:

- R1. S. Feuerstein, *Oracle PL/SQL Programming*, 6th Ed., O'Reilly, 2014.
 R2. M. McLaughlin, *Oracle Database 11g PL/SQL Programming*, 6th Ed., McGraw-Hill Education, 2014.
 R3. A. Silberschatz, H. F. Korth, and S. Sudarshan, *Database System Concepts*, 6th Ed., McGraw-Hill Education, 2013.

Online Resources:

1. <https://nptel.ac.in/courses/106106095>: By Prof. P. S. Kumar, IIT Madras
2. https://docs.oracle.com/cd/B28359_01/appdev.111/b28370.pdf
3. <https://www.javatpoint.com/oracle-tutorial>

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

CO1	Construct SQL queries and retrieve data using single/multi-row functions, and sub-queries.
CO2	Design relational tables with integrity constraints, operate on table using DDL/DML statements.
CO3	Create other database objects like views, sequences and indices.
CO4	Write PL/SQL programs including control structures, loops, and exception handling.
CO5	Implement the techniques using Procedures, Functions, and Parameters in PL/SQL.

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

Category	Code	Internet & Web Technology Lab	L-T-P	Credits	Marks
PCR	CS2012		0-0-4	2	100

Objectives	The objective of this course is to provide hands-on exposure on developing static & dynamic web pages using client-side and server-side scripting with database connectivity and deployment of web applications.
Pre-Requisites	Knowledge on programming, databases, internet and browsers is 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	Study of Web Browsers, Browser Settings, Security features, Cookies, Temporary files.
2	HTML - Basics, headings, text, image, hyperlinks, bookmarks.
3	HTML - MIME types, lists, tables.
4	Creating Web Forms and use of HTTP GET & POST Methods.
5	Embedding audio and video, image map and HTML5 schematic tags.
6	Cascading Style Sheets - Introduction, types and selectors.
7	Use of CSS Box Model and Layout Techniques.
8	Responsive Web Design with Media Queries.
9	JavaScript - Client side scripting, JavaScript DOM.
10	JavaScript - Using Elements of DOM, Accessing Form Elements.
11	Client Side Form Validation using JavaScript.
12	DHTML- Using JavaScript to change HTML content and CSS styles dynamically.
13	XML - Introduction to Extensible Markup Language, DTD and XSD.
14	JSP Basics and Introduction to Server-Side Scripting.
15	JSP Scripting Elements, directives and Implicit Objects.
16	FORM data handling and Server Side Validation.
17	Database connection using MySQL.
18	Session Management and Authentication Mechanisms.
19	JSP Code Reusability and Error Page.
20	JSP Standard Tag Library (JSTL) and Custom Tags.
21	Project Assignment (requirements, test scenarios & implementation criteria).
22-27	Development of assigned projects using various web technologies taught.
28	Demonstration of working project and presentation.

Text Books:

- T1. T. A. Powell, *The Complete Reference HTML and CSS*, 5th Ed., McGraw-Hill, 2017.
- T2. T. A. Powell and F. Schneider, *JavaScript the Complete Reference*, 3rd Ed., McGraw-Hill, 2001.
- T3. P. Hanna, *JSP 2.0 - The Complete Reference*, 1st Ed., McGraw-Hill, 2017.

Reference Books:

- R1. Kogent Learning Solutions, **Web Technologies: Black Book**, 1st Ed., Dreamtech Press, 2009.
 R2. DT Editorial Services, **HTML 5 Black Book**, 2nd Ed., Dreamtech Press, 2016.

Online Resources:

1. <https://nptel.ac.in/courses/106/105/106105084/>: Prof. I. Sengupta, IIT Kharagpur
2. <https://www.w3schools.com>: HTML & CSS with working examples
3. <https://www.tutorialspoint.com/javascript/index.htm>
4. <https://www.javatpoint.com/jsp-tutorial>
5. <https://www.geeksforgeeks.org/introduction-to-jsp/>

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

CO1	Explain the working of Browsers and Internet protocols.
CO2	Develop web pages using HTML and CSS.
CO3	Develop interactive Web pages using Java script and XML.
CO4	Use Web server software and Server side scripts to develop & deploy websites.
CO5	Create and host full fledged interactive web application, using various web technologies.

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

Category	Code	Computer Organization & Architecture Lab	L-T-P	Credits	Marks
PCR	CS2013		0-0-2	1	100

Objectives	The objective of this course is to study various computer components, develop assembly language programming skills, and understand memory management operations through simulations.
Pre-Requisites	Knowledge of computer basics and programming logic is required.
Teaching Scheme	Regular Laboratory classes with the use of ICT whenever required through demonstration of various computer system components and simulation of some of the concepts using Assembly Language and SciLab/MATLAB.

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 Computer Components.
2	Study of different types of Motherboards.
3	Assembling and disassembling of a system.
4	Introduction to 8085 Simulator and basic Assembly language programming.
5	Assembly language programming in 8085 simulator using conditional statements.
6	Assembly language programming in 8085 simulator using loop.
7	Introduction to SciLab/MATLAB.
8	Functions and Control Structures in SciLab/MATLAB.
9	Script files and Functions in SciLab/MATLAB.
10	Implementation of basic logic gates and design of Adders.
11	Simulation of Booth Algorithm and Integer division.
12	Simulation of Page Replacement Algorithms like FIFO, LRU and Optimal.
13	Simulation of Direct mapping, Associative mapping and Set-associative mapping.

Text Books:

- T1. N. K. Srinath, **8085 Microprocessor: Programming and Interfacing**, 1st Indian Ed., PHI Learning, 2005.
- T2. K. U. Kumar and B. S. Umashankar, **The 8085 Microprocessor: Architecture, Programming and Interfacing**, 1st Ed., Pearson Education, 2008.
- T3. T. Sheth, **SciLab : A Practical Introduction to Programming and Problem Solving**, 1st Ed., Create Space Independent Publishing Platform, 2016.

Reference Books:

- R1. S. Nagar, **Introduction to Scilab For Engineers and Scientists**, 1st Ed., Apress, 2017.
- R2. G. Roopali, **Programming with Assembly Language**, Lulu Press, 2019.
- R3. R. Pratap, **Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers**, 1st Ed., Oxford University Press, 2010.

Online Resources:

1. <https://www.scilab.org/tutorials>
2. https://www.scilab.org/sites/default/files/Scilab_beginners_0.pdf

3. <https://www.cse.iitb.ac.in/~cs626-449/scilab.pdf>
4. <https://www.javatpoint.com/programming-in-8085>

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

CO1	Identify the components, disassemble and assemble a modern digital computer.
CO2	Write assembly language programs to comprehend instruction execution on the 8085 simulator.
CO3	Analyze and develop programs in SciLab/MATLAB with control structures and functions.
CO4	Implement different logic gates for various binary arithmetic operations using SciLab/MATLAB.
CO5	Implement and analyze different cache memory mapping techniques and replacement policies.

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



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