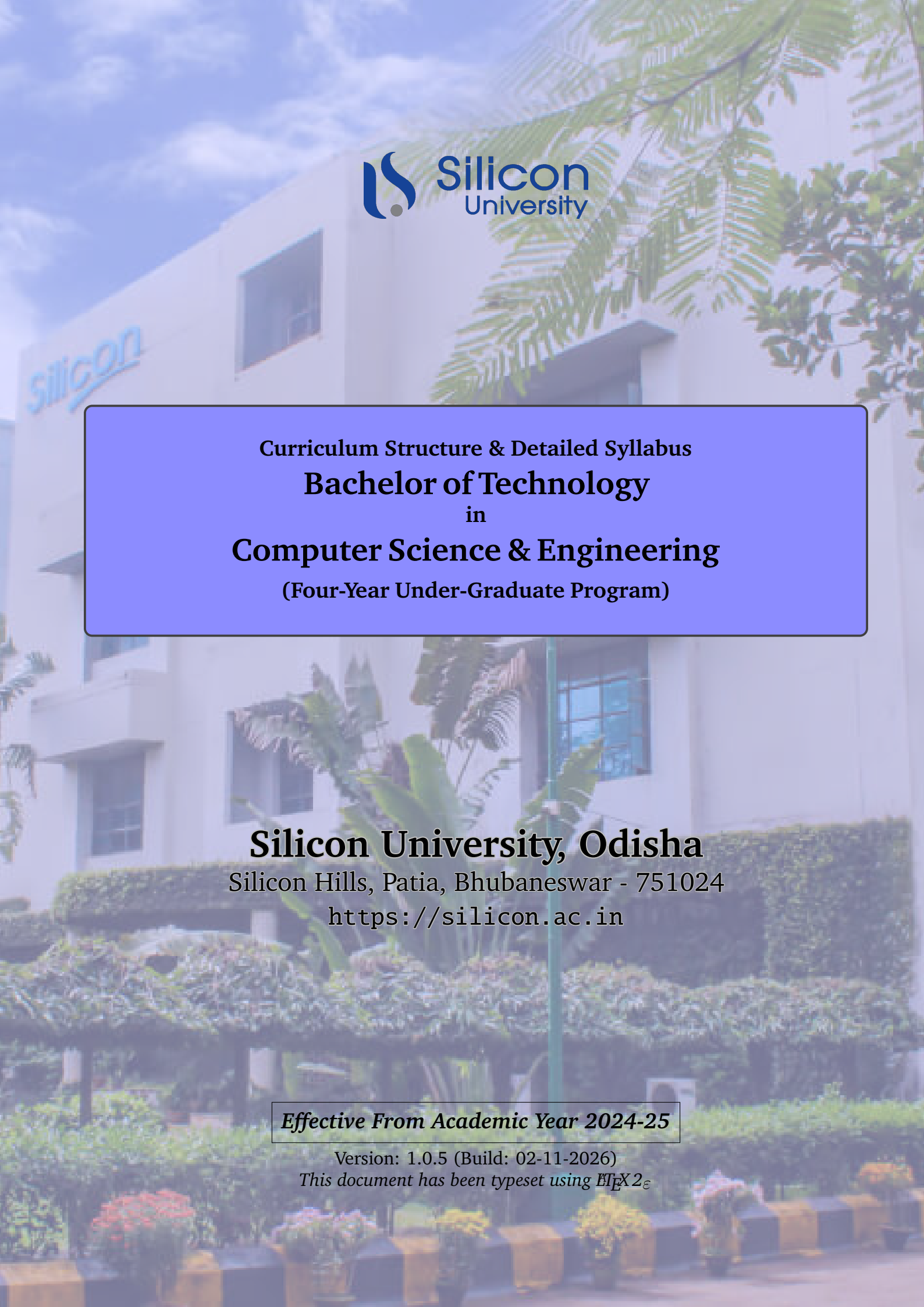


Curriculum Structure & Detailed Syllabus

Bachelor of Technology

in

Computer Science & Engineering

(Four-Year Under-Graduate Program)

Silicon University, Odisha

Silicon Hills, Patia, Bhubaneswar - 751024

https://silicon.ac.in

Effective From Academic Year 2024-25

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Silicon University

Our Vision

To become a centre of excellence in the fields of technical education & research and create responsible citizens.

Our Mission

To provide the best of technical skills, professional ethics, and human values in enriching the disciplines of Science, Engineering and Technology for Social development and Nation building.

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.
SU-5	07/02/2026	The detailed syllabus up to 3rd Year of B. Tech. (CSE) as recommended by the Board of Studies was approved by the Academic Council.
SU-6	01/08/2026	The detailed syllabus up to 4th Year of B. Tech. (CSE) as recommended by the Board of Studies was approved by the Academic Council.

Knowledge and Attitude Profile (WK's)

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

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

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

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

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

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

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

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

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

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

Program Outcomes (PO's)

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

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

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

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

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

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

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

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

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

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

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

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

Program Specific Outcomes (PSOs)

PSO1. Understand, analyze, 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
OOC	Open Online Course (on NPTEL / Swayam / Other)
INT	Summer Internship
PSI	Practice School / Industry Internship
PRJ	Project Work
SEC	Skill Enhancement Course
VAC	Value Addition Course

Contents

I Curriculum Structure 1

Induction Program 2

1st Year B.Tech.(Common) 3

Semester I 3

Semester II 4

2nd Year B.Tech.(CSE) 5

Semester III 5

Semester IV 5

3rd Year B.Tech.(CSE) 6

Semester V 6

Semester VI 6

4th Year B.Tech.(CSE) 7

Semester VII 7

Semester VIII 7

4th Year B.Tech.(CSE) - [PS-7] 8

Semester VII 8

Semester VIII 8

4th Year B.Tech.(CSE) - [PS-8] 9

Semester VII 9

Semester VIII 9

List of Electives 10

List of Tracks for Honours / Minor 11

II Detailed Syllabus 12

1st Year B.Tech. (Common) 13

Semesters I & II 13

Theory 13

ODE & Matrix Algebra 13

Engineering Chemistry 15

Engineering Physics 18

Basic Electronics Engineering 20

Basic Electrical Engineering 23

Engineering Mechanics 25

Engineering Thermodynamics 27

Computer Programming 29

Constitution of India & Professional Ethics 31

Environmental Science & Engineering 33

Probability & Statistics 35

Data Structures & Algorithms 37

Practical 39

Basic Electronics Engineering Lab 40

Basic Electrical Engineering Lab 42

Computer Programming Lab 44

Communicative & Technical English 46

Workbench Practices 49

Engineering Graphics 52

Data Structures & Algorithms Lab 54

Corporate Communication Skills . . . 56

2nd Year B.Tech. (CSE) **59**
Semester III . . . 59
Theory . . . 59
Discrete Mathematics . . . 59
OOP Using Java . . . 61
Management & Economics for Engineers . . . 63
Biology for Engineers . . . 65
Design & Analysis of Algorithms . . . 67
Operating Systems . . . 70
Digital Electronics . . . 73
Practical . . . 74
OOP Using Java Lab . . . 75
Design & Analysis of Algorithms Lab . . . 77
Digital Electronics Lab . . . 79
Operating Systems Lab . . . 81
Semester IV . . . 82
Theory . . . 82
Optimization Techniques . . . 83
Programming in Python . . . 85
Computer Organization & Architecture . . . 88
Database Management Systems . . . 90
Artificial Intelligence . . . 92
Computer Graphics . . . 94
Advanced Java Programming . . . 96
Statistical Inference . . . 98
Semiconductor Devices . . . 100
Embedded C Programming . . . 102
Circuit Theory . . . 104
Digital Marketing & SMO . . . 107
Fundamentals of Business Analytics . . . 110
Practical . . . 111
Programming in Python Lab . . . 112
Computer Organization & Architecture Lab . . . 114
Database Management Systems Lab . . . 116
Internet & Web Technology Lab . . . 118

3rd Year B.Tech. (CSE) **120**
Semester V . . . 120
Theory . . . 120
Computer Networks . . . 120
Machine Learning . . . 122
Software Engineering . . . 124
Formal Languages & Automata Theory . . . 127
Data Mining & Data Warehousing . . . 130
Cloud Computing . . . 132
System Programming . . . 135
Big Data Analytics . . . 137
Realtime Systems . . . 139
Distributed Databases . . . 141
Time Series Analysis . . . 143

CMOS VLSI Design . . . 145
Sensors & Transducers . . . 147
Renewable Energy Systems . . . 149
Human Resource Information Systems . . . 152
Data Analytics with Python . . . 155
Practical . . . 156
Computer Networks Lab . . . 157
Machine Learning Lab . . . 159
Software Engineering Lab . . . 161
Soft Skills for Professionals . . . 163
Semester VI . . . 164
Theory . . . 164
Internet of Things . . . 165
Soft Computing . . . 167
Compiler Design . . . 170
Natural Language Processing . . . 172
Wireless Sensor Networks . . . 174
Mobile Application Development . . . 176
Data Visualization & Reporting . . . 178
Bioinformatics Algorithms . . . 181
Cryptography & Network Security . . . 184
Mobile Computing . . . 186
Embedded Systems . . . 188
Blockchain Technology . . . 190
Deep Learning . . . 192
VLSI Fabrication Technology . . . 195
Embedded Systems & Microcontrollers . . . 197
Basics of Power Systems . . . 200
E-Commerce & Supply Chain Management . . . 202
Business Statistics & Predictive Modelling . . . 205
Practical . . . 207
Internet of Things Lab . . . 208
Soft Computing Lab . . . 210
Emerging Technologies Lab . . . 212
Technical & Research Writing . . . 215

4th Year B.Tech. (CSE) **217**
Semesters VII & VIII . . . 217
Theory . . . 217
Applied Linear Algebra . . . 217
Stochastic Processes . . . 219
Numerical Optimization . . . 221
Simulation & Modelling . . . 223
Fluid Mechanics . . . 225
Power Plant Engineering . . . 227
Project Management . . . 229
Organizational Behaviour . . . 231
Entrepreneurship Development . . . 233
Security Analysis, Investment & Trading . . . 235
Circular Economy . . . 238
Generative AI . . . 241
Nature Inspired Computing . . . 243

VLSI Chip Design & Verification 245
Analog Integrated Circuit Design 247
Realtime Embedded System Design 250
Industrial Internet of Things 252
Smart Power Systems 254
Intelligent Transportation & E-Mobility 257
Financial Management 260
Business Strategy 263
Business Intelligence & Visualization 266
Business Analytics Using Power of AI 269
Practical 271
Skill Lab & Project-I 272

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	EC2007	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	CS2006	Operating Systems Lab	0	0	2	0	0	1
PCR	EC2002	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	CS2013	Computer Organization & Architecture Lab	0	0	2	0	0	1
PCR	CS2011	Database Management Systems Lab	0	0	4	0	0	2
PCR	CS2012	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	CS3001	Computer Networks	3	0	0	3	0	0
PCR	CS3002	Machine Learning	3	1	0	3	1	0
PCR	CS3003	Software Engineering	3	0	0	3	0	0
PCR	CS3004	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	CS3005	Computer Networks Lab	0	0	2	0	0	1
PCR	CS3006	Machine Learning Lab	0	0	2	0	0	1
PCR	CS3007	Software Engineering Lab	0	0	2	0	0	1
SEC	HS3001	Soft Skills for Professionals	0	0	2	0	0	1
INT	IP3003	Summer Internship - II	0	0	0	0	0	1
		TOTAL	**27**			**24**		
		TOTAL (with Honours/Minor)	**30**			**27**		

Semester VI								
Category	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
PCR	CS3008	Internet of Things	3	0	0	3	0	0
PCR	CS3009	Soft Computing	3	0	0	3	0	0
PCR	CS3010	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	CS3011	Internet of Things Lab	0	0	2	0	0	1
PCR	CS3012	Soft Computing Lab	0	0	2	0	0	1
SEC	IP3001 / IP3002	Emerging Technologies Lab / Entrepreneurship & Innovation	0	0	4	0	0	2
SEC	HS3002	Technical & Research Writing	0	0	2	0	0	1
VAC	VA0001	Yoga / NSS / NCC / PES / CPA *	0	0	2	0	0	0
		TOTAL	**30**			**23**		
		TOTAL (with Honours/Minor)	**34**			**27**		

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

4th Year B.Tech.(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
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	IP4007	Skill Lab & Project - I	0	0	4	0	0	2
INT	IP4005	Summer Internship - III	0	0	0	0	0	1
		TOTAL	**7**			**9**		
		TOTAL (with Honours/Minor)	**15**			**17**		

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

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

4th Year B.Tech.(CSE)

(With Practice School Option in 7th Semester)

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

Semester VIII								
Category	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
OEL		Open Elective - II	3	0	0	3	0	0
OOC		MOOC - II	0	0	0	3	0	0
HNS/MNR		Honours / Minor - IV	3	1	0	3	1	0
HNS/MNR		Honours / Minor - V	3	1	0	3	1	0
PRACTICAL								
PRJ	IP4007	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. A 4-Credit Honours / Minor course may have L-T-P of 3-0-1 if the course requires some in-class practice or hands-on component. Refer to the detailed syllabus of the course for the allocated L-T-P.
4. MOOC - Massive Open Online Course (on NPTEL / Swayam / Other).
5. Approved list of courses for MOOC (self study) shall be published by the department. Students are advised to complete them before the end of 8th semester.
6. The Value Addition Course (Yoga / NSS / NCC) may be assigned in a different semester depending on available capacity.

4th Year B.Tech.(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	IP4007	Skill Lab & Project - I	0	0	4	0	0	2
INT	IP4005	Summer Internship - III	0	0	0	0	0	1
		TOTAL	**7**			**9**		
		TOTAL (with Honours/Minor)	**15**			**17**		

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

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

List of Electives

Code	Elective # and Subjects
Program Elective - I	
CS2014	Artificial Intelligence
CS2015	Computer Graphics
CS2016	Advanced Java Programming
Program Elective - II	
CS3013	Data Mining & Data Warehousing
CS3014	Cloud Computing
CS3015	System Programming
Program Elective - III	
CS3016	Big Data Analytics
CS3017	Realtime Systems
CS3018	Distributed Databases
Program Elective - IV	
CS3019	Natural Language Processing
CS3020	Wireless Sensor Networks
CS3021	Mobile Application Development
Program Elective - V	
CS3022	Data Visualization & Reporting
CS3025	Bioinformatics Algorithms
CS3024	Cryptography & Network Security
Program Elective - VI	
CS3023	Mobile Computing
CS3026	Embedded Systems
CS3027	Blockchain Technology
Open Elective - I & II (Basket)	
MT4001	Applied Linear Algebra
MT4002	Stochastic Processes
MT4003	Numerical Optimization
MT4004	Simulation & Modelling
ME4001	Fluid Mechanics
EE4001	Power Plant Engineering
MG4007	Project Management
HS4001	Organizational Behaviour
HS4002	Entrepreneurship Development
MG4001	Securities Analysis, Investment & Trading
MG4002	Circular Economy

List of Tracks for Honours / Minor

Code	Honours / Minor # and Subjects
Honours in Computer Science & Engineering	
MT2007	Statistical Inference
MT3001	Time Series Analysis
CS3029	Deep Learning
CS4027	Generative AI
CS4028	Nature Inspired Computing
Minor in "VLSI System Design & Verification"	
EC2013	Semiconductor Devices
EC3032	CMOS VLSI Design
EC3033	VLSI Fabrication Technology
EC4001	VLSI Chip Design & Verification
EC4002	Analog Integrated Circuit Design
Minor in "Smart Energy Systems"	
EE2010	Circuit Theory
EE2008	Renewable Energy Systems
EE3022	Basics of Power Systems
EE4006	Smart Power Systems
EE4005	Intelligent Transportation & E-Mobility
Minor in "Embedded & IoT System Design"	
EC2011	Embedded C Programming
EC3034	Sensors & Transducers
EC3035	Embedded Systems & Microcontrollers
EC4003	Realtime Embedded System Design
EC4004	Industrial Internet of Things
Minor in "Business Management"	
MG2002	Digital Marketing & SMO
MG3003	Human Resource Information Systems
MG3004	E-Commerce & Supply Chain Management
MG4005	Financial Management
MG4006	Business Strategy
Minor in "Business Analytics"	
MG2005	Fundamentals of Business Analytics
MG3001	Data Analytics with Python
MG3002	Business Statistics & Predictive Modelling
MG4003	Business Intelligence & Visualization
MG4004	Business Analytics using Power of AI

Note:

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

Part II

Detailed Syllabus

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

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

Program Outcomes Relevant to the Course:

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

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

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

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

Cont'd. . .

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

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	2	1	1	1	1				1	1	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.

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Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

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

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

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

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

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

P.T.O

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

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

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

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

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

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	1	2	3	2					2	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 discussionon the First law for cycle, closed system and open system (steady flow energy equation, SFEE), Perpetual Motion Machines, PMM1.	**7 Hours**
Module-3	Introduction to Second Law of Thermodynamics, Kelvin-Planck and Clausius' Statements and their Equivalence, Corollaries, PMM2, Carnot's Principle and Cycle, Entropy, Clausius' Inequality, Principle of Entropy and its application, T-s plot.	**7 Hours**
Module-4	Applications of Thermodynamics, Brief description and working principles of Steam Power Plant, Refrigerators and Heat pump, I.C. Engines (two-stroke and four-stroke, petrol and diesel) and Aircraft Propulsion Engines, Brayton Cycle, Rankine Cycle, Comparison.	**7 Hours**
	Total	**28 Hours**

Text Books:

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

Reference Books:

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

P.T.O

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

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

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

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	2							2	3	2	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 if to learn the concepts and functionalities of the electronic devices, tools and instruments. Students will understand general specifications and deployability of the electronic devices and assemblies, and also develop confidence in handling and usage of electronic devices, tools and instruments in engineering applications.
Pre-Requisites	Knowledge on intrinsic and extrinsic Semiconductors, Physics and Chemistry of Higher Secondary Science level.
Teaching Scheme	Regular laboratory experiments to be conducted under the supervision of teachers and demonstrators with the help of ICT, as and when required along with pre-lab session and demonstration for each experiment.

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1									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:

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

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

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

Program Outcomes Relevant to the Course:

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

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	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 Skils***, Oxford University Press, 2011.
R3. T. Panigrahi, ***Communicative Competence***, 1st *Ed.*, Notion Press, 2024.

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

Cont'd. . .

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

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

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

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

T1. B. H. Deshmukh, ***Electrical Materials and Wiring Practices***, Nirali Prakashan, 2018.

T2. G. Haldar, ***Electronics Course Book: Basic Components, IC boards, SMD, Logic Gates, Transistors, Resistors, Capacitors, Diodes, Audio Circuit and More***, GRPV Arts and Office Supplies, 2024.

T3. R. S. Khandpur, ***Printed Circuit Boards: Design, Fabrication, Assembly and Testing***, 1st *Ed.*, McGraw Hill,2006.

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

Cont'd. . .

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

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

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

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

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

Program Outcomes Relevant to the Course:

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

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	2	1	2				2	1	1			1
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:

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

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

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

Program Outcomes Relevant to the Course:

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

Cont'd. . .

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

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

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

Category	Code	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:

1. https://nptel.ac.in/courses/106104573: by Prof. N. Saxena, IIT Kanpur
2. https://nptel.ac.in/courses/106106183: by Dr. A. Shukla and Prof. S. Iyengar, IIT Ropar
3. https://nptel.ac.in/courses/106108227: by Prof. A. Choudhury, IIIT Bangalore
4. https://nptel.ac.in/courses/106103205: by Prof. B. George and Prof. S. Gopalan, IIT Guwahati
5. https://nptel.ac.in/courses/106106094: by Prof. K. Krithivasan, IIT Madras
6. 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)

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 Melay based model, FSM Design using Moore based model, Sequence detector (Melay based), Sequence detector (Moore based).	**8 Hours**
Module-5	Verilog HDL: Introduction to Verilog HDL, different modeling styles in Verilog - Data flow, Behavioral, Gate level and Structural modeling, Data types, Synthesis and simulation, Verilog design codes for combinational and sequential circuits, Verilog test bench for design simulation.	**8 Hours**
	Total	**42 Hours**

Text Books:

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

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

P.T.O

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

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

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

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	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 $\times$ 4 RAM: testing, simulating and memory expansion.
12	Clock-pulse generator: design, implement and test.
13	Binary Multiplier: design and implement a circuit that multiplies 4-bit unsigned numbers to produce a 8-bit product.

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	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:

1. https://www.technicalsymposium.com/sharelabcodings_os.html
2. https://www.cse.iitb.ac.in/~mythili/teaching/cs347_autumn2016/index.html

P.T.O

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

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

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

P.T.O

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

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

Category	Code	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 architecture of a digital computer and the functions of its basic units.
CO2	Interpret instruction formats and apply addressing modes to solve basic problems.
CO3	Perform binary arithmetic operations using techniques for fixed & floating-point arithmetic.
CO4	Analyze memory hierarchy, explain cache & virtual memory mapping & replacement techniques.
CO5	Explain control unit and compare between hardwired & microprogrammed control techniques.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	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 this course is to provide a strong foundation to AI approaches to build intelligent systems with perception, logic, reasoning and learning abilities.
Pre-Requisites	Knowledge of basic mathematics, algorithms & data structures is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Definitions of AI, Four approaches to AI, Turing Test; Intelligent Agents: Agent function & programs, Rationality, Environment types, PEAS description, Structure of Agents, Types of Agent Programs, Problems solving by Searching - Example Problems, State space search; Uninformed Search Strategies: BFS, DFS, Depth Limited, Iterative Deepening DFS, Uniform Cost, Bi-directional Searches.	**9 Hours**
Module-2	**Search Algorithms & Reasoning**:Introduction, Evaluation and Heuristic functions, Greedy Best First Search, A* Search, Example Problems; Local Search Algorithms: Hill Climbing Search and Simulated Annealing; Constraint Satisfaction Problems: Introduction & types of CSPs, Backtracking Search for CSPs; Adversarial Search: Introduction, Game playing, Minimax and α-β Pruning; Knowledge & Reasoning: KB-based Agents, The Wumpus World problem.	**9 Hours**
Module-3	**Logic & Reasoning**: Logic, Propositional Logic, First-Order Logic (FOPL): Syntax & Semantics of FOPL, Inference in FOPL Forward and Backward Chaining, Knowledge Representation: Ontological Engineering, Categories and Objects, Semantic Nets, Frames.	**8 Hours**
Module-4	**Planning**: The Planning Problem, Planning with State-Space Search, Partial Order Planning, Planning Graphs, Hierarchical Planning; Uncertain Knowledge: Acting under Uncertainty, Bayes Rule & its use; Probabilistic Reasoning, Representing Knowledge in an Uncertain Domain, Semantics of Bayesian Networks.	**8 Hours**
Module-5	**Learning & Expert Systems**: Introduction to Learning, Learning Agent, Paradigms of learning, Learning from Observations, Inductive Learning, Information Gain, Learning Decision Trees; Statistical Learning, Instance Based Learning, Neural Networks: Introduction, Perceptron, Introduction to Reinforcement Learning; Introduction to Expert Systems: Definition, Architecture, Applications.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Russell and P. Norvig, ***Artificial Intelligence - A Modern Approach***, 4th *Ed.*, Pearson Education, 2020.

T2. D. W. Patterson, ***Introduction to Artificial Intelligence & Expert Systems***, 1st *Ed.*, Pearson Education, 2015.

Reference Books:

R1. E. Rich, K. Knight, and S. B. Nair, ***Artificial Intelligence***, 3rd *Ed.*, McGraw Hill Education, 2017.
R2. M. Negnevitsky, ***Artificial Intelligence: A Guide to Intelligent Systems***, 3rd *Ed.*, Addison Wesley, 2011.
R3. G. F. Luger, ***Artificial Intelligence: Structures and Strategies for Complex Problem Solving***, 6th *Ed.*, Pearson Education, 2008.

Online Resources:

1. https://nptel.ac.in/courses/106102220/: by Prof. Mausam, IIT Delhi
2. https://nptel.ac.in/courses/106106140/: by Prof. D. Khemani, IIT Madras
3. https://nptel.ac.in/courses/106105079/: by Prof. P. Dasgupta, IIT Kharagpur
4. https://nptel.ac.in/courses/106105077/: by Prof. A. Basu and Prof. S. Sarkar, IIT Kharagpur

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

CO1	Explore agents, environments, and search goal state using uninformed techniques.
CO2	Apply search techniques for game playing and solving constraint satisfaction problems.
CO3	Interpret logic, inference rules for decision making, and represent knowledge by semantic nets.
CO4	Apply planning and reasoning to handle uncertainty in real life problems.
CO5	Apply learning to solve complex real-life problems and design expert systems.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	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. Huges, 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. Caritthers, ***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, Quires, 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	MT2007		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. Dhharmaraja, 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. Chaterjee, 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 – AlGaN/GaN HEMT structure and operation.	**8 Hours**
Module-5	Applications of MOSFETs: RF performance and linearity analysis of MOSFETs for high frequency applications, MOSFET application as bio-sensor, optoelectronic devices (LEDs, LASERs, Photo diodes, Solar cells).	**8 Hours**
	Total	**42 Hours**

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

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

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

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	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. Kabisatapathy, S. P. Ghosh, and A. K. Chakraborty, ***Network Theory***, 1st *Ed.*, Tata McGraw-Hill, 2009.
R3. A. Chakrabarti, ***Circuit Theory: Analysis and Synthesis***, 7th *Ed.*, Dhanpat Rai & Co., 2013.
R4. J. D. Irwin and R. M. Nelms, ***Basic Engineering Circuit Analysis***, 11th *Ed.*, Wiley, 2015.

Online Resources:

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

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

CO1	Describe network theorems, coupled circuits, and resonant circuits and apply them to solve complex network problems.
CO2	Explain the switching phenomena of electrical circuits and evaluate transient and steady-state performance using Laplace Transformation.
CO3	Analyze filter circuits and sinusoidal, and non-sinusoidal signals using the Fourier series and Fourier transform and its application in electrical & electronics circuit analysis.
CO4	Determine two-port network parameters and their practical application to electrical and electronic circuits.
CO5	Identify Network Functions and synthesize one port network using Foster and Cauer forms.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

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

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

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Cont'd. . .

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

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

Cont'd. . .

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

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

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

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

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

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

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

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

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

Reference Books:

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

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

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

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	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

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 relational databases and structured query language.
2	Basic DML commands: Simple Select queries for data retrieval.
3	Advanced SELECT queries: Using WHERE, ORDER BY and DISTINCT.
4	Functions in SQL: Single-row & Multi-row functions for data retrieval.
5	Aggregate functions: Queries using GROUP BY and HAVING clauses.
6, 7	Nested Queries and Subqueries: Scalar and Correlated subqueries.
8	DDL commands: CREATE, ALTER and manipulate design of tables.
9, 10	DML commands: INSERT, UPDATE & DELETE on the created table.
11	Constraints: Primary key, foreign key, unique, check and not null constraints on tables.
12, 13	JOIN: Retrieve data from multiple tables using various types of JOIN operations.
14	Views: CREATE, ALTER & Manage Views from single & multiple tables.
15	Indexes: Creating and managing indexes for performance optimization.
16	Sequences: Using sequences in relational databases.
17	DCL queries: Using GRANT and REVOKE for permissions on tables.
18	Set operations: UNION, INTERSECT and EXCEPT queries.
19	Introduction to PL/SQL: Identifiers, Literals and Keywords.
20, 21	PL/SQL loops and conditional statements.
22	Exception handling in PL/SQL blocks.
23	PL/SQL block by using numeric, string & other miscellaneous datatypes.
24, 25	Cursors: Use of implicit & explicit cursors in PL/SQL.
26	Stored Procedures: Write PL/SQL block using procedures.
27, 28	Triggers: Creating BEFORE & AFTER row-level triggers.

Text Books:

T1. S. Saxena, ***Essential PostgreSQL***, 1st *Ed.*, BPB Publications, 2025.
T2. M. S. Hussain, ***PostgreSQL 15 Cookbook***, 1st *Ed.*, BPB Publications, 2024.
T3. R. Obe and L. Hsu, ***PostgreSQL: Up and Running***, 3rd *Ed.*, Shroff/O'Reilly, 2017.

Reference Books:

R1. S. Valeja and D. Gonzalez, ***PostgreSQL for Jobseekers***, 1st *Ed.*, BPB Publications, 2023.
R2. L. Ferrari and E. Pirozzi, ***Learn PostgreSQL***, 2nd *Ed.*, Packt Publishing, 2023.
R3. H. -J. Schönig, ***Mastering PostgreSQL 12***, 3rd *Ed.*, Packt Publishing, 2019.

Online Resources:

1. https://nptel.ac.in/courses/106106095: By Prof. P. S. Kumar, IIT Madras
2. https://nptel.ac.in/courses/106105175: by Prof. P. P. Das and others, IIT Kharagpur
3. https://www.postgresql.org/docs/online-resources/

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

CO1	Write SQL queries to retrieve & manipulate data with single & multi-row functions.
CO2	Create relational database with integrity constraints and query data from multiple tables.
CO3	Create views, sequences and indexes to optimize database performance.
CO4	Develop PL/SQL programs for problem-solving and simplifying complex queries.
CO5	Construct PL/SQL programs with cursors and triggers to ensure data integrity.

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

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2		2	2	3						3	2		1
CO2	3		2		2						3	2		1
CO3	3		3	2	3						2	2		1
CO4	2		2	2	2						3	3		2
CO5	2		2	2	3						3	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 Networks	L-T-P	Credits	Marks
PCR	CS3001		3-0-0	3	100

Objectives	The objective of this course is to learn the concepts of computer networks and develop an understanding of modern network architectures from design and performance perspective.
Pre-Requisites	Basic knowledge of a computer system and Internet is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on real world examples.

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, Basics of communication, Network criteria, Network topologies & types, OSI Reference model, TCP/IP Protocol Suite; **Physical Layer**: Analog & Digital signals, Signal Impairments, Data rate limits, Performance, Multiplexing - FDM & TDM; Transmission Media - Guided & Unguided media; Switching - Introduction to Circuit Switched, Datagram & Virtual-Circuit Networks.	**10 Hours**
Module-2	**Data Link Control**: Error Control - Linear codes, Hamming codes, CRC & Checksum; Data Link Control & Protocols – Framing, HDLC & PPP; Flow & Error Control - Stop-and-Wait, Go-Back-N & Selective Repeat ARQ; Multiple Access Mechanisms - Random Access protocols (CSMA, CSMA/CD & CSMA/CA); Ethernet - Traditional, Fast & Gigabit Ethernet; Wireless LANs & IEEE802.11 Standards; Connecting Devices - Repeaters, Switches, Routers, Bridges, Modems & Hubs.	**10 Hours**
Module-3	**Network Layer**: IPV4 & IPV6 addresses, Subnets, Internet Protocol - Internetworking, IPV4 & IPV6 datagram format; Network Layer Protocols - ARP, RARP, ICMP, Working principles & datagram format; Unicast Routing Protocols - Distance vector routing, Linked state routing.	**8 Hours**
Module-4	**Transport Layer**: Process to Process Delivery, User Datagram Protocol (UDP) & Transmission Control Protocol (TCP), TCP & UDP segments, Flow Control.	**7 Hours**
Module-5	**Domain Name System (DNS)**: Name Space, Domain Name Space & Distribution; Resolution - Recursive & Iterative DNS Queries; FTP, SMTP & HTTP.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. B. A. Forouzan, ***Data Communication and Networking***, 5th *Ed.*, Tata McGraw-Hill, 2017.
T2. A. S. Tannenbum and D. Wetherall, ***Computer Networks***, 5th *Ed.*, Prentice Hall, Imprint of Pearson, 2016.

Reference Books:

R1. L. L. Peterson and B. S. Davie, ***Computer Networks: A System Approach***, 5th *Ed.*, Elsevier, 2011.
R2. W. Stallings, ***Data and Computer Communications***, 10th *Ed.*, Pearson Education, 2017.
R3. B. A. Forouzan and F. Mosharraf, ***Computer Networks: A Top-Down Approach***, McGraw-Hill Education, 2017.

Online Resources:

1. https://nptel.ac.in/courses/106105183/: by Prof. S. Chakraborty and S. K. Ghosh, IIT Kharagpur
2. https://nptel.ac.in/courses/106106091/: by Prof. H. A. Murthy, IIT Madras
3. https://nptel.ac.in/courses/106105080/: by Prof. A. Pal, IIT Kharagpur
4. https://nptel.ac.in/courses/106105081/: by Prof. S. Ghosh, IIT Kharagpur

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

CO1	Describe the basics of computer networks, the layered architecture of TCP/IP & OSI model.
CO2	Distinguish among various Link Layer protocols and Ethernet standards.
CO3	Explain various Network Layer protocols, addressing schemes, subnets and routing principles.
CO4	Articulate the Transport Layer protocols, Segmentation and Flow control mechanism.
CO5	Recognize the Application Layer protocols, DNS hierarchy and DNS Queries.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Machine Learning	L-T-P	Credits	Marks
PCR	CS3002		3-1-0	4	100

Objectives	The objective of the course is to learn the fundamental concepts behind supervised, unsupervised and reinforcement learning, assess and select appropriate model and use cross validation to tune their parameters.
Pre-Requisites	Basic knowledge of engineering mathematics, linear algebra, probability and statistics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Supervised Learning Techniques**: Overview of supervised learning, K-nearest neighbour, Multiple linear regression, Shrinkage methods (Ridge & Lasso regressions), Logistic regression, Linear Discriminant Analysis, Feature selection.	**11 Hours**
Module-2	**Model Evaluation & Performance Metrics**: Bias, Variance and model complexity, Bias-variance trade off, Bayesian approach and BIC, Cross-validation, Performance of Classification algorithms (Confusion matrix, Precision, Recall and ROC Curve).	**11 Hours**
Module-3	**Advanced Classification Techniques**: Generative model for discrete data (Bayesian concept learning and Naïve Bayes classifier), SVM for classification and regression, Reproducing Kernels, Regression and classification trees, Random Forest.	**11 Hours**
Module-4	**Clustering & Feature Extraction**: Clustering (K-means, Spectral clustering), Feature Extraction (Principal Component Analysis (PCA), kernel based PCA, Independent Component Analysis (IDA), Non-negative matrix factorization and Collaborative filtering), Mixture of Gaussians, Expectation Maximization (EM) algorithm.	**12 Hours**
Module-5	**Ensemble Approaches & Reinforcement learning**: Bootstrap methods, Boosting methods - exponential loss and AdaBoost, Numerical Optimization via Gradient boosting; Introduction to Reinforcement learning, Elements of Reinforcement learning, Single state case: K-Armed Bandit, Model-based learning (Value and Policy Iterations).	**11 Hours**
	Total	**56 Hours**

Text Books:

T1. T. Hastie, R. Tibshirani, and J. Friedman, ***The Elements of Statistical Learning - Data Mining, Inference, and Prediction***, 9th *Ed.*, Springer, 2017.

T2. S. Haykin, ***Neural Networks and Learning Machines***, 3rd *Ed.*, Pearson Education, 2009.

T3. E. Alpaydın, ***Introduction to Machine Learning***, 2nd *Ed.*, Prentice Hall of India, 2010.

Reference Books:

R1. Y. G. James, D. Witten, T. Hastie, and R. Tibshirani, ***An Introduction to Statistical Learning with Applications in R***, 2nd *Ed.*, Springer, 2013.

R2. T. M. Mitchell, ***Machine Learning***, 1st *Ed.*, McGrow-Hill Education, 2013.
R3. C. M. Bishop, ***Pattern Recognition and Machine Learning***, 1st *Ed.*, Springer, 2006.

Online Resources:

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

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

CO1	Apply the concepts of supervised machine learning and its functionalities.
CO2	Determine most appropriate model in a specific context using model selection techniques.
CO3	Perform classification using Bayes classifier, SVM, Decision Tree, and Random Forest.
CO4	Reduce dimensionality using feature selection and apply unsupervised machine learning for different problems and use cases.
CO5	Apply the basic concepts of boosting methods and reinforcement learning to real life problems.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Software Engineering	L-T-P	Credits	Marks
PCR	CS3003		3-0-0	3	100

Objectives	The objective of this course is to learn & implement software engineering practices including different phases of software product creation, maintenance & project management activities undertaken in software development organizations.
Pre-Requisites	Basic knowledge of logic, programming languages, process flow diagrams & understanding of database is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples, case-studies, and latest trends.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Software Engineering**: Introduction, Abstraction, Decomposition, Evolution of software engineering, Process Framework, SDLC models: Waterfall, Iterative, V-Process, Incremental, Evolutionary (Prototyping & Spiral), Agile (Extreme programming, Crystal, Scrum) & RAD models, Unified process.	**8 Hours**
Module-2	**Requirements Engineering**: Stages of requirements engineering, Requirement gathering, analysis & specification, SRS document, Functional & Non-functional requirements, Decision trees & Decision tables, Formal specification (Axiomatic specs for Stacks & Queues).	**8 Hours**
Module-3	**Software Project Management**: Software project planning, Project size estimation (Cost, Time, Effort), COCOMO model, Project scheduling: Activity network diagram, Critical Path Method, Estimation techniques (Algorithmic, Empirical, Expert judgment, Analogical, Top-down & Bottom-up methods).	**8 Hours**
Module-4	**Design Engineering**: Function-oriented software design (HLD & DD), DFDs, Structure charts, Characteristics of a good design, Cohesion & Coupling, Object-oriented design using UML models (five views & nine diagrams); **Coding**: Coding standards & guidelines, Code inspection & walkthrough; **Software Testing**: Introduction, Verification & Validation, Black-Box testing (Equivalence class partitioning & Boundary value analysis), White-Box testing (Statement, Branch, Condition, Path coverage, Control flow graph & Cyclomatic complexity), Unit, Integration & System testing, Basis path, Regression & Mutation testing, Error seeding.	**10 Hours**
Module-5	**Maintenance**: Maintenance types, Reverse engineering & Re-Engineering; Advanced Topics: SEI-Capability Maturity Model, Software quality: Quality assurance & Quality control, Six sigma, Risk engineering & matrix, Reliability.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. R. Mall, ***Fundamentals of Software Engineering***, 4th *Ed.*, PHI, 2014.
T2. R. S. Pressman, ***Software Engineering : A Practitioners Approach***, 7th *Ed.*, McGraw Hill, 2010.
T3. B. Hughs and M. Cotterell, ***Software Project Management***, 1st *Ed.*, Ingram Publications, 2009.

Reference Books:

R1. I. Sommerville, ***Software Engineering***, 9th *Ed.*, Pearson Education, 2011.
R2. R. C. Martin, ***Clean Code: A Handbook of Agile Software Craftsmanship***, 10th *Ed.*, PHI Learning, 2017.

Online Resources:

1. https://nptel.ac.in/courses/106101061/: by Prof. Joshi, Bellur, and Sarda, IIT Bombay.
2. https://nptel.ac.in/courses/106105182/: by Prof. R. Mall, IIT Kharagpur.
3. https://nptel.ac.in/courses/106101163/: by Prof. M. D'souza, IIIT Bangalore.
4. https://nptel.ac.in/courses/106105218/: by Prof. D. P. Mohapatra, NIT Rourkela, and Prof. R. Mall, IIT Kharagpur.

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

CO1	Understand SDLC models and apply the suitable one while creating a software product.
CO2	Apply requirement analysis techniques to gather, analyze and specify the system requirements.
CO3	Comprehend project management activities, applying them for cost, time & effort estimations.
CO4	Develop the design artifacts using standard methodologies followed by construction and testing.
CO5	Implement maintenance, quality and risk engineering activities to gain competitive advantage.

Program Outcomes Relevant to the Course:

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

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

Category	Code	Formal Languages & Automata Theory	L-T-P	Credits	Marks
PCR	CS3004		3-0-0	3	100

Objectives	The objective of this course is to learn the mathematical foundations and abstract models of computation consisting of automata theory, formal languages, grammars, computability and concept of Turing machines.
Pre-Requisites	Basic knowledge of discrete mathematics 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: Automata theory, Computability theory, Complexity theory; Mathematical Notations & Terminology: Alphabet, String, Languages & Operations on strings; Finite Automata (Deterministic): Formal definition, Transition function, Extended transition function, Language & Design of DFA; Finite Automata (Non-deterministic): Formal definition, Language of NFA, Equivalence of DFA & NFA; NFA with Epsilon Transition: Eliminating ϵ-transitions from NFA, Conversion from ϵ-NFA to DFA, Minimization of DFA.	**9 Hours**
Module-2	Regular Expressions: Operators & their precedence, Building Regular expressions, DFA to Regular Expressions, Regular Expressions to DFA, Arden's theorem, Pumping Lemma for Regular languages, Closure properties of Regular languages. Moore Machines, Mealy Machines.	**8 Hours**
Module-3	Introduction to Grammars: Definition, Derivation of string, Left & right linear grammars, Regular grammars; Context Free Grammars: Definition, Derivation of string, Language of CFG, Parse Tree, Ambiguity in grammar, Elimination of ambiguity; Normal forms of CFG: Chomsky normal form & Greibach normal form, Converting CFG to CNF & GNF, Cook, Younger, Kasami algorithm; Closure Properties of context free languages.	**9 Hours**
Module-4	Push Down Automata: Basic Model, Components, Moves of a PDA, ID of a PDA, Design of a PDA, PDA to CFG and CFG to PDA conversion; Pumping Lemma for CFL; Turing Machines: Model, Components, ID of TM, Design of a TM, Variation of TM model, Recursively Enumerable Languages, Universal Turing Machine & un-decidable problems.	**9 Hours**
Module-5	Turing Decidable & Recognizable Languages: Church Turing hypothesis, Recursive and recursively enumerable sets, Chomsky's hierarchy of languages; Un-decidability of Post correspondence problem, Linear Bounded Automata and Context Sensitive Languages; Primitive Recursive Functions: μ-Recursive functions, Ackermann's function, Turing computable functions, Cantor & Gödel numbering; NP Completeness: P, NP, NP complete & NP Hard problems.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. J. E. Hopcroft, R. Motwani, and J. D. Ullman, ***Introduction to Automata Theory, Languages and Computation***, 3rd *Ed.*, Pearson Education, 2007.

T2. P. Linz, ***An Introduction to Formal Languages and Automata***, 4th *Ed.*, Jones & Bartlett Learning, 2006.

Reference Books:

R1. M. Sipser, ***Introduction to the Theory of Computation***, 3rd *Ed.*, Cengage Learning, 2012.
R2. J. C. Martin, ***Introduction to Languages and the Theory of Computation***, 4th *Ed.*, Tata McGraw-Hill, 2010.
R3. K. L. P. Mishra, and N. Chandrasekaran, ***Theory of Computer Science: Automata, Languages and Computation***, 3rd *Ed.*, PHI, 2012.

Online Resources:

1. https://nptel.ac.in/courses/111103016/: by Dr. K.V. Krishna and Dr. D. Goswami, IIT Guwahati
2. https://nptel.ac.in/courses/106106049/: by Prof. K. Krithivasan, IIT Madras
3. https://nptel.ac.in/courses/106105196/: by Prof. S. Mukhopadhyay, IIT Kharagpur
4. https://www.ics.uci.edu/~goodrich/teach/cs162/notes/: by Prof. M. T. Goodrich, University of California, Irvine, USA

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

CO1	Develop mathematical models with DFA, NFA for regular languages & grammar for real life applications.
CO2	Design grammar & PDA for context free languages and demonstrate their properties.
CO3	Construct Turing machines for context sensitive and unrestricted languages.
CO4	Describe the Chomsky hierarchy of Formal Languages and Grammar.
CO5	Illustrate the Church-Turing thesis and explain the concept of decidability, recursive enumerability, and classify a given language to the P, NP or NPC complexity classes.

Program Outcomes Relevant to the Course:

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

P.T.O

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

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

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

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

P.T.O

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Cloud Computing	L-T-P	Credits	Marks
PEL	CS3014		3-0-0	3	100

Objectives	The objective of this course is to study fundamental concepts of cloud computing platforms, technologies, service & deployment models, commercial implementations, and security aspects of applications on cloud.
Pre-Requisites	Knowledge on computer networking, client-server concepts, internet & web technologies is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples, case-studies, and latest trends.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Computing Fundamentals: Client/Server systems, Thin & Thick Clients, Centralized computing, Parallel & Distributed Computing, Amdahl's Law, P2P Computing, Cluster Computing, Grid Computing, Utility Computing, Autonomic Computing, Hosting, Data Center, Evolution of Computing Paradigms, Convergence of Technologies, Role of Open Standards.	**8 Hours**
Module-2	Cloud Technology: The NIST Model of Cloud Computing, Characteristics, Deployment Models, Service Models & their comparison, Advantages & disadvantages, Cloud Computing Stack, Virtualization, Types of Hypervisors, Levels of Virtualization, Requirements of VMM, Hypervisor & the Xen Architecture, Types of Virtualization, Memory Virtualization, Storage Virtualization, Load Balancing, Horizontal & Vertical Scaling.	**9 Hours**
Module-3	Cloud Implementations: Infrastructure as a Service (IaaS) – Amazon Web Services, Elastic Compute Cloud (EC2), Simple Storage Service (S3), Simple Queuing Service (SQS), VMWare vCloud, vCloud Express; Platform as a Service (PaaS) – Google App Engine, Java & Python Runtime Environments, Google File System, Google BigTable.	**9 Hours**
Module-4	Cloud Platforms: Windows Azure, SQL Azure, Windows Azure AppFabric; Software as a Service (SaaS): Introduction, Web Services, Web 2.0, Web OS, Case studies on SaaS - SalesForce.com, Force.com, MS Office Live, Google Apps; Service Level Agreements, Billing & Accounting in SaaS models.	**8 Hours**
Module-5	Cloud Security: Infrastructure Security - Network level, Host level, Application level, Data Security – Aspects, Mitigation, Provider Data & its Security, Identity & Access Management, Trust Boundaries, Challenges, Definitions, Architecture & Practice, IAM Standards & Protocols, Access Control, Privacy, Audit & Compliance.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. K. Hwang, G. C. Fox, and J. J. Dongarra, ***Distributed and Cloud Computing - From Parallel Processing to the Internet of Things***, 1st *Ed.*, Elsevier, 2012.

T2. B. Sosinsky, ***Cloud Computing Bible***, 1st *Ed.*, Wiley-India, 2011.

T3. T. Mather, S. K. Swamy, and S. Latif, ***Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance***, 1st *Ed.*, O'Reilly Media, 2009.

Reference Books:

R1. A. T. Velte, T. J. Velte, and R. Elsenpeter, ***Cloud Computing: A Practical Approach***, 1st *Ed.*, McGraw-Hill Education, 2017.
R2. A. Bahga and V. Madisetti, ***Cloud Computing: A Hands-On Approach***, 1st *Ed.*, Orient Blackswan, 2014.
R3. T. Erl, Z. Mahmood, and R. Puttini, ***Cloud Computing: Concepts, Technology & Architecture***, 1st *Ed.*, Pearson India Education, 2014.

Online Resources:

1. https://nptel.ac.in/courses/106105167/: by Prof. S. K. Ghosh, IIT Kharagpur
2. https://nptel.ac.in/courses/106104182/: by Dr. R. Misra, IIT Kanpur
3. http://web.mit.edu/6.897/www/readings.html: by Prof. H. Balakrishnan, MIT
4. http://web.mit.edu/6.897/www/readings.html

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

CO1	Define different types of computing paradigms and concepts of cloud technologies.
CO2	Explain the cloud computing architecture, models, and various virtualization techniques.
CO3	Understand the IaaS and PaaS implementations by leading vendors in the industry.
CO4	Appreciate the SaaS model implementations and importance of SLA in cloud environment.
CO5	Describe various aspects of security, privacy, and performance in cloud environments.

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).
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).
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)

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

Category	Code	System Programming	L-T-P	Credits	Marks
PEL	CS3015		3-0-0	3	100

Objectives	The objective of this course is to learn the basic concepts and principles of system programming and to provide the knowledge about the methods and techniques for designing system programs.
Pre-Requisites	Fundamentals of computer architecture, concept of hardware, software 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 programming activities.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: System software and application software, Machine structure; OS - Origin and evolution, Types, OS as resource manager, Facilities provided by OS; Machine Structure - Stored program computer concept, Micro flowchart of ADD instruction, Machine structure – 360 & 370; Machine Language - Long way, No looping, Address modification, Looping with example; Introduction to assembly language program, examples using literals.	**10 Hours**
Module-2	**Assemblers & Table Processing**: Design of two pass assembler – Statement of problem, Data structure, Format of data bases, Algorithm and flowchart of Pass-I and II; Equivalent machine code generation of a sample assembly program; Table Processing: Linear and Binary search, Bubble sort – 360 assembly code and illustration, Radix sort, Shell sort, Address calculation sort, Radix exchange sort and Random entry searching.	**10 Hours**
Module-3	**Macro Processor & Programming Languages**: Macro instruction arguments, Conditional macro expansion, Macro calls within macro, Macro instruction defining macro; Two pass algorithm for implementation of macro processor – Problem statement, Data bases specification, Format of data bases, Algorithm, Pass-I and Pass-II flowcharts; Creation of MDT and MNT for macro calls; Programming Languages - importance of high-level languages, Features, Data types and data structures; Storage allocation and scope names, Accessing flexibility; Functional modularity, Asynchronous operations.	**7 Hours**
Module-4	**Loaders**: Function, Compile–and–go, General loader scheme, Absolute loader, Subroutine linkages & relocating loaders; Other loader schemes – Dynamic loading and linking, Overlays, Bootstrap loader, Design of an absolute loader; Design of direct linking loader – Problem statement, Data structure specification, Format of data bases, Algorithm, Pass–I & II flowcharts.	**7 Hours**
Module-5	**Compilers & Formal Systems**: Phases of a compiler – Lexical analysis, Syntax analysis, Semantic analysis, Intermediate code generation, Machine dependent & independent optimization, Storage assignment, Code generation, Assembly and output; Formal Systems - Uses of formal systems, Formal specification, Formal grammars, Backus–Naur form, Canonic systems.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. J. Donovan, ***Systems Programming***, 1st *Ed.*, McGraw Hill Education, 2017.
T2. S. Pal, ***Systems Programming***, 1st *Ed.*, Oxford University Press, 2012.

Reference Books:

R1. D. M. Dhamdhere, ***Systems Programming and Operating Systems***, 2nd *Ed.*, Tata McGraw-Hill, 2011.
R2. A. R. John, ***Systems Programming***, 1st *Ed.*, Morgan Kaufmann, 2015.

Online Resources:

1. http://infolab.stanford.edu/pub/cstr/reports/cs/tr/66/52/CS-TR-66-52.pdf: Notes by Prof. A. C. Shaw, Stanford University

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

CO1	Explain the concept of stored programs and operations of a general machine structure.
CO2	Formulate assembly language programs in mnemonic form and design pass I & II assemblers.
CO3	Design two pass macro processors for a hypothetical system.
CO4	Distinguish between various loading schemes and design absolute & direct linking loaders.
CO5	Describe the phases of compilation process and use of formal system & grammars.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Big Data Analytics	L-T-P	Credits	Marks
PEL	CS3016		3-0-0	3	100

Objectives	The objective of this course is to learn and implement key Big Data Analytic techniques including finding of similar items, mining data streams, link analysis, clustering techniques, recommendation systems, collaborative filtering, batch processing, Hadoop, MapReduce and Spark.
Pre-Requisites	Knowledge of data mining and design of 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 to Big Data: Data management for Big Data, Data exploration and reproducibility, Data quality; Introduction to MapReduce: MapReduce algorithm, Patterns & relations, Parallel databases vs. MapReduce, Storage solutions.	**7 Hours**
Module-2	Big Data Algorithms-I: Nearest neighbor search, Shingling of documents, Similarity preserving summaries of sets, Locality sensitive hashing for documents, Distance measures, Theory of locality sensitive functions, LSH families for high degree of similarities.	**9 Hours**
Module-3	Big Data Algorithms-II: Streaming data models, Sampling data in a stream, Filtering streams, Counting distinct elements in a stream, Estimating moments, Counting Ones in window, Page rank, Efficient computation of Page rank, Topic sensitive page rank.	**9 Hours**
Module-4	Big Data Algorithms-III: Clustering techniques – BFR & CURE algorithms, clustering in non-Euclidean space, Clustering for streams and parallelism; Matrix factorization, Recommendation systems and Collaborative filtering.	**9 Hours**
Module-5	Introduction to Spark, Hadoop Big Data, Hive Big Data, Pig-Latin and Large Scale Visualization.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. Leskovec, A. Rajaraman, and J. D. Ullman, ***Mining of Massive Datasets***, 2nd *Ed.*, Cambridge University Press, 2014.

T2. J. Bell, ***Machine Learning for Big Data: Hands-On for Developers and Technical Professionals***, Wiley, 2014.

Reference Books:

R1. J. Han, M. Kamber, and J. Pei, ***Data Mining Concepts and Techniques***, 3rd *Ed.*, Morgan Kaufman Publications, 2011.

R2. T. M. Mitchell, ***Machine Learning***, 1st *Ed.*, McGraw-Hill Education, 2017.

P.T.O

Online Resources:

1. https://nptel.ac.in/courses/106106142/: by Prof. J. Augustine, IIT Madras
2. https://nptel.ac.in/courses/106104189/: by Dr. R. Misra, IIT Patna
3. http://www.mmds.org: Material on Mining of Massive Data Sets

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

CO1	Explain the concepts of Big Data and Map Reduce techniques.
CO2	Apply shingling and locality sensitive hashing techniques in order to find similar items.
CO3	Implement the Big Data algorithms for analysis of streaming data and link analysis.
CO4	Illustrate the techniques for recommendation systems, collaborative filtering and compare the clustering techniques by applying them on large datasets.
CO5	Explore Hadoop, MapReduce, Spark for use cases in real life big data applications.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Realtime Systems	L-T-P	Credits	Marks
PEL	CS3017		3-0-0	3	100

Objectives	The objective of this course is to study the concepts & approaches in the design & analysis of real-time systems covering real-time operating systems, communication, and databases.
Pre-Requisites	Knowledge of operating systems, computer networks, and database management is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples and 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**: Concepts, Applications, Characteristics, Basic model, Safety and reliability, Types of realtime tasks, Timing constraints and its modelling.	**8 Hours**
Module-2	**Realtime Task Scheduling**: Concepts & terminologies, Types of realtime tasks and their characteristics, Classification of realtime task scheduling algorithms, Clock-driven, Event driven, EDF, RMA & Hybrid scheduling; Scheduling Realtime Tasks in Multiprocessor and Distributed Systems: Dynamic allocation and fault-tolerant scheduling of tasks, Clocks in distributed realtime systems, Centralized and Distributed clock synchronization.	**9 Hours**
Module-3	**Resource Sharing and Dependencies**: Resource sharing among realtime tasks, Priority inversion, Priority Inversion Protocol (PIP), Highest Locker Protocol (HLP), Priority Ceiling Protocol (PCP), Different types of priority inversions under PCP, Important features of PCP, Issues in using resource sharing protocol and Handling task dependencies.	**9 Hours**
Module-4	**Realtime Operating Systems**: Time services, Features, Unix and Windows as realtime operating systems, POSIX, A survey of contemporary real-time operating systems, Benchmarking realtime systems.	**8 Hours**
Module-5	**Realtime Communication and Databases**: Concepts, applications and examples of realtime communication, Soft and hard realtime communication in a LAN; Realtime Databases: Concepts, examples, and applications of realtime databases, Characteristics of temporal data, Concurrency control, Commercial realtime databases.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. R. Mall, ***Real-Time Systems***, 2nd *Ed.*, Pearson Education, 2010.

Reference Books:

R1. J. W. S. Liu, ***Real-Time Systems***, 1st *Ed.*, Pearson Education, 2002.
R2. C. M. Krishna and K. G. Shin, ***Real-Time Systems***, 1st *Ed.*, McGraw-Hill Education, 2017.

Online Resources:

1. https://nptel.ac.in/courses/106105036/: by Prof. R. Mall, IIT Kharagpur
2. https://nptel.ac.in/courses/106105172/: by Prof. R. Mall, IIT Kharagpur

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

CO1	Describe characteristics & applications of real-time systems and their timing constraints.
CO2	Compare realtime task scheduling algorithms and analyze their schedulability criteria.
CO3	Explain the PIP, HLP & PCP protocols for sharing critical resources among realtime tasks.
CO4	Describe the principles, structure & operation of RTOS and evaluate their suitability for different realtime applications.
CO5	Explain the concepts of real-time communication and real-time 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).
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

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

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

Category	Code	Distributed Databases	L-T-P	Credits	Marks
PEL	CS3018		3-0-0	3	100

Objectives	This course aims to introduce the key concepts, techniques and challenges of managing large volumes of shared data in parallel and distributed environments, while offering insights into related research.
Pre-Requisites	Knowledge of database fundamentals, computer networking, operating systems, design of algorithms and programming skills is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples, case-studies, and research.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction, Distributed vs. Centralized Databases, Need of Distributed Databases, Components of DDBSs; Reference Architecture of DDBs, Types of Data Fragmentation, Distribution Transparency, Access Primitives, Integrity Constraints in DDBs.	**9 Hours**
Module-2	Distributed Database Design, Framework, Objectives and Approaches, Design of Database Fragmentation, Horizontal, Vertical and Mixed Fragmentation, Allocation of Fragments; Equivalence Transformations for Queries, Transforming Global Queries into Fragment Queries, Distributed Grouping & Aggregate Function, Parametric Queries.	**8 Hours**
Module-3	Framework for Query Optimization, Importance of Distributed Query Optimization, Join and General Queries; Issues of Transaction Management, Supporting Atomicity of Distributed Transaction, Concurrency Control for Distributed Transaction and Architectural Aspects of Distributed Transaction.	**9 Hours**
Module-4	Foundations of Distributed Concurrency Control, Distributed Deadlocks, Concurrency Control Based on Timestamps, Optimistic Methods for Distributed Concurrency Control; Basic Concepts, Nonblocking Commitment Protocols, Reliability and Concurrency Control, Determining a Consistent View of the Network, Detection and Resolution of Inconsistency, Checkpoints and Cold Restart; Catalog Management in Distributed Databases, Authorization & Protection.	**9 Hours**
Module-5	Emerging Trends, Cloud-native distributed databases, Multi-model and Graph databases; Security challenges in distributed environments, Authentication, Authorization, and access control, Data encryption and secure communication between nodes.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Ceri and G. Pelagatti, ***Distributed Databases: Principles and Systems***, 1st *Ed.*, McGraw-Hill, 2008.
T2. M. T. Özsu and P. Valduriez, ***Principles of Distributed Database Systems***, 4th *Ed.*, Springer, 2020.

Reference Books:

R1. S. K. Rahimi and S. H. Frank, ***Distributed Database Management Systems***, 1st *Ed.*, Wiley-IEEE Computer Society, 2011.

R2. D. Bell and J. Grimson, ***Distributed Database Systems***, 1st *Ed.*, Addison-Wesley, 1992.

Online Resources:

1. https://nptel.ac.in/courses/106106107: by Prof. Ananthanarayana V.S., IIT Madras

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

CO1	Describe the fundamentals, architecture and data fragmentation in distributed databases.
CO2	Understand design of distributed databases and query execution in a distributed environment.
CO3	Explain query optimization strategies and transaction processing for distributed database.
CO4	Describe concurrency control approaches and administration in a distributed database.
CO5	Explore latest trends and security aspects in enterprise distributed 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).
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	2	2					2	3	2	3
CO2	3	3		3	2	1					3	3	2	3
CO3	3	3		2	2	1					2	3	2	3
CO4	3	3		3	3	1					3	3	2	3
CO5	3	3		2	2	2					2	3	2	2

Category	Code	Time Series Analysis	L-T-P	Credits	Marks
HNS	MT3001		3-0-0	3	100

Objectives	The objective of this course is to learn the basic concepts and methods for analysis of time series data including preprocessing, statistics, machine learning models, and advanced techniques to arrive at accurate predictions.
Pre-Requisites	Knowledge of statistics, linear algebra and R/Python programming is required.
Teaching Scheme	Regular classroom lectures with the use of ICT as required, sessions are planned to be interactive with a focus on problem solving & applications.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Definition, Applications of time series in real-world problems, Types of time series data - Univariate, Multivariate, Stationary, Non-stationary, Continuous & Discrete; Components of time series - Trend, Seasonality, Cyclic, and Irregular; Time series plots & Exploratory data analysis.	**9 Hours**
Module-2	**Data Preprocessing**: Resampling, Smoothing (moving averages and exponential smoothing); Handling missing values; Transformation - Log, Differencing, Box-Cox; Stationarity testing - Augmented Dickey-Fuller (ADF) test.	**7 Hours**
Module-3	**Classical Models & Diagnostics**: Autocorrelation & Partial Autocorrelation functions (ACF &PACF); AR (Autoregressive), MA (Moving Average), ARMA & ARIMA models; Seasonal ARIMA (SARIMA), Parameter selection using AIC/BIC; Simple linear regression; Model diagnostics & Residual analysis.	**9 Hours**
Module-4	**Advanced Models & Applications**: Exponential smoothing models (SES, Holt & Holt-Winters); Vector Auto Regression (VAR) for multivariate time series; Prophet for time series data; ARCH, GARCH models for financial time series; State-space representations - Basic structural model, State-space representation of ARIMA models, Kalman Recursions, Estimation for state-space models; Model evaluation: MSE, RMSE, MAPE; Case Studies – Stock market prediction, Weather Forecasting.	**10 Hours**
Module-5	**Deep Learning & Feature Engineering**: Feature engineering for time series; Recurrent Neural Networks (RNN), LSTM for Deep Learning based forecasting; Cross-validation in time series (Walk Forward Validation).	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. R. Shumway and D. Stoffer, ***Time Series Analysis and its Applications with R Examples***, 5th *Ed.*, Springer, 2025.

T2. G. E. P. Box, G. M. Jenkins, G. C. Reinsel, and G. M. Ljung, ***Time Series Analysis: Forecasting and Control***, 5th *Ed.*, Prentice Hall, 2015.

T3. P. J. Brockwell and R. A. Davis, ***Introduction to Time Series and Forecasting***, 3rd *Ed.*, Springer-Verlag, 2016.

Reference Books:

R1. J. D. Hamilton, ***Time Series Analysis***, 1st *Ed.*, Princeton University Press, 1994.

R2. T. W. Anderson, ***The Statistical Analysis of Time Series***, Wiley Publication, 1994.
R3. R. S. Tsay, ***Analysis of Financial Time Series***, 2nd *Ed.*, Wiley Publication, 2005.

Online Resources:

1. https://online.stat.psu.edu/stat510/: by Penn State University
2. https://ocw.mit.edu/courses/14-384-time-series-analysis-fall-2013/pages/lecture-notes/

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

CO1	Describe the basic concepts & types of time series used in real-world problems.
CO2	Apply various preprocessing techniques to time series data for modelling.
CO3	Develop statistical models for analysis of time series data.
CO4	Understand & demonstrate advanced time series forecasting methods.
CO5	Implement machine learning models for time series forecasting.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	CMOS VLSI Design	L-T-P	Credits	Marks
MNR	EC3032		3-0-0	3	100

Objectives	The objective of this course is to study the design, fabrication & testing of devices, circuits & systems using integrated micro fabrication technologies providing a broad coverage of VLSI technology.
Pre-Requisites	Fundamental knowledge of MOSFET, analog and digital electronics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction & Fabrication of MOSFETs**: VLSI Design Methodologies, VLSI Design Flow, Design Hierarchy, Concept of Regularity, Modularity & Locality, VLSI Design Styles; Fabrication of MOSFETs - Introduction, Fabrication Processes Flow - Basic Concepts, The CMOS n-Well Process, Layout Design Rules, Stick Diagrams of complex CMOS Logic Gates (Euler Method).	**9 Hours**
Module-2	**MOS Transistor**: The Metal Oxide Semiconductor (MOS) Structure, The MOS System under External Bias, Structure and Operation of MOS Transistor (MOSFET), MOSFET Current-Voltage Characteristics, MOSFET Scaling and Small-Geometry Effects, MOSFET Capacitance.	**8 Hours**
Module-3	**MOS Inverter Circuit**s: Introduction, Voltage Transfer Characteristics, Noise Margin Definitions, Resistive Load Devices, CMOS Inverters, Sizing Inverters; **Static MOS Gate Circuits**: Introduction, CMOS Gate Circuits, Complex CMOS Gates, Calculation of Inverter Equivalent for NAND, NOR and other Complex Logic Circuits.	**9 Hours**
Module-4	**Switching Characteristics & Interconnect Effects**: Introduction, Switching Time Analysis, Calculation of Interconnect Parasitics, Calculation of Interconnect Delay (Elmore Delay), Power Dissipation in CMOS Gates, Schematic of sequential circuits.	**8 Hours**
Module-5	**Transfer Gate & Dynamic Logic Design**: Introduction, Pass Transistor concepts, CMOS Transmission Gate, Dynamic logic; Basics of Semiconductor Memory - DRAM, SRAM Cell Design & Operation, Memory Architecture.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. -M. Kang and Y. Leblebici, ***CMOS Digital Integrated Circuits - Analysis and Design***, 3rd *Ed.*, Tata McGraw-Hill, 2002.

T2. D. A. Hodges, H. G. Jackson, and R. Saleh, ***Analysis and Design of Digital Integrated Circuits in Deep Submicron Technology***, 3rd *International Ed.*, McGraw Hill Education, 2004.

Reference Books:

R1. J. M. Rabaey, A. P. Chandrakasan, and B.Nikolić, ***Digital Integrated Circuits: A Design Perspective***, 2nd *Ed.*, Pearson Education, 2016.

R2. N. H. E. Weste, D. Harris, and A. Banerjee, ***CMOS VLSI Design - A Circuits and Systems Perspective***, 4th *Ed.*, Pearson Education, 2010.

R3. D. A. Pucknell and K. Eshraghian, ***Basic VLSI Design***, 3rd *Ed.*, PHI Learning, 1995.

Online Resources:

1. https://nptel.ac.in/courses/117101058: by Prof. A. N. Chandorkar, IIT Bombay
2. https://nptel.ac.in/courses/108107129: by Prof. S. Dasgupta, IIT Roorkee
3. https://nptel.ac.in/courses/117106149: by Prof. M. Rao, IIIT Bangalore

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

CO1	Identify suitable VLSI design methods using proper design flow and fabrication steps.
CO2	Describe MOSFET structure & operation under bias, including effects of scaling & geometry.
CO3	Design and analyze inverter, combinational & sequential circuits using CMOS technology.
CO4	Analyze inverter switching to estimate delay, interconnect effects and power consumption.
CO5	Design and analyze transmission gates, memory cells and understand testing techniques.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Sensors & Transducers	L-T-P	Credits	Marks
MNR	EC3034		3-0-0	3	100

Objectives	The objective of this course is to learn the characteristics of different types of measurement systems and industrial applications of various transducers & sensors for design and construction of precise measuring instruments.
Pre-Requisites	Basic knowledge of physics, mathematics, electrical and electronics is required
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**General Measurement Systems**: Introduction, Significance of measurement, Functional elements of generalized measurement systems, Static Characteristics - Systematic and statistical characteristics, Calibration; Dynamic characteristics - Transfer functions of typical sensing elements, Step and frequency response of first and second order elements, Dynamic error in measurement systems.	**9 Hours**
Module-2	**Basic Sensing Elements**: Resistive Sensing – Potentiometers, Resistance Temperature Detector (RTD), Thermistors & Strain gages; Capacitive Sensing – Variable separation, Area & dielectric piezoelectric transducers; Inductive Sensing – LVDT displacement sensors.	**8 Hours**
Module-3	**Thermoelectric & Elastic Sensing Elements**: Laws, Thermocouple characteristics, Installation problems, Cold junction compensation, IC temperature sensor; Elastic sensing elements - Bourdon tube, Bellows & diaphragms for pressure sensing, Force measurement; Miscellaneous Sensors - Optical sensors, Principle, Intensity & phase-modulated sensors, FBG sensor.	**9 Hours**
Module-4	**Signal Conditioning Elements**: DC Bridge - Wheatstone Bridge, Calibration of the bridge, AC bridges, Linearization by Bridge circuit, Modulation and demodulation techniques, Signal conditioning system, Signal transmission.	**8 Hours**
Module-5	**Amplifiers**: Operational amplifier - Ideal & non-Ideal performances, Inverting, Non-inverting and differential amplifiers, Instrumentation amplifier, Filters, A.C. carrier systems, Phase sensitive demodulators and its applications in instrumentation.	**8 Hours**
	Total	**42 Hours**

Text Books:

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

Reference Books:

R1. D. Patranabis, ***Sensors and Transducers***, 2nd *Ed.*, PHI Learning, 2013.
R2. D. V. S. Murthy, ***Transducers and Instrumentation***, 2nd *Ed.*, PHI Learning, 2008.
R3. E. O. Doeblin, ***Measurement Systems - Applications and Design***, 6th *Ed.*, McGraw Hill, 2007.
R4. C. Rangan, G. Sarma, and V. S. V. Mani, ***Instrumentation : Devices and Systems***, 2nd *Ed.*, McGraw Hill, 2017.

Online Resources:

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

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

CO1	Explain elements, characteristics and dynamic behavior of general measurement systems.
CO2	Describe resistive, capacitive and inductive sensing elements and their operating principles.
CO3	Explain thermoelectric, elastic and optical sensing elements and their measurement uses.
CO4	Analyze bridge circuits, modulation methods and signal conditioning techniques in measurement.
CO5	Apply operational and instrumentation amplifiers, filters, and demodulators in measurement.

Program Outcomes Relevant to the Course:

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

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

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

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

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

Evaluation Scheme

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

Detailed Syllabus

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

Cont'd. . .

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

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

Cont'd. . .

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

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

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

Category	Code	Human Resource Information Systems	L-T-P	Credits	Marks
MNR	MG3003		3-0-0	3	100

Objectives	This course aims to provide the students with a managerial understanding of Human Resource Information Systems (HRIS) as enterprise platforms supporting workforce operations, talent management, and decision-making. Students will learn how HRIS integrates people data, business processes, and digital technologies to enable efficient HR services, compliance, and analytics in modern organizations.
Pre-Requisites	Basic understanding of organizational concepts and familiarity with information systems, databases, use of online tools & platforms is desirable.
Teaching Scheme	Regular classroom lectures with the use of ICT and advanced tools as and when required; sessions emphasize interactive discussions, real-world case studies, and practical application of human resource information systems concepts.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**HRIS Fundamentals & Enterprise Roles**: HRIS, HRMS, HCM concepts and evolution, Overview of HR platforms, Enterprise system of record, Implementation lifecycle (strategy, design, build, test, deploy, support), High-level HRIS architecture, Requirements matrix, Core HR and employee master data, HR data architecture, Stakeholder roles (PM, architects, Security lead, Change manager) and interviews, Governance and ownership HRIS.	**8 Hours**
Module-2	**Organizational Data & Talent Acquisition**: Employee data model, Organization and job architectures, Matrix organization, Master and temporal data management, Employment types, Organizational hierarchy & reporting, ERD for core HR, Effective dating, Master data accuracy; Recruiting lifecycle (requisition, sourcing, screening, interviewing, offer, hire), Applicant tracking, Background checks, Assessment tools, Onboarding workflow, Swimlane diagrams, Candidate-to-employee data transition.	**9 Hours**
Module-3	**Workforce Operations, Payroll & Benefits**: Time and attendance systems, Workforce scheduling and leave management, Labor rule automation, Business rules engine, Time-to-payroll integration & challenges, Payroll process overview - earnings, deductions, pay cycles, Benefits administration overview - enrollment, life events, HRIS–payroll–benefits data flow, Employee data privacy and sensitivity.	**8 Hours**
Module-4	**Performance, Learning & Rewards Systems**: Performance management systems, SMART goal setting, Organization–individual alignment, OKRs, Feedback, Appraisal, Workflows, Performance–compensation linkage; LMS & HRMS integration, Skills & competency tracking, Career development, Succession and internal mobility; Salary structures, Merit and bonus planning, Pay equity, Total rewards.	**9 Hours**

Cont'd. . .

Module-#	Topics	Hours
Module-5	**HR Service Delivery, Integration & Analytics**: HR service delivery and self-service systems, HR case management, Knowledge base usage, Chatbot-enabled support; HRIS security - role-based access, Data privacy, Regulatory awareness, Audit & compliance; Change management, Testing strategies; HRIS integration with enterprise systems, APIs & data exchange fundamentals; Operational reporting vs strategic analytics, HR dashboards, KPIs, Data-driven decision-making.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. M. J. Kavanagh, M. Thite, and R. D. Johnson, ***Human Resource Information Systems: Basics, Applications, and Future Directions***, 4th *Ed.*, Sage Publications, 2018.

T2. S. M. Badgi, ***Practical Guide to Human Resource Information Systems (HRIS)***, 1st *Ed.*, PHI Learning, 2014.

T3. P. M. Gupta, ***HR Analytics: The Future of HR***, 1st *Ed.*, BPB Publications, 2019.

Reference Books:

R1. N. Khan, ***Introduction to People Analytics: A Practical Guide to Data-Driven HR***, 1st *Ed.*, Wiley India, 2020.

R2. S. D. Waters, ***The Practical Guide to HR Analytics***, 1st *Ed.*, Society for Human Resource Management (SHRM)/Kogan Page, 2019.

R3. C. Ostroff and A. Schweyer, ***Winning on HR Analytics: Leveraging Data for Competitive Advantage***, 1st *Ed.*, Pearson Education, 2016.

Online Resources:

1. https://nptel.ac.in/courses/110107492: By Prof. S. Rangnekar, Prof. A. Singh, IIT Roorkee, XLRI JSP
2. https://nptel.ac.in/courses/110103626: By Prof. A. C. Issac, IIT Guwahati
3. https://nptel.ac.in/courses/110105069: By Prof. A. Malik, IIT Kharagpur
4. https://www.coursera.org/learn/wharton-people-analytic
5. https://www.coursera.org/learn/human-resources-analytics

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

CO1	Explain the role of HRIS as an enterprise system for workforce data and managerial decisions.
CO2	Analyze organizational and recruitment data structures used in HRIS for hiring and onboarding.
CO3	Describe workforce operations, payroll, and benefits enabled through integrated HRIS.
CO4	Evaluate performance, learning, and compensation systems using HRIS-based talent data.
CO5	Apply HRIS concepts for service delivery, system integration, security, and people analytics.

Program Outcomes Relevant to the Course:

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

Cont'd. . .

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

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

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

Category	Code	Data Analytics with Python	L-T-P	Credits	Marks
MNR	MG3001		3-0-0	3	100

Objectives	The objective of this course is to learn the key aspects of business analytics and using Python as a programming tool for data analytics.
Pre-Requisites	Fundamentals of business analytics and python programming is required.
Teaching Scheme	Regular classroom lectures, power point presentations with use of ICT as required, with examples, real-life case studies, assignments and projects.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Review of Python**: Features, variables, input, output, operators; Control flow statements - if, nested if, if-elif-else, Loops - while, for, error and exception handling; Data Structures - List, tuples, dictionary, Modules – Math, random, statistics, array, string.	**7 Hours**
Module-2	**Data Wrangling with Python**: Introduction to NumPy arrays and vectorized computation, array creation, indexing, slicing and reshaping; DataFrame operations in Pandas - importing data, handling missing values, merging, grouping, filtering and sorting; Basic data cleaning and transformation for analytical readiness.	**9 Hours**
Module-3	**Visual Analytics with Python**: Creating and customizing visualizations — line charts, bar plots, histograms, scatter plots, boxplots, heatmaps and pairplots; Use of Matplotlib for fine-tuned control and Seaborn for statistical visualization, Emphasis on aesthetics, storytelling with data and communicating analytical findings effectively.	**8 Hours**
Module-4	**Exploratory Data Analysis with Python**: Understanding data distributions, identifying outliers and detecting correlations; Techniques for data cleaning, normalization, encoding categorical variables and feature scaling; Generating descriptive statistics and correlation matrices; Applying EDA concepts to real-world datasets using Pandas and Seaborn.	**9 Hours**
Module-5	**Applied ML with Scikit-Learn**: Overview of supervised learning techniques using Scikit-learn, Splitting datasets, Fitting models, Evaluating simple regression and classification models; Introduction to metrics - Accuracy, MAE, and R^2; Mini-project with data cleaning, visualization, and basic modeling using Python tools.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. J. Rogel-Salazar, ***Data Science and Analytics with Python***, 1st *Ed.*, CRC Press, 2017.
T2. W. McKinney, ***Python for Data Analysis***, 3rd *Ed.*, O'Reilly Media, 2022.

Reference Books:

R1. J. Vanderplas, ***Python Data Science Handbook***, 1st *Ed.*, O'Reilly Media, 2016.
R2. J. Grus, ***Data Science from Scratch: First Principles with Python***, 2nd *Ed.*, O'Reilly Media, 2019.
R3. A. Géron, ***Hands-On Machine Learning with Scikit-Learn, Keras and TensorFlow***, 3rd *Ed.*, O'Reilly Media, 2022.

Online Resources:

1. https://nptel.ac.in/courses/110107129: by Prof. G. Dixit, IIT Roorkee
2. https://nptel.ac.in/courses/106107220: By Prof. A. Ramesh, IIT Roorkee
3. https://nptel.ac.in/courses/106106361: by Prof. S. K. Mathew, IIT Madras

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

CO1	Recall Python fundamentals, control structures and data types and solve analytical problems.
CO2	Apply NumPy and Pandas for data handling, cleaning, and transformation for analysis.
CO3	Design and interpret effective visualizations using Matplotlib and Seaborn to uncover insights.
CO4	Perform EDA with data preprocessing, and correlation analysis to derive meaningful insights.
CO5	Integrate data handling, visualization, and modeling to build and assess predictive workflows.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Computer Networks Lab	L-T-P	Credits	Marks
PCR	CS3005		0-0-2	1	100

Objectives	The objective of this course is to implement various computer networking protocols in a high-level programming language, become acquainted with socket programming & simulate networks using appropriate simulation tools.
Pre-Requisites	Knowledge of programming & concepts of computer networks taught in the theory classes are required.
Teaching Scheme	Regular laboratory classes conducted under supervision of the teacher. The experiments shall comprise of programming and simulation 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 Network Hardware and Software, Network Commands like Netstat, Tracert, Ping, Path-ping, Telnet, FTP etc.
2	Basic idea about IPv4 addressing and programming to find the IP address of a machine and Ethernet address.
3	Socket Programming for Echo Client and Echo Server using TCP socket.
4	Socket Programming for Chatting between two Machines using TCP socket.
5	Socket Programming for Echo Client and Echo Server using UDP socket.
6	Socket Programming for communicating between two Machines using UDP socket.
7	Implementation of ARP/RARP Protocols using a programming language.
8	Introduction to Network Simulator.
9	To study various types of connector devices (Router, Hub, Switch, Bridge) and verification of standard network topologies using simulator.
10	Simulate a given network with proper labeling of the devices using simulator.
11	Configure the DNS, DHCP, HTTP, FTP servers using simulator.
12	Configure an email server and establish a Virtual LAN (VLAN) using simulator.
13	Configure static & dynamic routing protocols using simulator.
14	Construct a wireless network and set up communication using simulator.

Text Books:

T1. R. Stevens and S. A Rago, ***Advanced UNIX Programming***, 3rd *Ed.*, Pearson Education, 2013.
T2. L. V. Winkle, ***Hands-On Network Programming with C***, 1st *Ed.*, Packt Publishing, 2019.

Reference Books:

R1. S. Walton, ***LINUX Socket Programming***, 2nd *Ed.*, SAMS Publication, 2007.
R2. M. J. Donahoo and K. L. Calvert, ***TCP/IP Sockets in C : Practical Guide for Programmers***, 2nd *Ed.*, Morgan Kaufmann, 2009.

P.T.O

Online Resources:

1. http://home.iitk.ac.in/~chebrolu/ee673-f06/sockets.pdf: Socket Programming by Prof. K. Chebrolu, IIT Kanpur
2. https://www.cs.cmu.edu/~srini/15-441/S10/lectures/r01-sockets.pdf

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

CO1	Recognize different networking devices and basic network commands for Windows/Linux OS.
CO2	Implement client-server applications with TCP/UDP socket programming in a standalone machine and over a network.
CO3	Apply HTTP over TCP/UDP connection with help of a Browser.
CO4	Design, setup, simulate, and test different types of computer networks.
CO5	Configure DNS, DHCP, HTTP, FTP, servers mail servers & VLANS.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Machine Learning Lab	L-T-P	Credits	Marks
PCR	CS3006		0-0-2	1	100

Objectives	The objective of this course is to provide practical exposure on implementation of various unsupervised and supervised machine learning techniques, extraction of features from data sets and comparison of the results obtained.
Pre-Requisites	Knowledge of optimization and matrix theory is required.
Teaching Scheme	Regular laboratory classes conducted under supervision of the teacher with the help of ICT; 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 and overview of Scikit-Learn and its features.
2	Implement K-Nearest Neighbor (KNN) algorithm.
3	Implement Simple and Multiple linear regression.
4	Implement Ridge regression.
5	Implement Logistic regression.
6	Implement Naïve Bayes classifier for discrete and continuous feature of the dataset.
7	Implement SVM for classification and regression.
8	Implement Decision Tree.
9	Implement K-Means clustering and Spectral clustering.
10	Experiments on Principal Component Analysis (PCA) and Kernel PCA
11	Implement AdaBoost and Gradient boosting algorithms.
12-13	Mini Project.
14	Demonstration of working project, presentation, and viva voce.

Text Books:

T1. T. Hastie, R. Tibshirani, and J. Friedman, ***The Elements of Statistical Learning - Data Mining, Inference, and Prediction***, 9th *Ed.*, Springer, 2017.

T2. C. M. Bishop, ***Pattern Recognition and Machine Learning***, 1st *Ed.*, Springer, 2006.

T3. A. Géron, ***Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems***, 3rd *Ed.*, Shroff Publishers, 2022.

Reference Books:

R1. K. P. Murphy, ***Machine Learning: A Probabilistic Perspective***, 4th *Ed.*, MIT Press, 2012.

R2. T. M. Mitchell, ***Machine Learning***, 1st *Ed.*, McGrow-Hill Education, 2013.

R3. S. Shalev-Shwartz and S. Ben-David, ***Understanding Machine Learning: From Theory to Algorithms***, 1st *Ed.*, Cambridge University Press, 2014.

Online Resources:

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

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

CO1	Develop expertise with different machine learning toolkits.
CO2	Apply basic machine learning algorithms for predictive modeling.
CO3	Compare and contrast pros and cons of various machine learning techniques.
CO4	Extract meaningful information using non-statistical modeling on real world applications.
CO5	Evaluate recent advances & latest research in the field of machine learning.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Software Engineering Lab	L-T-P	Credits	Marks
PCR	CS3007		0-0-2	1	100

Objectives	The objective of this course is to impart hands on training on all phases of SDLC including Requirements, Function and Object oriented designs, Coding and Testing.
Pre-Requisites	Knowledge of any Programming language, Process flow diagramming, Object-Oriented concepts and Technical documentation skills are required.
Teaching Scheme	Regular laboratory classes conducted under supervision of the teacher. The experiments shall comprise of analysis, designing, and documentation.

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 Problem Statements for which the software solutions are to be created.
2	The Requirement analysis activities to be done for the selected systems.
3	Creating SRS for the selected systems - Functional Requirements.
4	Creating SRS for the selected systems - Non-Functional Requirements.
5	Function-Oriented Design: Structured Analysis - Data Flow Diagrams (DFD-0).
6	Function-Oriented Design: Structured Analysis - DFD-1 & DFD-2.
7	Object Oriented Analysis & Design - Use Case Diagram.
8	The Structural view for the system - Class diagram.
9	The Behavioral view for the system - Sequence & Collaboration diagrams.
10	The Behavioral view for the system - Activity diagram and State-chart diagrams.
11	Testing - Test cases and Test suite creation.
12	Project effort, schedule and cost estimations.

Text Books:

T1. R. Mall, ***Fundamentals of Software Engineering***, 5th *Ed.*, PHI Learning, 2018.
T2. B. Hughs and M. Cotterell, ***Software Project Management***, 1st *Ed.*, Ingram Publications, 2009.

Reference Books:

R1. R. S. Pressman, ***Software Engineering : A Practitioners Approach***, 7th *Ed.*, McGraw Hill, 2010.
R2. I. Sommerville, ***Software Engineering***, 10th *Ed.*, Pearson Education, 2017.
R3. R. C. Martin, ***Clean Code: A Handbook of Agile Software Craftsmanship***, 10th *Ed.*, PHI Learning, 2017.

Online Resources:

1. https://nptel.ac.in/courses/106101061: by Prof. Joshi, Bellur, and Sarda, IIT Bombay
2. https://nptel.ac.in/courses/106105182: by Prof. R. Mall, IIT Kharagpur
3. https://nptel.ac.in/courses/106101163: by Prof. M. D'souza, IIIT Bangalore

P.T.O

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

CO1	Select suitable SDLC model and conduct requirement analysis and specification.
CO2	Create the prescribed design artifacts following the Function oriented design approach.
CO3	Develop the recommended design artifacts following Object oriented design methodology.
CO4	Implement the system using suitable language(s) or tool(s) followed by testing.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Soft Skills for Professionals	L-T-P	Credits	Marks
SEC	HS3001		0-0-2	1	100

Objectives	The objective of this laboratory course is to make learners understand aspects of soft skills, which are essential for all professionals, by making them participate in mock GD, PI, presentations & verbal ability tests.
Pre-Requisites	Knowledge of Technical Communication in English is required.
Teaching Scheme	Regular laboratory classes with various tasks designed to facilitate communication through pair and/or team activities with regular assessments, presentations, discussions, role plays, audio-visual supplements, writing activities, business writing practices & vocabulary enhancement.

Evaluation Scheme

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

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	GD input and discussion
2	Mock GD 1: Content Development
3	Mock GD 2: Group Behaviour
4	GD test
5	Presentation inputs and discussions
6	PPT I
7	PPT II
8	PPT III
9	PPT IV
10	Writing an effective résumé
11	Mock PI I
12	Mock PI II
13	Verbal Ability I
14	Verbal Ability II

Text Books:

T1. B. K. Mitra, ***Personality Development and Soft Skills***, 3rd *Ed.*, Oxford University Press, 2024.

Reference Books:

R1. B. K. Das *et. al.*, ***An Introduction to Professional English and Soft Skills***, Cambridge University Press, 2009.
R2. B. K. Mitra, ***Effective Technical Communication - A Guide for Scientists and Engineers***, 1st *Ed.*, Oxford University Press, 2006.

Online Resources:

1. https://nptel.ac.in/courses/109107121: by B. Mishra, IIT Roorkee
2. https://owl.purdue.edu/owl/purdue_owl.html
3. https://www.usingenglish.com/
4. http://www.english-test.net/

5. https://www.ef.com/wwen/english-resources/

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

CO1	Understand and practice vital soft skills for professional success.
CO2	Participate actively in recruitment related group discussions.
CO3	Understand aspects of public speaking and apply them to make impactful multimedia presentations.
CO4	Compose compelling résumés and persuasive cover letters.
CO5	Perform efficiently and effectively in job interviews.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Internet of Things	L-T-P	Credits	Marks
PCR	CS3008		3-0-0	3	100

Objectives	The objective of this course is to learn the concepts, technologies, design principles, communication protocols, challenges, application areas and develop IoT applications for the real world.
Pre-Requisites	Basic knowledge of programming, computer networks, sensors, micro-processor and micro-controllers is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples, case-studies, and latest trends.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction & Concepts**: Definition and Characteristics, Physical Design and Things in IoT, Protocol, Logical Design, Functional Blocks, Communication Models, Communication APIs, Enabling Technologies, IoT Levels and Development Templates.	**9 Hours**
Module-2	**Domain Specific IoTs**: Home Automation, Cities, Environment, Energy, Retail, Logistics, Agriculture, Industry, Health, Life Style, Challenges and Issues, Study of relevant sensors for the above domains.	**7 Hours**
Module-3	**M2M & System Management with NETCONF-YANG**: M2M, Difference between IoT and M2M, SDN and NFV for IoT, Software Defined Networking, Network Function Virtualization, Need for IoT Systems Management, Simple Network Management Protocol, Limitations of SNMP.	**8 Hours**
Module-4	**Internet of Things**: Review of Networking and the Internet, Designing the Architecture of an IP-based IoT, Physical/Link Layer, IEEE 802.15.4 and ZigBee, Low-power Wi-Fi, Bluetooth and BLE, Powerline Communications, Network, 6LoWPAN Adaptation, Transport and Application Layers, MQTT, REST API, CoAP, CoSIP Protocol Specification.	**10 Hours**
Module-5	**IoT Application Development**: IoT Infrastructures Security, Industries, IoT Electronic Equipment, Sensors and Sensor Node Interfacing using Raspberry Pi/Arduino, Web Enabled Constrained Devices, Use of Data Analytics, Big Data and Visualization in IoT, Industrial IoT and Industry 4.0 concepts.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. A. Bahga and V. Madisetti, ***Internet of Things: A Hands-on Approach***, 1st *Ed.*, University Press, 2018.
T2. R. Kamal, ***Internet of Things: Architecture and Design Principles***, 1st *Ed.*, McGraw-Hill Education, 2017.

Reference Books:

R1. H. Zhou, ***The Internet of Things in the Cloud: A Middleware Perspective***, CRC Press, 2012.
R2. O. Hersent, D. Boswarthick, and O. Elloumi, ***The Internet of Things: Key Applications and Protocols***, Student Edition, John Wiley & Sons, 2016.
R3. A. McEwen and H. Cassimally, ***Designing the Internet of Things***, Wiley Publishers, 2013.

P.T.O

Online Resources:

1. https://nptel.ac.in/courses/106105166/: by Prof. S. Misra, IIT Kharagpur
2. https://nptel.ac.in/courses/108108098/: by Prof. T. V. Prabhakar, IISc Bangalore

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

CO1	Explain and explore the basic building blocks of IoT and design levels.
CO2	Design and develop IoT solutions for different application domains.
CO3	Explore the evolution of IoT from other existing technologies and protocols.
CO4	Design IoT systems using IP-based architecture and protocol stacks.
CO5	Develop IoT solutions using appropriate hardware components & protocols, and explore recent trends in IoT and Industry 4.0.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Soft Computing	L-T-P	Credits	Marks
PCR	CS3009		3-0-0	3	100

Objectives	The objective of this course is to learn non-traditional computing techniques to solve hard real-world problems using following key techniques: Fuzzy systems, Genetic algorithm, and Artificial neural networks. Different aspects of hybridization with case studies also to be discussed.
Pre-Requisites	Knowledge of Linear Algebra, Data Structures, and Algorithm Design is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on problem solving and applications.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction and Fuzzy Logic**: Soft vs. Hard Computing, Motivation, Characteristics, Major constituents (Neural networks, Fuzzy logic and Evolutionary computing); Fundamentals of Fuzzy Sets: Crisp vs. Fuzzy sets, Membership functions and Basic operations; Fuzzy Relations: Tolerance, Equivalence, Cartesian product, Fuzzy relations and Composition; Fuzzy Rule-Based Systems: Fuzzy propositions, IF–THEN rule, rule base structure.	**9 Hours**
Module-2	**Fuzzy Inference Systems**: Mamdani vs. Sugeno vs. Tsukamoto models; Fuzzification and Defuzzification; Inference engines, Fuzzy Implications, Fuzzy algorithms; Fuzzy controller design in industrial applications.	**8 Hours**
Module-3	**Genetic Algorithms (GA) and Optimization**: Introduction - Biological inspiration, GA vs Traditional Optimization; Basic Terminology and Workflow - Working cycle of a GA, Binary Coded GA, GA-parameter setting; Single objective GA vs. multi-objective (MOEA, Pareto/non Pareto) techniques; Constraint Handling - Penalty functions (static/dynamic), Deb's Feasibility Rules, Repair methods, Decoders (encoding feasible regions only).	**9 Hours**
Module-4	**Neural Networks**: Biological and Artificial neurons, Feed-forward & Feedback architectures, Activation functions, Knowledge representation, McCulloch Pitts; Learning rules - Error correction, Memory based, Hebbian, Competitive, Boltzmann learnings, Learning with & without a teacher; Perceptron, Adaline, Multilayer Perceptron and Backpropagation; XOR problem, Madaline; Self-organizing Maps - Two basic feature mapping models, SOM, RBFN, Introduction to ART.	**8 Hours**
Module-5	**Hybrid Systems**: Hybrid Soft Computing & Neuro Fuzzy Systems, ANFIS, Genetic Neuro, Genetic Fuzzy & Fuzzy Genetic hybrids: Architectures and use cases, Real-world applications.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. N. Sivanandam and S. N. Deepa, ***Principles of Soft Computing***, 2nd *Ed.*, Wiley India, 2011.

T2. J. S. R. Jang, C. T. Sun, and E. Mizutani, ***Neuro Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence***, 1st *Ed.*, Pearson Education, 2015.

T3. D. K. Pratihar, ***Soft Computing***, Revised Edition, Narosa Publishing, 2015.

Reference Books:

R1. S. Haykin, ***Neural Networks: A Comprehensive Foundation***, 2nd *Ed.*, Pearson Education, 2006.
R2. T. Munakata, ***Fundamentals of the New Artificial Intelligence: Neural, Evolutionary, Fuzzy and More***, 2nd *Ed.*, Springer, 2014.
R3. F. O. Karray and C. De Silva, ***Soft Computing and Intelligent Systems Design: Theory, Tools and Applications***, 1st *Ed.*, Pearson Education, 2009.
R4. T. J. Ross, ***Fuzzy Logic with Engineering Applications***, 4th *Ed.*, Wiley India, 2016.
R5. D. E. Goldberg, ***Genetic Algorithms in Search, Optimization and Machine Learning***, 1st *Ed.*, Addison-Wesley, 1989.
R6. S. Haykin, ***Neural Networks and Learning Machines***, 3rd *Ed.*, Pearson Education, 2009.

Online Resources:

1. https://nptel.ac.in/courses/111105614/: by Prof. S. Kundu, IIT-ISM Dhanbad
2. https://nptel.ac.in/courses/117105084/: by Prof. S. Sengupta, IIT Kharagpur
3. https://nptel.ac.in/courses/127105006/: by Prof. D. K. Pratihar, IIT Kharagpur
4. https://cse.iitkgp.ac.in/~dsamanta/courses/sca/index.html#resources

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

CO1	Describe the principles of soft computing and its major components.
CO2	Apply fuzzy logic and fuzzy control systems to solve complex real world problems.
CO3	Apply Genetic Algorithms for optimization and solve constraint-based real world problems.
CO4	Understand and implement neural network models and learning algorithms.
CO5	Design hybrid soft computing systems and evaluate their performance.

Program Outcomes Relevant to the Course:

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

P.T.O

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

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

Category	Code	Compiler Design	L-T-P	Credits	Marks
PCR	CS3010		3-0-0	3	100

Objectives	The objective of this course is to learn the components of compiler and the principles involved in design of compilers for modern computer languages.
Pre-Requisites	Knowledge of formal language & automata theory and proficiency in any programming language is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on algorithms, problem solving, 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	**Introduction To Compilers and Lexical Analysis**: Language Processors, Structure of a Compiler, Role of the Lexical Analyzer, Input Buffering, Specification of Tokens, Recognition of Tokens, Finite Automata, Regular Expressions to Automata, Optimization of DFA-Based Pattern Matchers, Lexical-Analyzer Generator Lex.	**8 Hours**
Module-2	**Syntax Analysis**: Role of Parser, Grammars, Context-free grammars, Writing a grammar, Top Down Parsing, Recursive Descent Parser, FIRST & FOLLOW, LL(l) Grammars, Non-recursive Predictive Parsing, Bottom-Up Parsing, Reductions, Handle Pruning-Shift-Reduce Parsing, Simple LR-Items & the LR(O) Automaton, The LR-Parsing Algorithm, Constructing SLR-Parsing Tables, Powerful LR Parsers (CLR & LALR), Parser Generator Yacc.	**10 Hours**
Module-3	**Syntax Directed Translation and Intermediate Code Generation**: Syntax-directed definitions, Evaluation orders for SDD's, Syntax-directed Translation schemes, Intermediate-code generation, Variants of syntax trees, Three Address Code, Translation of Expressions, Translation of Array References, Short-Circuit Code, Backpatching.	**8 Hours**
Module-4	**Run-Time Environment and Code Generation**: Symbol Tables, Runtime Environments, Storage organization, Activation Trees & Records, Issues in the Design of a Code Generator, Basic Blocks & Flow graphs, Optimization of Basic Blocks, A simple Code Generator.	**8 Hours**
Module-5	**Code Optimization**: Peephole Optimization, Principal Sources of Optimization, Data Flow Analysis, Reaching Definitions, Live-Variable Analysis, Available Expressions, Loops in Flow Graphs, Dominators, Depth-First Ordering, Back Edges and Reducibility, Natural Loops.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. A. V. Aho, M. S. Lam, R. Sethi, and J. D. Ullman, ***Compilers: Principles, Techniques and Tools***, 2nd *Ed.*, Pearson Education, 2009.

Reference Books:

R1. K. D. Cooper and L. Torczon, ***Engineering a Compiler***, 2nd *Ed.*, Morgan Kaufmann, 2011.
R2. A. I. Holub, ***Compiler Design in C***, 2nd *Ed.*, Prentice Hall of India, 2002.

Online Resources:

1. https://nptel.ac.in/courses/106106237: by Prof. R. Nasre, IIT Madras
2. https://nptel.ac.in/courses/106105190: by Prof. S. Chattopadhyay, IIT Kharagpur
3. https://nptel.ac.in/courses/106104123:by Prof. S. K. Aggarwal, IIT Kanpur
4. https://nptel.ac.in/courses/106108113: by Prof. Y. N. Srikanth, IISc Bangalore

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

CO1	Describe basics of a compiler, language processors, lexical analyzers and token recognition.
CO2	Analyze context-free grammars and construct parsers using different parsing techniques.
CO3	Apply syntax directed translation, intermediate code generation and backpatching techniques.
CO4	Describe runtime environments, activation records and basic code generation strategies.
CO5	Adapt optimization techniques, global data flow analysis and developments in compiler design.

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

Category	Code	Natural Language Processing	L-T-P	Credits	Marks
PEL	CS3019		3-0-0	3	100

Objectives	The objective of this course is to study fundamentals, algorithms, and techniques to enable processing of natural languages by computers in order to design different human-computer interactive systems.
Pre-Requisites	Knowledge on grammar rules, statistics, regular expressions, and automata theory is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples, problem solving, and latest advances.

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 NLP, Applications, Phases of NLP, Issues and Processing complexities, Language modeling, Grammar-based and Statistical language models, n-gram model, Smoothing techniques.	**8 Hours**
Module-2	Word level analysis, Regular expressions, Finite state automata, Finite state transducers, Text pre-processing, Tokenization, Normalization, Stop word removal, Stemming, Lemmatization, Part-of-speech tagging, Named-entity recognition, Spelling error detection and Correction.	**8 Hours**
Module-3	Syntactic analysis, Top-down & bottom-up parsings, Earley, CYK and Probabilistic parsing, Semantic analysis, Meaning representation languages, Dependency parsing, Word sense disambiguation, Discourse and pragmatic analysis.	**8 Hours**
Module-4	Word representations - BoW, TF-IDF, Word embeddings: Word2Vec (CBOW, Skip-Gram), Word senses and Contextual embeddings, Word similarity measures, ML for NLP, Sentiment analysis, Evaluation metrics, Large language models.	**9 Hours**
Module-5	Machine translation, Information retrieval, Information extraction, Text summarization, Question answering system, Natural language generation, Chatbots & Dialogue systems, other advanced applications of NLP.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. D. Jurafsky and J. H. Martin, ***Speech and Language Processing - An introduction to Language Processing, Computational Linguistics, and Speech Recognition***, 2nd *Ed.*, Pearson Education, 2013.
T2. T. Siddiqui and U. S. Tiwary, ***Natural language Processing and Information Retrieval***, 1st *Ed.*, Oxford University Press, 2008.

Reference Books:

R1. J. Allen, ***Natural Language Understanding***, 2nd *Ed.*, Pearson Education, 2008.
R2. C. D. Manning and H. Schütze, ***Foundations of Statistical Natural Language Processing***, 2nd *Ed.*, MIT Press, 2000.

P.T.O

Online Resources:

1. https://nptel.ac.in/courses/106101007/: by Prof. P. Bhattacharyya, IIT Bombay
2. https://nptel.ac.in/courses/106105158/: by Prof. P. Goyal, IIT Kharagpur
3. https://nlp.stanford.edu/fsnlp/
4. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-863j-natural-language-and-the-computer-representation-of-knowledge-spring-2003/lecture-notes/

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

CO1	Explain the fundamental concepts and language models for natural language processing.
CO2	Apply word-level analysis techniques to prepare raw text for analysis.
CO3	Perform syntactic, semantic and discourse level analysis of natural language text.
CO4	Design various statistical and machine learning models for NLP tasks.
CO5	Implement applications of NLP in human-computer interactive systems.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Wireless Sensor Networks	L-T-P	Credits	Marks
PEL	CS3020		3-0-0	3	100

Objectives	The objective of this course is to learn the basic concepts & design aspects of wireless sensor networks and programming skills for WSNs at the system, network, and application levels.
Pre-Requisites	Knowledge of computer networks and wireless communication is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples, applications, and latest research.

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 WSN & its technology, motivation and applications, Taxonomy of WSN technologies, Traditional layered stack, Cross-layer designs, Sensor network architecture.	**8 Hours**
Module-2	**Sensor Node Technology & MAC**: Overview, Hardware & software, Sensor taxonomy, Wireless network trends, Wireless transmission technology and systems, Radio technology primer, Available wireless technologies; Medium access control protocols for WSN - Fundamentals of MAC protocols, MAC protocols for WSNs, Sensor-MAC case study, IEEE 802.15.4 LR-WPANs Standard case study, MAC protocols analysis using Markov Chain.	**9 Hours**
Module-3	**Routing Protocols**: Data dissemination and gathering, Routing challenges, design issues, and strategies; Transport Control Protocols: Design issues, Resource aware routing, Data-centric routing, Geographic routing, Opportunistic routing.	**9 Hours**
Module-4	**Middleware & Security Issues**: Principles, Architecture, Existing middleware, Network management - requirements, traditional models, design issues; Security issues of WSN - Possible attacks, Countermeasures, Static & dynamic key distribution.	**8 Hours**
Module-5	**Platforms & Tools**: Sensor node Hardware, Berkeley Motes, Programming challenges, Node-level software platforms, Node-level simulators, State-centric programming; Applications of WSNs - Ultra-wide band radio communication, Wireless fidelity systems, Future directions, Home automation, Smart metering applications.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. W. Dargie and C. Poellabauer, ***Fundamentals of Wireless Sensor Networks - Theory and Practice***, 1st *Ed.*, Wiley, 2011.

T2. K. Sohraby, D. Minoli, and T. Znati, ***Wireless Sensor Networks - Technology, Protocols, and Applications***, 1st *Ed.*, Wiley InterScience, 2007.

Reference Books:

R1. T. Hara, V. I. Zadorozhny, and E. Buchmann, ***Wireless Sensor Network - Technologies for the Information Explosion Era***, 1st *Ed.*, Springer, 2010.

R2. B. Krishnamachari, ***Networking Wireless Sensors***, 1st *Ed.*, Cambridge University Press, 2005.

Online Resources:

1. https://nptel.ac.in/courses/106105160/: by Prof. S. Misra, IIT Kharagpur
2. https://ocw.mit.edu/courses/1-264j-database-internet-and-systems-integration-technologies-fall-2013/7ed97701d93fa60abae3643005ac64b7_MIT1_264JF13_lect_36.pdf: MIT OpenCourseWare.

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

CO1	Describe different types of wireless networks, their architecture and supporting protocols.
CO2	Explain the hardware & software of WSNs and MAC layer protocols to address media accessing.
CO3	Analyze network & transport layer protocols to handle addressing, route optimization, handover and reliability challenges.
CO4	Explore WSN middleware, identify security issues and apply necessary countermeasures.
CO5	Apply various WSN platforms and tools to design real world applications.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Mobile Application Development	L-T-P	Credits	Marks
PEL	CS3021		3-0-0	3	100

Objectives	The objective of this course is to develop applications for mobile OS platforms taking Android as the base OS for learning programming techniques, design patterns, processes, tools and frameworks.
Pre-Requisites	Basic knowledge of operating systems and Java programming language is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples and application programs.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction & Tools**: Mobile Computing, CDMA, GSM, 3G, 4G Types of mobile computing devices, Android platform, Architecture, Android components; Development Tools - Android Studio IDE, Jetpack compose, Kotlin and developing first app; Activities and Lifecycle - Fragments and Intents, Fragments, Intent Object to Invoke Built-in Application.	**8 Hours**
Module-2	**UI Design and Events**: Android Layout Managers – Linear Layout, Relative Layout, ScrollView, Table Layout, Frame Layout; Working with Views - Text, EditText, Button, RadioButton, CheckBox; UI Events - Understanding Android Events, Event Handling, Event Listener and Callback Method, Intercepting Touch Events; Data binding in Android - Adapter Views, ListView Class, AutoTextCompleteView, GridView, Displaying Pictures & Menus with Views; Embedding Web Browser in an Activity using WebView.	**9 Hours**
Module-3	**Networking in Android**: Accessing the network, Permission to access the network, Checking Network Availability, Sending Email, Displaying Maps, Getting Location Data, monitoring a Location, Google Maps API (using Geocoder); Telephony and SMS - Handling Telephony, Handling SMS, Sending SMS Using Intent.	**9 Hours**
Module-4	**Working with Bluetooth and Wi-Fi**: Bluetooth Adapter and Managing Wi-Fi connectivity using Wifi Manager; Threads and Thread Handlers - Introduction to Threads, Worker threads - asyncTask, interprocess communication and Services; Playing Audio and Video - Recording Audio and Video, Using the Camera to capture & process Pictures.	**8 Hours**
Module-5	**Android Data & Storage APIs**: Managing data using Sqlite, Sharing Data between Applications with Content Providers, Using Android Networking APIs, Using Android Web APIs.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. R. Meier, ***Professional Android 4 Application Development***, 1st *Ed.*, John Wiley & Sons, 2012.
T2. P. Kothari, ***Android Application Development: Black Book***, 1st *Ed.*, Kogent Learning Solutions, Dreamtech Press, 2014.

Reference Books:

R1. D. Griffiths and D. Griffiths, ***Head First Android Development: A Brain-Friendly Guide***, 1st *Ed.*, O'Reilly, 2017.
R2. B. Phillips, C. Stewart, and K. Marsicano, ***Android Programming: The Big Nerd Ranch Guide***, 4th *Ed.*, Big Nerd Ranch Guides, 2019.

Online Resources:

1. https://developer.android.com/courses/android-basics-compose/course
2. https://kotlinlang.org/docs/home.html

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

CO1	Explain the concepts of mobile application programming and platforms.
CO2	Create, test and debug mobile applications by setting up a development environment.
CO3	Demonstrate the methods for storing, sharing and retrieving data in mobile applications.
CO4	Apply rapid prototyping techniques to design and develop sophisticated mobile interfaces.
CO5	Create rich interactive mobile applications using databases, audio, video, and notifications.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Data Visualization & Reporting	L-T-P	Credits	Marks
PEL	CS3022		3-0-0	3	100

Objectives	The objective of this course is to learn the principles and techniques for analyzing and visualizing data through interactive and insightful graphical representations. The course shall cover essential theories, strategies & tools for constructing meaningful visualizations for reporting & interpretation.
Pre-Requisites	Basic knowledge of data structures, data analysis, statistics, graphs & charts is required. Prior experience of programming in Python/R is desirable.
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**: Visualization process, Seven stages of data visualization, Types of data, Perception, Eight visual variables – position, shape, size, brightness, color, orientation, texture and motion.	**8 Hours**
Module-2	**Visualization of Multivariate Data**: Point-Based, Line-Based & Region-Based Techniques; Visualization of Trees, Graphs and Networks – Display of Hierarchical Structures and Arbitrary Graphs/Networks, Text and Document Visualization.	**8 Hours**
Module-3	**Visualization of Special Data**: Visualization of Spatial, Geospatial and Time-oriented data, Evaluating visualizations.	**8 Hours**
Module-4	**Visualization using D3**: Working with data, Data-binding, Creating an axis, line charts, interpolating data points, Pie & Stack Layouts (Pie charts, Stack layout), Drawing a Histogram, Visualization with Scalable Vector Graphics (SVG), Drawing, Transformations, Building Charts with SVG.	**9 Hours**
Module-5	**Visualization using R/Python**: Matplotlib (Histograms, Bar Charts, Line plots, Pie Charts, Box Plots, Scatter Plots), Seaborn (Box, Violin & Regression Plots, Heatmaps), Base graph functions in R (Line & Bar Plots, Pie chart, Box Plots), ggplot2, Creating Dashboards with Plotly & Dash.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. M. Ward, G. Grinstein, and D. Keim, ***Interactive Data Visualization : Foundations, Techniques, and Applications***, 2nd *Ed.*, CRC Press, 2015.
T2. E. Meeks, ***D3.js in Action : Data Visualization with JavaScript***, 3rd *Ed.*, Manning Publications, 2024.
T3. A. C. Telea, ***Data Visualization Principles and Practice***, 2nd *Ed.*, CRC Press, 2015.

Reference Books:

R1. B. Fry, ***Visualizing Data***, O'Reilly Media, 2007.
R2. S. Murray, ***Interactive Data Visualization for the Web***, 2nd *Ed.*, O'Reilly Media, 2017.
R3. K. Sosulski, ***Data Visualization Made Simple : Insights Into Becoming Visual***, Routledge, 2018.
R4. K. Healy, ***Data Visualization : A Practical Introduction***, Princeton University Press, 2019.

Online Resources:

1. https://matplotlib.org/stable/tutorials/index.html
2. https://seaborn.pydata.org/tutorial.html
3. https://docs.bokeh.org/en/latest/docs/gallery.html
4. https://www.r-graph-gallery.com/ggplot2-package.html

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

CO1	Explain the process of data visualization and visual variables based on perceptual principles.
CO2	Apply visualization techniques to multivariate, hierarchical, textual and network-based data.
CO3	Apply visualization techniques to special types of data and evaluate their effectiveness.
CO4	Develop interactive visualizations using D3.js with data-binding, layouts and SVG.
CO5	Build informative charts and dashboards using Python/R libraries for real-time data reporting.

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)
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

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

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

Category	Code	Bioinformatics Algorithms	L-T-P	Credits	Marks
PEL	CS3025		3-0-0	3	100

Objectives	The objective of this course are to learn biological data and databases, map biological problems as computational problems & solve them using key statistical and computational techniques.
Pre-Requisites	Knowledge of design and analysis of algorithms 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	**Bioinformatics**: Applications, Role of internet in bioinformatics, Basic biomolecular concepts - Protein & amino acid, DNA & RNA, Sequence, Structure and Function, Types of Nucleotide Sequence - Genomic DNA, Complementary DNA (cDNA), Recombinant DNA (rDNA), Expressed sequence tags (ESTs), Genomic survey sequences (GSSs), DNA sequencing methods: Basic and Automated DNA sequencing, DNA sequencing by capillary array and electrophoresis, Gene expression data.	**12 Hours**
Module-2	**Sequence Alignment**: Measurement of sequence similarity, Similarity and homology, Pairwise sequence alignment - Basic concepts, Needleman & Wunsch, Smith & Waterman algorithms for pairwise alignments, Gap penalties, Use of pairwise alignments for analysis of nucleic acid and protein sequences, Interpretation of results.	**8 Hours**
Module-3	**Sequencing**: Sequencing by hybridization, Shortest common super string, Algorithms for overlap multi-graph, Fragment assembly, Protein sequencing and Identification, The peptide sequencing problem, spectrum graph.	**6 Hours**
Module-4	**Multiple Sequence Alignment & Analysis**: Need of MSA, Family & Super Family representation, Multiple sequence comparisons for structural inferences, Multiple alignments with sum-of-pairs, Sequence Analysis - Concepts of sequence similarity, identity and homology, Definitions of homologues, orthologues, paralogues & xenologues; Scoring matrices - Concept of a scoring matrix, Matrices for nucleic acid and protein sequences, PAM & BLOSUM series.	**8 Hours**
Module-5	**Evolutionary Trees**: Distance and character based methods for tree reconstructions, Gene expression clustering, Tumor classification with SVM, Reconstruction of biological network by Supervised Learning approaches, Short review on deep learning for computational biology.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. N. C. Jones and P. A. Pevzner, ***An Introduction to Bioinformatics Algorithms***, MIT Press, 2005.

T2. D. Gusfields, ***Algorithms on Strings, Trees and Sequences : Computer Science and Computational Biology***, Cambridge University Press, 1997.

T3. J. C. Setubal and J. Meidanis, ***Introduction to Computational Molecular Biology***, 1st *Ed.*, PWS Publishing Co., 1997.

Reference Books:

R1. W. J. Ewens and G. R. Grant, ***Statistical Methods in Bioinformatics : An Introduction***, 2nd *Ed.*, Springer Science & Business Media, 2006.
R2. R. Durbin, S. R. Eddy, A. Krogh, and G. Mitchison, ***Biological Sequence Analysis : Probabilistic Models of Proteins and Nucleic Acid***, Cambridge University Press, 1999.
R3. D. E. Krane and M. L. Raymer, ***Fundamental Concepts of Bioinformatics***, 1st *Ed.*, Pearson Education, 2003.
R4. H. M. Lodhi and S. H. Muggleton, ***Elements of Computational Systems Biology (Vol. 08)***, 1st *Ed.*, John Willey & Sons, 2010.

Online Resources:

1. https://nptel.ac.in/courses/102106065/: By Prof. M. M. Gromiha, IIT Madras
2. https://ocw.mit.edu/courses/biology/7-91j-foundations-of-computational-and-systems-biology-spring-2014/index.htm
3. https://dspace.mit.edu/bitstream/handle/1721.1/103560/6-047-fall-2008/contents/lecture-notes/index.htm
4. https://www.embopress.org/doi/pdf/10.15252/msb.20156651

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

CO1	Explain biomolecular concepts, DNA sequencing, data types and bioinformatics applications.
CO2	Apply pairwise sequence alignment methods to analyze and interpret biological sequences.
CO3	Analyze sequencing algorithms for DNA assembly, protein identification and peptide sequencing.
CO4	Apply multiple sequence alignment and scoring matrices for comparative sequence analysis.
CO5	Analyze phylogenetic tree construction and apply ML methods for biological data modeling.

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.

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

Category	Code	Cryptography & Network Security	L-T-P	Credits	Marks
PEL	CS3024		3-0-0	3	100

Objectives	The objective of this course is to introduce the security goals, services and mechanisms with primary focus on key cryptography techniques used to protect computer networks and data communications from security threats.
Pre-Requisites	Knowledge on computer networks and engineering mathematics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on problem solving and examples.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction, Concepts of Computer Security, Security Attacks, Services & Mechanisms, Symmetric Cipher model, Cryptography & Cryptanalysis; Substitution Techniques, Monoalphabetic Ciphers (Caesar, Playfair & Hill), Polyalphabetic ciphers: Vignere, Vernam and Transposition ciphers.	**8 Hours**
Module-2	Integer & Modular Arithmetics, Euclidean and Extended Euclidean Algorithms, Concept of groups, rings and fields; Difference between GF(p) & GF(2^m), Block cipher principles, Data Encryption Standard (DES), Advanced Encryption Standard (AES).	**9 Hours**
Module-3	Fermat's, Euler's and Chinese Remainder Theorems, Integer Factorization, Discrete Logarithms, Discrete Logarithm Problem; Public Key Cryptography - RSA, ElGamal, Diffie-Hellman Key Exchange; Elliptic Curve Cryptography - Introduction to elliptic curve, arithmetic, application.	**9 Hours**
Module-4	Message Integrity and Authentication; Cryptographic Hash Functions: MD5, SHA-512, Digital Signature and applications: ElGamal, RSA.	**8 Hours**
Module-5	Key Distribution, Certificate Authority, X.509, Kerberos, E-mail security - PGP, S/MIME, Security at Transport Layer: SSL/TLS, Security at Network Layer - IPSec, Malicious Software, Firewall, Intrusion Detection.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. W. Stallings, ***Cryptography and Network Security: Principle and Practice***, 7th *Ed.*, Pearson Education, 2017.

T2. A. Kahate, ***Cryptography and Network Security***, 4th *Ed.*, McGraw-Hill Education, 2019.

Reference Books:

R1. B. A. Forouzan and D. Mukhopadhaya, ***Cryptography and Network Security***, 2nd *Ed.*, McGraw-Hill Education, 2010.

R2. C. P. Pfleeger, S. L. Pfleeger, and J. Margulies, ***Security in Computing***, 5th *Ed.*, Prentice Hall India, 2015.

R3. C. Kaufman, R. Perlman, and M. Speciner, ***Network Security: Private Communication in a Public World***, 2nd *Ed.*, Prentice Hall India, 2002.

R4. A. J. Menezes, P. C. van Oorschot, and S. A. Vanstone, ***Handbook of Applied Cryptography***, CRC Press, 1996.

Online Resources:

1. https://nptel.ac.in/courses/106105031/: by Dr. D. Mukhopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/106105162/: by Prof. S. Mukhopadhyay, IIT Kharagpur
3. https://nptel.ac.in/courses/106106221/: by Prof. A. Choudhury, IIIT Bangalore
4. https://www.cryptool.org/en/

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

CO1	Identify security goals, threats, services and mechanisms for countermeasures.
CO2	Explain modular arithmetic and number theory in foundations of cryptography.
CO3	Analyze symmetric key techniques and modern block ciphers like DES and AES.
CO4	Apply public key cryptography, hash functions, signatures and authentication.
CO5	Implement cryptography techniques in SSL, TLS, PGP, S/MIME and IPSec security.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Mobile Computing	L-T-P	Credits	Marks
PEL	CS3023		3-0-0	3	100

Objectives	The objectives of this course is to provide students with a comprehensive understanding of mobile computing concepts, wireless architectures, mobility management, security, operating systems, and emerging trends, preparing them to analyze, design, and apply effective mobile solutions.
Pre-Requisites	Basic knowledge of Computer Networks, OS and DBMS is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples, case-studies, and latest trends.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Overview, Characteristics, Applications & their structure, Mobile computing vs Wireless networking; MAC Mechanisms - SDMA, FDMA, TDMA & CDMA; GSM - Channels, Bands, Architecture, Mobility management, Handover detection & management; GPRS - Architecture, GPRS Interfaces, GPRS Network Protocols.	**8 Hours**
Module-2	**WLAN and Bluetooth**: IEEE 802.11 System Architecture, Ad-Hoc and Infrastructural Mode, MAC Frame Format; Bluetooth - Piconet, Scatternet, Protocol stack and Profile; WAP - Architecture, Components, Gateway and Protocol Stack; WML Script - Variables, Control structure & functions; IMT 2000 Standards - WCDMA & CDMA 2000.	**9 Hours**
Module-3	**Mobile IP & Transport Layer**: Overview, Requirements, Entities, Agent advertisement & discovery, Registration, IP packet delivery, Tunneling and encapsulation, IPv6, DHCP, ICMP; Mobile Transport Layer - I-TCP, Snooping TCP, M-TCP, T-TCP; WLL - Architecture, Components, Functionalities; Wireless Enterprise Networks.	**8 Hours**
Module-4	**MANET and VPN**: Introduction, Application and challenges; Routing in Ad-hoc Networks - Types, Reactive (DSR & AODV) protocols, Proactive (DSDV & WRP) protocols; VPN - Features, Remote access, Site to site VPN & VPN Protocols; Security challenges in mobile computing.	**9 Hours**
Module-5	**Data Dissemination & Synchronization**: Communications asymmetry, Classification of data delivery mechanisms, Data dissemination; Introduction to Mobile OS - Android & iOS; 3-tier architecture for mobile computing, Design considerations and computing through Internet, IoT, Latest trends and research.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. Schiller, ***Mobile Communication***, 2nd *Ed.*, Pearson Education, 2008.

T2. Y. –B. Lin and I. Chlamtac, ***Wireless and Mobile Network Architectures***, 1st *Ed.*, John Wiley & Sons, 2008.

T3. R. Kamal, ***Mobile Computing***, 2nd *Ed.*, Oxford University Press, 2011.

Reference Books:

R1. U. Hansmann, L. Merk, M. Nicklous, and T. Stober, ***Principles of Mobile Computing***, 2nd *Ed.*, Springer, 2003.
R2. A. K. Talukder, H. Ahmed, and R. Yavagal, ***Mobile Computing***, 2nd *Ed.*, Tata McGraw Hill, 2010.

Online Resources:

1. https://nptel.ac.in/courses/106106147/: by Prof. P. Singh and Prof. S. Iyer, IIT Madras
2. https://nptel.ac.in/courses/117104099/: by Prof. A. K. Jagannatham, IIT Kanpur
3. https://nptel.ac.in/courses/106106167/: by Prof. D. K. Pillai, IIT Madras

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

CO1	Explain mobile computing concepts, MAC mechanisms, GSM/GPRS architecture and mobility.
CO2	Illustrate WLAN, Bluetooth protocols, WAP framework and IMT-2000 wireless standards.
CO3	Compare mobile IP and transport layer protocols with their features and performance.
CO4	Apply MANET routing strategies, demonstrate VPN technologies and evaluate security.
CO5	Analyze data dissemination, synchronization methods, mobile OS, IoT & latest trends.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems (WK1 to WK4).
PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

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

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

Category	Code	Embedded Systems	L-T-P	Credits	Marks
PEL	CS3026		3-0-0	3	100

Objectives	The objective of this course is to learn the features, applications, architecture and interfaces of Embedded Systems including ARM microcontroller, Realtime Operating Systems, Hardware-Software Co-simulation & Partitioning.
Pre-Requisites	Knowledge of computer architecture, programming languages, and operating systems is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples, case-studies and latest trends.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Fundamentals & Features of Embedded Systems, Applications, Characteristics, Architectures, Overview of Hardware & Software Units, Design Metrics, System Design Flow.	**7 Hours**
Module-2	**ARM Microcontroller**: Introduction & Structure of ARM, ARM Pipeline, Instruction Set Architecture (ISA), Registers, Data Processing, Data transfer & Multiplication Instructions, Software Interrupt, Conditional, Branch & Swap instructions, THUMB instructions.	**8 Hours**
Module-3	**Field Programmable Gate Arrays**: Field Programmable Devices, Programmability of FPGA, FPGA Logic Block Variations & FPGA Design Flow; Interfacing: SPI, IIC, RS-232C, RS-422, RS-485, USB, Physical interface, IrDA, CAN & Bluetooth.	**9 Hours**
Module-4	**Sensors and Actuators**: Introduction, Parameters & Classification of Sensors, Introduction & Classification of Actuators; Realtime Operating Systems: Types of Realtime Tasks, Task Periodicity, Task Scheduling; Classification of Scheduling Algorithms: Clock Driven, Table Driven, Cyclic, Event Driven, Foreground–background, RMA, EDF Schedulings, Resource Sharing, PIP, Commercial RTOS, General Purpose OS-RT Extensions, Windows CE, LynxOS, VxWorks & pSOS.	**10 Hours**
Module-5	**Specification Techniques**: Introduction, StateChart, SDL, Embedded System Modeling with Petri Nets, UML-Usecase, Class, Sequence & Activity diagrams; Hardware–Software Co-simulation: Co-simulation approaches, Typical Co-simulation environment, Abstract & Detailed-level Co-simulation; Hardware–Software Partitioning: Partitioning using Integer Programming, KL-Heuristic, GA, PSO for Hardware–Software partitioning.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Chattopadhyay, ***Embedded System Design***, 3rd *Ed.*, PHI Learning, 2023.

T2. F. Vahid and T. Givargis, ***Embedded Systems Design: A Unified Hardware/Software Introduction***, 1st *Student Ed.*, Wiley India, 2006.

T3. R. Mall, ***Real-Time Systems***, 2nd *Ed.*, Pearson Education, 2010.

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Reference Books:

R1. S. V. Iyer and P. Gupta, ***Embedded Realtime Systems Programming***, 1st *Ed.*, McGraw-Hill, 2017.
R2. P. Marwedel, ***Embedded System Design***, 1st *Ed.*, Springer, 2006.

Online Resources:

1. https://nptel.ac.in/courses/106105159: by Prof. A. Basu, IIT Kharagpur
2. https://nptel.ac.in/courses/108105057: by Prof. R. Mall, *et al.*, IIT Kharagpur
3. https://nptel.ac.in/courses/108102045: by Prof. S. Chaudhary, IIT Delhi
4. https://nptel.ac.in/courses/106105193: by Prof. I. Sengupta and Prof. K. Datta, IIT Kharagpur

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

CO1	Explain the Concepts, Architectures & Design flow of Embedded Systems.
CO2	Describe ARM Microcontroller, Instruction types & THUMB instructions.
CO3	Analyze Field Programmable devices & Interfacing types.
CO4	Explore Sensors, Actuators & Types of Realtime Operating Systems.
CO5	Apply Specification techniques, Hardware-Software Co-simulation & Partitioning.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Blockchain Technology	L-T-P	Credits	Marks
PEL	CS3027		3-0-0	3	100

Objectives	The objective of this course is to provide comprehensive understanding of the fundamental principles, architecture, cryptographic foundations, consensus mechanisms, smart contracts and real-world applications of Blockchain technology.
Pre-Requisites	Knowledge of computer systems, network, cryptography and security with programming language skill is required.
Teaching Scheme	Regular classroom lectures with use of whiteboard, power point slides, and animation with focus on real world case studies wherever applicable.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Distributed systems and decentralization concepts, Blockchain structure – blocks, chains, nodes, P2P networks, Types of blockchain – Public, Private, Consortium, Blockchain layers – network, consensus, application, Ethereum and Bitcoin overview.	**9 Hours**
Module-2	**Cryptographic Hash Functions**: SHA family, Applications, Merkle Trees and data verification, Digital signatures, ECDSA - Public key infrastructure (PKI), Wallets and address generation, Cryptographic security in blockchain systems.	**9 Hours**
Module-3	**Consensus Protocols**: The need for consensus in distributed systems, Proof of Work (PoW) – algorithm, mining, difficulty adjustment, Proof of Stake (PoS), DPoS, and other alternatives, Byzantine Fault Tolerance and PBFT, Nakamoto Consensus and game-theoretic security.	**8 Hours**
Module-4	**Smart Contract & Lifecycle**: Introduction to Solidity, Syntax and structure, Ethereum Virtual Machine (EVM) architecture, Comparison of platforms – Ethereum, Hyperledger Fabric, Corda, Private vs Public blockchain features.	**8 Hours**
Module-5	**Blockchain Use Cases**: Supply chain, Identity, Healthcare, Finance - Tokenization, NFTs, and Decentralized Finance (DeFi), Scalability solutions – Layer 1 vs Layer 2, sharding, rollups, Interoperability protocols – Polkadot, Cosmos, Zero-Knowledge Proofs and privacy enhancements, Blockchain with IoT, AI, and 5G, regulatory and legal landscape.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. I. Bashir, ***Mastering Blockchain***, 4th *Ed.*, Packt Publication, 2023.

Reference Books:

R1. A. M. Antonopoulos and D. A. Harding, ***Mastering Bitcoin Programming the Open Blockchain***, 3rd *Ed.*, O'Reilly Media, 2023.
R2. G. Zheng, L. Gao, L. Huang, and J. Guan, ***Ethereum Smart Contract Development in Solidity***, 1st *Ed.*, Springer, 2021.
R3. E. Elrom, ***The Blockchain Developer***, 1st *Ed.*, Apress Berkeley, 2019.
R4. D. Drescher, ***Blockchain Basics: A Non-Technical Introduction in 30 Steps***, 2nd *Ed.*,Apress Berkeley, 2026.

Online Resources:

1. https://nptel.ac.in/courses/106105184: by Prof. S. Chakraborty and P. Jayachandran, IIT Kharagpur
2. https://nptel.ac.in/courses/106104220: by Prof. S. Shukla, IIT Kanpur
3. https://docs.soliditylang.org/_/downloads/en/latest/pdf/
4. https://www.redbooks.ibm.com/abstracts/crse0401.html

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

CO1	Explain distributed system concepts, blockchain structure, types, layers and key platforms.
CO2	Apply cryptographic hashes, digital signatures and PKI for blockchain security.
CO3	Analyze consensus mechanisms like PoW, PoS and BFT to ensure trust in blockchain systems.
CO4	Understand smart contracts, Solidity, EVM, and blockchain platform features and differences.
CO5	Explore blockchain use cases, scalability, interoperability, and emerging 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).
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	1	1					2	2	2	2
CO2	3	3	3	2	2	1					2	3	2	2
CO3	3	2	2	3	2	1					3	3	2	2
CO4	2	1	3	3	3	1					3	3	2	3
CO5	2	2	3	3	3	3					3	3	2	3

Category	Code	Deep Learning	L-T-P	Credits	Marks
HNS	CS3029		3-0-1	4	100

Objectives	The aim of this course is to learn key deep learning techniques, architectures, training strategies, design, and optimization; encoder-decoder networks, and regularization for the real-world applications.
Pre-Requisites	Fundamental knowledge of machine learning and probability theory is required.
Teaching Scheme	Regular classroom lectures with the use of ICT as and when required; sessions are planned to be interactive with a focus on problem solving and applications.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Deep Networks**: Introduction, Evolution of deep neural networks, Mcculloch-Pitts Neuron, Thresholding logic, Perceptron learning algorithm, Learning XOR, Gradient descent, Activation functions; Deep Neural Networks – Forward & Back propagation, Parameters, Hyper-Parameters; Implementation of a feed forward neural network; Regularization for Deep Learning – Parameter norm penalties, Dataset augmentation, Noise robustness, Early stopping, Parameter tying and sharing, Dropout.	**13 Hours**
Module-2	**Optimization**: Optimization for training deep models – Learning vs. Optimization, Challenges in neural network optimization; Basic Algorithms – Stochastic Gradient Descent (SGD) and Nesterov Momentums, Implementation Of SGD; Parameter initialization strategies, Algorithms with Adaptive Learning Rates – Adaptive gradient algorithm (Adagrad), Root Mean Square Propagation (RMSProp), Adaptive Moment Estimation (Adam), Implementation of Adagrad, RMSProp and Adam; Hyper Parameters Tuning - Batch normalization.	**11 Hours**
Module-3	**Convolutional Neural Networks (CNNs)**: Foundation of CNNs – The Convolution operation; Convolution Ideas – Sparse interaction, Parameter sharing and equivalent representation, Pooling, Variants of basic convolution function, Transposed convolution, Implementation of CNN; Deep Convolutional Models – LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet.	**11 Hours**
Module-4	**Sequence Modelling & RNNs**: Sequence modeling, Recurrent networks, RNN and its implementation, Bidirectional RNN, Long-term dependency challenges, Vanishing & exploding gradients, Long Short-term Memory (LSTM) cells and its implementation, Gated Recurrent Units (GRU) and its implementation.	**11 Hours**
Module-5	**Advanced Architectures**: Encoder, Decoder, Auto Encoders. Training an auto-encoder for data compression and reconstruction, Applications of encoder-decoder models, Transfer Learning, Fine tuning and implementation, Image captioning, Textual entailment, Machine translation, Transliteration, Image question answering, Document summarization, Video captioning & classification.	**10 Hours**
	Total	**56 Hours**

Text Books:

T1. I. Goodfellow, Y. Bengio, and A. Courville, ***Deep Learning***, MIT Press, 2016.
T2. C. C. Aggarwal, ***Neural Networks and Deep Learning: A Textbook***, 2nd *Ed.*, Springer, 2023.
T3. K. P. Murphy, ***Probabilistic Machine Learning: Advanced Topics***, The MIT Press, 2023.

Reference Books:

R1. A. Geron, ***Hands-on Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems***, 2nd *Ed.*, O'Reilly Media, 2019.
R2. D. Barber, ***Bayesian Reasoning and Machine Learning***, 1st *Ed.*, Cambridge University Press, 2012.
R3. M. A. Nielsen, ***Neural Networks and Deep Learning***, 1st *Ed.*, Determination Press, 2015.

Online Resources:

1. https://nptel.ac.in/courses/106106184: by Prof. S. Iyengar, IIT Roper
2. https://nptel.ac.in/courses/108103192: by Prof. M. K. Bhuyan, IIT Guwahati

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

CO1	Describe deep FFNN, back propagation, and regularization techniques.
CO2	Implement optimization techniques for training robust and efficient deep models.
CO3	Explore CNN foundations, convolution, pooling, and deep CNN architectures like ResNet.
CO4	Analyze sequence modeling using RNN, BiRNN, LSTM, and GRU.
CO5	Apply encoder–decoder architectures and their applications in advanced real-world tasks.

Program Outcomes Relevant to the Course:

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

P.T.O

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

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

Category	Code	VLSI Fabrication Technology	L-T-P	Credits	Marks
MNR	EC3033		3-1-0	4	100

Objectives	The objective of this course is to learn the fabrication flow and chip integration process of semiconductor devices and semiconductor integrated circuits in VLSI.
Pre-Requisites	Basic knowledge of semiconductor devices such as NMOS, PMOS, CMOS, BJT and digital VLSI design is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Moore's Law and material processing, Defects in crystals, Eutectic phase diagram, Solid solubility, Homogeneous nucleation, Heterogeneous nucleation; Growth Processes - Crystal Growth – Necking and dislocation free CZ crystal growth, Segregation of impurities along length and diameter, Defects in CZ crystals, FZ Crystal growth; Epitaxy - Vapor phase epitaxy, LPE, MBE, CVD deposition of poly-silicon, SILOX process.	**12 Hours**
Module-2	**Diffusion**: Constant and limited source diffusion, Concentration dependent diffusion, Field assisted diffusion, Junction depth, Diffusion sources; **Ion Implantation**: Basic process, Ion implantation systems, Ion penetration and profile, Ion implantation damage.	**10 Hours**
Module-3	**Annealing Oxidation**: Purpose, Dry and wet oxidation, Deal-Grove model, Oxidation system, Properties of oxides – Masking and charges in oxides; Deposition processes - Fundamentals of vacuum systems, Vacuum evaporation of thin films, DC and RF sputtering of thin films, Interconnects, Contacts and dielectrics in IC fabrication, Deposition of silicon nitride.	**12 Hours**
Module-4	**Lithography**: Pattern generation and mask making, Optical lithography – Contact, Proximity and projection printing, Photoresists – Negative, Positive, Lift-off process, Electron beam and X-ray lithographic techniques. Etching - Wet etching, Isotropic and anisotropic etching, Plasma etching, Reactive ion beam etching.	**12 Hours**
Module-5	**IC Process Integration**: Bipolar transistor fabrication, Isolation techniques, P-MOS, N-MOS and C-MOS processes.	**10 Hours**
	Total	**56 Hours**

Text Books:

T1. S. M. Sze, ***VLSI Technology***, 2nd *Ed.*, Tata McGraw Hill, 2003.
T2. S. K. Gandhi, ***VLSI Fabrication Principles: Silicon and Gallium Arsenide***, 2nd *Ed.*, Wiley India, 1994.

Reference Books:

R1. J. Plummer, M. Deal, and P. Griffin, ***Silicon VLSI Technology: Fundamentals, Practice, and Modeling***, Prentice Hall, 2000.
R2. M. J. Madou, ***Fundamentals of Micro Fabrication: The Science of Miniaturization***, 2nd *Ed.*, CRC Press, 2002.
R3. S. Mahajan, ***Principles of Growth and Processing of Semiconductors***, McGraw-Hill Education, 1999.

R4. S. A. Campbell, ***The Science & Engineering of Microelectronics Fabrication***, 2nd *Ed.*, Oxford University Press, 2001.

Online Resources:

1. https://nptel.ac.in/courses/108101089: by Prof. A. N. Chandorkar, IIT Bombay
2. https://nptel.ac.in/courses/113106062: by Prof. P. Swaminathan, IIT Madras
3. https://nptel.ac.in/courses/103106075: by Dr. S. Ramanathan, IIT Madras
4. https://nptel.ac.in/courses/117106093: by Dr. N. Dasgupta, IIT Madras
5. https://ocw.mit.edu/courses/6-780-semiconductor-manufacturing-spring-2003/

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

CO1	Explain fundamental concepts of IC fabrication including crystal growth, epitaxy and deposition.
CO2	Describe diffusion and ion implantation techniques and their role in IC fabrication processes.
CO3	Explain annealing oxidation and various material deposition techniques used in IC fabrication.
CO4	Analyze and explain lithography techniques and various etching processes in IC fabrication.
CO5	Analyze and explain the integration of bipolar, MOS and CMOS processes in IC fabrication.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Embedded Systems & Microcontrollers	L-T-P	Credits	Marks
MNR	EC3035		3-1-0	4	100

Objectives	The objective of this course is to provide a fundamental understanding of embedded systems and their design principles along with programming and interfacing with 8051 and ARM controllers to develop embedded systems.
Pre-Requisites	Knowledge of digital electronics, computer organization, and programming is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on design and programming activities.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Embedded Systems**: Introduction, Embedded Systems vs General-Purpose Computing Systems, History, Classification, Applications and Domain Areas, Purpose, Wearable Devices, Embedded Technologies & Lifestyle, Core Components (Microprocessors, Microcontrollers, DSPs, ASICs, FPGAs), Memory (RAM, ROM, types, testing), Sensors and Actuators, Communication Interface (Serial, Parallel, Network, Wireless), Embedded Firmware, Other System Components (Timers, Watchdog Timers, Power Supply), PCB and Passive Components.	**11 Hours**
Module-2	**Embedded Architectures & Design**: Characteristics of Embedded Systems, Quality Attributes of Embedded Systems, Application-Specific Embedded System, Domain-Specific Examples of Embedded System, Designing Embedded System with Microcontrollers, Factors to be Considered in Selecting a Controller, FPGA and other Architectures.	**10 Hours**
Module-3	**8051 Architecture & Programming**: Performance Metrics, Comparison of Microprocessors and Microcontrollers, 8051 Microcontroller - Intel MCS-51 family features, 8051 Organization and Architecture, Registers, Addressing Modes, Instruction Set, Conditional Instructions.	**12 Hours**
Module-4	**ARM Architecture & Programming**: ARM and Microcontrollers, The ARM Family, ARM Architecture and Assembly Language Programming, General Purpose Registers, ARM Memory Map, Load and Store Instructions, ARM CPSR (Current Program Status Register), ARM Data Format and Directives, ARM Assembly Programming, Assembling an ARM Program, Program Counter and Program ROM Space, ARM Addressing Modes, RISC Architecture in ARM.	**12 Hours**
Module-5	**Advanced ARM Programming**: Arithmetic & Logic Instructions, Branch, Call and Looping, Memory Access and Stack, ARM Pipeline and CPU Evolution, Other CPU Enhancements, Design Case Studies, Embedded System Trends and Careers.	**11 Hours**
	Total	**56 Hours**

Text Books:

T1. S. Chattopadhayay, ***Embedded Systems Design***, 3rd *Ed.*, PHI Learning, 2023.
T2. K. V. Shibu, ***Introduction to Embedded Systems***, 2nd *Ed.*, Tata McGraw-Hill, 2017.

T3. R. Kamal, ***Embedded Systems – Architecture, Programming and Design***, 12th *Ed.*, McGraw-Hill, 2007.
T4. M. A. Mazidi *et al.*, ***ARM Assembly Language Programming & Architecture***, 2nd *Ed.*, Microdigitaled.com, 2016.

Reference Books:

R1. D. E. Simon, ***An Embedded Software Primer***, 1st *Ed.*, Addison Wesley, 1999.
R2. J. Ganssle, ***The Art of Designing Embedded Systems***, 2nd *Ed.*, Elsevier, 2008.
R3. K. Short, ***Embedded Microprocessor System Design***, 1st *Ed.*, Prentice Hall, 1998.
R4. C. Baron, J. Geffroy, and G. Motet (Eds), ***Embedded System Applications***, Springer, 1997.
R5. D. Gajski, ***Embedded System Design: Modeling, Synthesis and Verification***, Springer, 2009.

Online Resources:

1. https://nptel.ac.in/courses/117105234: by Prof. S. Chattopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/108106176: by Prof. L. S. Jayashree , IIT Madras

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

CO1	Describe embedded systems, their classification, core components, interfaces, and applications
CO2	Explain embedded system design principles, quality attributes, and controller/FPGA selection.
CO3	Explain microcontrollers and the 8051 architecture, instruction set, and programming concepts.
CO4	Realize ARM architecture and develop basic assembly programs using RISC principles.
CO5	Apply advanced ARM features to analyze system design and understand industry trends.

Program Outcomes Relevant to the Course:

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

P.T.O

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

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

Category	Code	Basics of Power Systems	L-T-P	Credits	Marks
MNR	EE3022		3-1-0	4	100

Objectives	The objective of this course is to study different aspects of power systems, the complete path of electrical energy from generation up to the consumers, and various components used in operation & control of modern power systems.
Pre-Requisites	Knowledge of Basic Electrical Engineering is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on real world examples and case studies.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Generation of Electrical Energy**: Basics of electrical generation sources - Thermal, Hydro, Nuclear; Layout, Basic components, Advantages & Disadvantages; **Renewable Energy**: Wind, Solar; Layout, Basic components; Grid connected renewable sources, operational issues.	**11 Hours**
Module-2	**Transmission Lines**: Components of transmission lines - Conductors & Supporting structures, Insulators, Air gaps, Shielding; DC & AC transmission lines, Comparison, Underground cables, Design Parameters, Benefits of high-voltage transmission; **Substation Equipment**: Transformers, Regulators, Circuit breakers, Isolators, Their relationship to system protection, Maintenance & System control; Digital substation equipment for modernization and Reliability.	**11 Hours**
Module-3	**Distribution System**: Primary & Secondary, Overhead & Underground, Consumers - Residential, Commercial, Industrial; Voltage classifications, Common equipment; Modernization & Automation, Intelligent Electronic Devices, Outage management, Customer information systems; **Consumption**: Wiring to the consumer's load, Emergency generators, Uninterruptible Power Supply (UPS), Systems to enhance reliable power service and Their operating issues, Smart meters, Service reliability indicators, Common problems and Solutions for large power consumers.	**12 Hours**
Module-4	**System Protection**: System vs. Personal protection, Protection against equipment failures, Faults on power lines, Lightning strikes, Inadvertent operations, Causes of system disturbances, Protective relays, Protection against faults, Lightning strikes, Minimization of system disturbances; Personal protection and Safe working procedures in & around high-voltage power systems; Common safety procedures & methods; Equipotential grounding, Ground potential rise, Touch potential, Step potential; Precautions around high-voltage power lines, Substations and around home.	**12 Hours**
Module-5	**Interconnected Power Systems**: Concept of Interconnection, Hierarchical Grid arrangements, Cascade Tripping, Islanding, Load dispatch center, use of SCADA (Supervisory Control and Data Acquisition) and EMS (Energy Management Systems) for reliable operation of large power systems.	**10 Hours**
	Total	**56 Hours**

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	E-Commerce & Supply Chain Management	L-T-P	Credits	Marks
MNR	MG3004		3-1-0	4	100

Objectives	The objective of this course is to enable students to understand e-commerce systems & supply chain operations and apply analytical, data-driven approaches for product validation, customer acquisition, and scalable e-commerce growth.
Pre-Requisites	Basic understanding of internet technologies, databases, and introductory concepts of management and operations. Familiarity with data analysis fundamentals and web-based applications will be beneficial.
Teaching Scheme	Regular classroom lectures with the use of ICT tools as and when required; sessions emphasize interactive discussions, real-world case studies, and practical application of e-commerce and supply chain concepts.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**E-Commerce Foundations & Industry Roles**: Overview of digital commerce, Traditional and emerging e-commerce roles - Hiring trends, Skill requirements, Hybrid technical–business skill development, Website traffic acquisition, Payment gateways, Loyalty management, Customer retention; E-commerce marketplaces and quick commerce models: D2C, B2B, Supply Chain Management (SCM), Business development, Unit economics, Profitability drivers, Merchandising strategies, ROAS basics, Customer feedback analysis using NPS and loyalty metrics.	**12 Hours**
Module-2	**D2C Channels & Operations**: Genesis and evolution of D2C channels, D2C manufacturing, Fulfillment, Delivery optimization, Brand loyalty and customer intimacy, Case studies of D2C brands, White space identification, product opportunity analysis, Product design aligned to brand positioning, Accelerated product development and time-to-market, Early-stage D2C growth, Scaling, ROAS optimization, Channel mix strategies.	**11 Hours**
Module-3	**Product–Market Fit (PMF) & Minimum Viable Product (MVP)**: PMF and MVP concepts, PMF discovery and optimization, MVP-based pricing to reduce cost and risk, Customer acquisition, Iterative testing frameworks, Feature prioritization, Competitive positioning, Market research for validation, Customer feedback loops, Faster time-to-market through streamlined development processes.	**10 Hours**
Module-4	**Scaling & Performance Marketing**: Scaling from zero to one; Marketplace vs. owned-website strategy; Channel mix decisions across product categories; Spend management & attribution models; ROAS optimization techniques; Commerce media and retail advertising ecosystems; Vertical and B2B marketplaces; Data-driven scaling decisions.	**11 Hours**

Cont'd. . .

Module-#	Topics	Hours
Module-5	**Customer Acquisition & Growth Management**: Early-stage customer acquisition, Organic vs Paid growth, Scaling E-commerce operations from startup to large scale, Growth scaling through operational excellence and process optimization, Quality maintenance during growth, Customer feedback management, Bottlenecks and risk mitigations, SCM and fulfilment scaling, Operational challenges, Ethical, Legal, and Sustainability aspects of E-commerce growth.	**12 Hours**
	Total	**56 Hours**

Text Books:

T1. K. C. Laudon and C. G. Traver, ***E-Commerce: Business, Technology, Society***, 17th *Ed.*, Pearson Education, 2023.
T2. M. H. Hugos, ***Essentials of Supply Chain Management***, 4th *Ed.*, Wiley India, 2018.
T3. S. Chopra and P. Meindl, ***Supply Chain Management: Strategy, Planning, and Operation***, 7th *Ed.*, Pearson Education, 2021.

Reference Books:

R1. Harvard Business Review, ***HBR's 10 Must Reads on Platforms and Ecosystems***, 1st *Ed.*, Harvard Business Review Press, 2021.
R2. J. B. Ayers and M. A. Odegaard, ***Retail Supply Chain Management***, 2nd *Ed.*, McGraw-Hill Education, 2019.
R3. M. Christopher, ***Logistics and Supply Chain Management***, 6th *Ed.*, Pearson Education, 2016.

Online Resources:

1. https://nptel.ac.in/courses/110106045: By Prof. G. Srinivasan, IIT Madras
2. https://nptel.ac.in/courses/110108056: By Prof. N. Viswanadham, IISc Bangalore
3. https://nptel.ac.in/courses/110105083: Prof. M. Jenamani, IIT Kharagpur
4. https://www.hubspot.com/resources/courses/ecommerce
5. https://www.futurelearn.com/courses/digital-transformation-e-commerce

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

CO1	Explain e-commerce systems, business models, industry roles, and core operational metrics.
CO2	Analyze D2C channel architectures, operational workflows, and data-driven design decisions.
CO3	Apply PMF and MVP validation frameworks using analytical and feedback-based methods.
CO4	Evaluate scaling, channel selection, and performance optimization using ROAS and analytics.
CO5	Analyze customer acquisition, growth control, and supply chain scaling in e-commerce systems.

Program Outcomes Relevant to the Course:

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

Cont'd...

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

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

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

Category	Code	Business Statistics & Predictive Modelling	L-T-P	Credits	Marks
MNR	MG3002		3-1-0	4	100

Objectives	The aim of this course is to learn the statistical and analytical skills required to interpret business data and make data-driven decisions applying statistical models and predictive techniques.
Pre-Requisites	Knowledge of mathematics, statistics and worksheet operations, and Python programming is required.
Teaching Scheme	Regular classroom lectures, power point presentations with use of ICT as required, with examples, real-life case studies, assignments and projects.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Foundations of Business Statistics**: Descriptive statistics, data types, data visualization, central tendency and dispersion, probability distributions (normal, binomial, Poisson), sampling and sampling distributions. Use of Excel or Python (Pandas, NumPy) to compute mean, variance, skewness, and kurtosis. visualize frequency distributions.	**10 Hours**
Module-2	**Hypothesis Testing & Confidence Intervals**: Null and alternative hypotheses, Type I & II errors, one & two-tailed tests, t-test, z-test, chi-square test, ANOVA and confidence intervals for mean and proportion. Hypothesis testing on sample datasets (sales performance, A/B testing).	**9 Hours**
Module-3	**Regression Analysis**: Simple and multiple linear regression, correlation, multicollinearity, model fit (R^2, adjusted R^2), residual analysis, logistic regression for classification problems; Building regression models for revenue forecasting or demand estimation; Applying logistic regression for churn prediction using Python statsmodels and scikit-learn.	**10 Hours**
Module-4	**Time Series Forecasting**: Components of time series (trend, seasonality, irregularity), moving averages, exponential smoothing, ARIMA models and model evaluation metrics (RMSE, MAPE); Forecasting monthly sales or price trends using spreadsheets or Python (statsmodels ARIMA); Visualizing trends and residual patterns.	**9 Hours**
Module-5	**Clustering & Classification**: Unsupervised learning concepts, K-means clustering, hierarchical clustering, decision trees, random forests and model evaluation (confusion matrix, ROC curve, AUC); Customer segmentation using K-means; Credit risk classification using decision trees.	**9 Hours**
Module-6	**Predictive Analytics**: Integrating statistical and predictive models, business problem formulation, model interpretation and communication of results; Case studies - Churn prediction, inventory management, sales forecasting and credit scoring; End-to-end mini project combining regression, classification and forecasting.	**9 Hours**
	Total	**56 Hours**

P.T.O

Text Books:

T1. J. Rogel-Salazar, ***Data Science and Analytics with Python***, 1st *Ed.*, CRC Press, 2017.
T2. W. McKinney, ***Python for Data Analysis***, 3rd *Ed.*, O'Reilly Media, 2022.

Reference Books:

R1. G. James, D. Witten, T. Hastie, and R. Tibshirani, ***An Introduction to Statistical Learning with Applications in Python***, Springer, 2021.
R2. D. R. Anderson, D. J. Sweeney, T. A. Williams, *et al.*, ***Statistics for Business and Economics***, Cengage Learning, 2020.
R3. S. C. Albright and W. L. Winston, ***Business Analytics: Data Analysis and Decision Making***, Cengage Learning, 2023.

Online Resources:

1. https://nptel.ac.in/courses/111106164: by Prof. S. Das, CMI
2. https://nptel.ac.in/courses/110107129: by Prof. G. Dixit, IIT Roorkee
3. https://nptel.ac.in/courses/106107220: By Prof. A. Ramesh, IIT Roorkee
4. https://nptel.ac.in/courses/106106361: by Prof. S. K. Mathew, IIT Madras

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

CO1	Describe and summarize business data using descriptive statistics and visual tools.
CO2	Apply hypothesis testing and confidence intervals to draw inferences from data.
CO3	Develop and interpret regression and logistic regression models for prediction.
CO4	Build and evaluate time series forecasting models for business applications.
CO5	Apply clustering and classification models to segment and predict business outcomes.
CO6	Integrate statistical and predictive methods for end-to-end business analytics solutions.

Program Outcomes Relevant to the Course:

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

P.T.O

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

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

Category	Code	Internet of Things Lab	L-T-P	Credits	Marks
PCR	CS3011		0-0-2	1	100

Objectives	The objective of this laboratory course is to provide practical exposure to interfacing sensors & actuators with IoT controllers, learn UART, I2C, SPI & MQTT protocols and apply them in diverse domains.
Pre-Requisites	Basic knowledge of digital electronics and programming is required.
Teaching Scheme	Regular Laboratory classes with the use of ICT whenever required; experiments shall comprise of developing end-to-end IoT systems for specific applications.

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	Installation and configuration of Raspberry Pi, blinking LED program, creating different LED patterns using loops and functions.
2	Interfacing Sensors & Actuators: Digital I/O.
3	Interfacing Sensors & Actuators: Analog I/O.
4	Interfacing Sensors & Actuators: DHT11 and LCD/OLED.
5	Protocol: UART.
6	Protocol: I2C.
7	Protocol: SPI.
8	Protocol: MQTT, Connect to cloud server and create an IoT solution.
9	Protocol: LoRa.
10	Project: Healthcare (Pulse rate monitoring).
11	Project: Environment (Ambient air quality monitoring).
12	Project: Agriculture (Soil quality monitoring).
13	Project: Energy (Energy monitoring System).
14	Project: Smart Home (appliances control and security system).

Text Books:

T1. S. Monk, ***Raspberry Pi Cookbook***, 3rd *Ed.*, O'Reilly Media, 2019.
T2. A. Bahga and V. Madisetti, ***Internet of Things: A Hands-on-Approach***, University Press, 2014.

Reference Books:

R1. M. Margolis, B. Jepson, and N. R. Weldin, ***Arduino Cookbook***, 3rd *Ed.*, O'Reilly Media, 2020.
R2. A. Kurniawan, ***Internet of Things Projects with ESP32***, Packt Publishing, 2019.

Online Resources:

1. https://nptel.ac.in/courses/106105166: by Prof. S. Misra, IIT Kharagpur
2. https://www.instructables.com/Raspberry-Pi-Class/
3. https://www.raspberrypi.org/learn/
4. http://esp32.net/#Info

P.T.O

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

CO1	Setup and configure Raspberry Pi and create basic programs for LED patterns.
CO2	Interface digital/analog sensors to read data from the physical world and control actuators.
CO3	Explore and utilize various communication protocols for specific applications.
CO4	Control GPIO outputs using a web interface.
CO5	Design and develop IoT-based solutions for diverse domain or verticals.

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

Category	Code	Soft Computing Lab	L-T-P	Credits	Marks
PCR	CS3012		0-0-2	1	100

Objectives	The objective of this course is to get hands on experience on key soft computing algorithms using Python programming applied on real life problems.
Pre-Requisites	Knowledge of python programming & concepts of soft computing algorithms taught in the theory classes 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	Write functions to generate parameterized fuzzy membership functions, visualize them for following parameter values: Triangular, Trapezoidal, Gaussian, Generalized Bell & Sigmoidal MFs.
2	Write functions for fuzzy complement operations on continuous membership functions, visualize for following parameter values: Classical, Sugano's & Yager's fuzzy complements.
3	Write functions to implement fuzzy intersection operations (T-norms) on continuous membership functions, visualize them for following parameter values: Minimum, Algebraic, Bounded & Drastic products.
4	Write a function to compute the max-min, max-product & max-average composition of two fuzzy relations & demonstrate the effect of contrast intensification on fuzzy membership function.
5	Write functions for implementing cylindrical extension of a 1D membership function & projection of a 2D membership function. Demonstrate the results visually.
6	Write programs to implement selection, crossover & mutation operations.
7	Write program to solve unconstrained optimization problems using GA.
8	Write programs to solve optimization problems with constraint satisfaction using GA.
9	Implement McCulloch Pitts Neural network for AND, OR & NAND gates.
10	Plot the graphs of different activation functions & implement Adaline for OR gate.
11	Implement AND, OR & XOR Gates using Single Layer Perceptron Neural Network, Madaline for XOR gate.
12	Design a classifier using Multilayer Back propagation Neural Network to classify Iris data.

Text Books:

T1. D. K. Pratihar, ***Soft Computing***, Revised Edition, Narosa Publishing, 2015.

T2. J. S. R. Jang, C. T. Sun, and E. Mizutani, ***Neuro Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence***, 1st *Ed.*, Pearson Education, 2015.

Reference Books:

R1. T. J. Ross, ***Fuzzy Logic with Engineering Applications***, 3rd *Ed.*, Wiley, 2010.

R2. D. E. Goldberg, ***Genetic Algorithms In Search, Optimization and Machine Learning***, 1st *Ed.*, Pearson Education, 2002.
R3. S. Haykin, ***Neural Networks: A Comprehensive Foundation***, 2nd *Ed.*, Pearson Education, 2006.

Online Resources:

1. https://nptel.ac.in/courses/111105614/: by Prof. S. Kundu, IIT-ISM Dhanbad
2. https://nptel.ac.in/courses/117105084/: by Prof. S. Sengupta, IIT Kharagpur
3. https://nptel.ac.in/courses/127105006/: by Prof. D. K. Pratihar, IIT Kharagpur
4. https://cse.iitkgp.ac.in/~dsamanta/courses/sca/index.html#resources

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

CO1	Understand the concepts of fuzzy logic, implement fuzzy membership functions & operations.
CO2	Apply fuzzy relations & transformations in practical systems.
CO3	Implement genetic algorithms for optimization problems with and without constraints.
CO4	Implement single & multi layer neural networks for basic logic operations & classification.
CO5	Design & evaluate a multilayer neural network classifier using real-world datasets.

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

Category	Code	Emerging Technologies Lab	L-T-P	Credits	Marks
SEC	IP3001		0-0-4	2	100

Objectives	The objective of this laboratory course is to provide practical exposure to emerging technologies in building modern enterprise level rich interactive web application development using various latest frameworks, languages and databases.
Pre-Requisites	Knowledge of programming, basic concepts of internet technology, database design and query languages is required.
Teaching Scheme	Regular laboratory classes conducted under supervision of the teacher. The experiments shall comprise of programming assignments involving different platforms and technologies.

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	Review of HTML-Basic tags, lists, tables, form, div and span.
2	CSS and Bootstrap – Use of CSS3, CDN and Bootstrap 5.
3	JS – ES6 Features, Functions, Arrow Function and Callback Function.
4	JS – Array and higher-order array methods.
5	JS - Asynchronous JS, Class and Object.
6-7	JSON, JSON Server, AXIOS, RESTAPI, HTTP Methods and Status Code.
8	Node.js – NPM, Path Module, File System,OS Module and URL Module.
9	Node.js - HTTP Module, Create Server using Node.js Render HTML pages.
10	Express.js – Installation, setup, creating routes and rendering HTML and static files.
11	Express.js - Build REST API using express and middleware.
12	MongoDB–BSON, NoSQL Database and MongoDB Queries.
13	Installation of Mongoose for NodeJS, Connect Express with MongoDB, Fetching data and display it to the users.
14	Define routes and perform CRUD operations.
15-16	API Authentication and Middleware.
17	React.js – Introduction to React.js, Hello World in React, JSX and Rendering Elements.
18	React.js - Components, props, functional & class-based components, conditional rendering.
19	React.js – Event handling and Lifecycle Methods.
20-22	React.js–Hooks, Router and Form Handling.
23	React.js – Project using React.js, AXIOS and JSON Server.
24–26	Build End-to-End application with MongoDB, Express.js, React.js and Node.js.
27-28	Demonstration of the working project, presentation, and viva-voce.

Text Books:

T1. G. Lim, ***Beginning MERN Stack: Build and Deploy a Full Stack MongoDB, Express, React, Node.js App***, 1st *Ed.*, Independently Published, 2020.

T2. E. Brown, ***Web Development with Node and Express***, 2nd *Ed.*, O'Reilly Media, 2019.

Reference Books:

R1. D. Crockford, ***JavaScript: The Good Parts***, 1st *Ed.*, Yahoo Press, 2008.
R2. S. Bradshaw, E. Brazil, and K. Chodorow, ***MongoDB: Powerful and Scalable Data Storage***, 3rd *Ed.*, O'Reilly Media, 2019.

Online Resources:

1. https://developer.mozilla.org/en-US/docs/Web/JavaScript
2. https://nodejs.org/en/docs/
3. https://expressjs.com/
4. https://docs.mongodb.com/manual/tutorial/query-documents/
5. https://www.mongodb.com/developer/quickstart/node-crud-tutorial/
6. https://react.dev/learn

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

CO1	Develop Server-Side Applications with Node.js and Express.js.
CO2	Integrate and Manage Data with MongoDB & Mongoose.
CO3	Build and Deploy REST APIs with Authentication and Middleware.
CO4	Design Dynamic Front-End Interfaces with React.js and API Integration.
CO5	Implement a Full-Stack MERN Application with Secure Authentication.

Program Outcomes Relevant to the Course:

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

P.T.O

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

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

Category	Code	Technical & Research Writing	L-T-P	Credits	Marks
SEC	HS3002		0-0-2	1	100

Objectives	The objective of this course is to hone the professional writing skills of the learners, especially pertaining to technical reports, proposals and research writing.
Pre-Requisites	Knowledge of Technical Communication in English is required.
Teaching Scheme	Regular laboratory classes with tasks designed to facilitate communication through pair and/or team activities with regular assessment of writing activities.

Evaluation Scheme

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

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Introduction to technical writing
2	Reports: importance, types, report language
3	Writing an informational report: parts, format
4	Writing an analytical report: parts, executive summary
5	Proposals: importance, format, writing a short proposal.
6	Writing proposal for grants: format
7	What is research? Elements of academic research writing.
8	Ethics in research.
9	Review of Literature.
10	Writing an abstract.
11	Writing a research article - I.
12	Writing a research article - II.
13	Preparing works cited list as per MLA/APA format.
14	Dealing with plagiarism: paraphrasing.

Text Books:

T1. K. Samantray, ***Academic and Research Writing***, 1st *Ed.*, Orient Black Swan, 2011.
T2. R. Chaturvedi, S. Pandey, and P. K. Pandey, ***Research Methodology & Scientific Writing***, 1st *Ed.*, Book Rivers, 2023.
T3. Modern Language Association of America, ***MLA Handbook***, 9th *Ed.*, MLA, 2021.
T4. American Psychological Association, ***Publication Manual of the American Psychological Association***, 7th *Ed.*, APA, 2019.

Reference Books:

R1. W. Zinsser, ***On Writing Well: The Classic Guide to Writing Nonfiction***, 1st *Ed.*, Harper Perennial, 2020.
R2. W. Strunk Jr., ***The Elements of Style***, 1st *Ed.*, Fingerprint Publishing, 2020.

Online Resources:

1. https://nptel.ac.in/courses/110105091: Prof. A. Malik, IIT Kharagpur
2. https://library.leeds.ac.uk/info/14011/writing/114/report-writing
3. https://www.anu.edu.au/students/academic-skills/research-writing

4. https://initiatives.iitgn.ac.in/scientificwriting/thesis-dissertation-writing/
5. https://www.babson.edu/media/babson/assets/teaching-research/writing-a-successful-proposal.pdf

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

CO1	Develop analytical and informational reports with proper structure, tone and language.
CO2	Compose executive summaries, proposals and abstracts for technical or research work.
CO3	Apply citation styles, paraphrasing and ethical writing practices to avoid plagiarism.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Applied Linear Algebra	L-T-P	Credits	Marks
OEL	MT4001		3-0-0	3	100

Objectives	The objective of this course is to learn how to handle computation with matrices, difference equation, and similarity transformation for key engineering applications.
Pre-Requisites	Knowledge of complex numbers, matrix algebra, and vector space is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Geometry of Linear Equations, Gauss Elimination, Concept of Matrices with Applications, Vector Spaces and Subspaces, Echelon Form, Solution in Matrix Method, L.I, Basis & Dimension, Four Fundamental Subspaces, Linear Transformations.	**9 Hours**
Module-2	Orthogonal Vectors and Subspaces, Cosines and Projections on to Lines, Projections and Least Squares, Orthogonal Bases and Gram-Schmidt Process.	**8 Hours**
Module-3	Introduction and Properties of Determinants, Formulas for Determinant, Applications of Determinants, Introduction to Eigen values & Eigenvectors, Diagonalization of Matrix, Difference Equations, Complex Matrices, Similarity Transformations.	**8 Hours**
Module-4	Maxima, Minima and Saddle Points, Tests for Positive Definiteness, Singular Value Decomposition, Minimum Principles.	**8 Hours**
Module-5	Introduction to Computations with Matrices, Matrix Norm and Condition Number, Computation of Eigen values, Iterative Methods.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. G. Strang, ***Linear Algebra and Its Applications***, 4th *Ed.*, Cengage Learning, 2007.

Reference Books:

R1. G. Strang, ***Introduction to Linear Algebra***, 3rd *Ed.*, Wellesley-Cambridge, 2003.

Online Resources:

1. https://nptel.ac.in/courses/108101371: by Prof. D. Mukherjee, IIT Bombay
2. https://nptel.ac.in/courses/111101115: by Prof. I. K. Rana, IIT Bombay
3. https://nptel.ac.in/courses/111106135: by Prof. P. Haridas, IIT Madras
4. https://nptel.ac.in/courses/111107106: by Prof. P.N. Agrawal, IIT Roorkee
5. https://nptel.ac.in/courses/111107164: by Prof. P. Bera, IIT Roorkee
6. https://nptel.ac.in/courses/111105165: by Prof. S. Khare, IIT Kharagpur

P.T.O

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

CO1	Explain and apply matrix methods for solving a system of linear equations.
CO2	Describe orthogonal & projection in vector space and apply it to least square solution.
CO3	Identify and apply Eigen values and Eigen vectors to diagonalization.
CO4	Explain and apply Singular Value Decomposition and to obtain pseudo inverse of a matrix.
CO5	Develop algorithms and write programs to solve linear algebra problems on computers.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Stochastic Processes	L-T-P	Credits	Marks
OEL	MT4002		3-0-0	3	100

Objectives	The objectives of this course is to gain mathematical maturity by equipping the students to handle computing probability in different conditions and studying the concepts of Markov chain & Queuing theory.
Pre-Requisites	Knowledge of Sets, Probability, and Linear Algebra is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Review of basics of Probability - Probability of an event, Conditional probability, Independent event and Bayes' formula, Random variables, Discrete and Continuous, Distribution functions, Joint distribution & independent random variables, Expectation, Variance and covariance, Variance of a sum, Conditional distribution & conditional expectation (discrete case), Conditional distribution & conditional expectation (continuous case), Computing expectation & variance by conditioning, Computing probabilities by conditioning.	**8 Hours**
Module-2	Stochastic Processes and Markov Chain - Introduction and definition, Chapman-Kolmogorov equations, Classification of states, Limiting probabilities, Some application problems, Mean time spent in transient state, Branching processes, Time reversible Markov chains.	**11 Hours**
Module-3	Markov decision process, Hidden Markov chain, Exponential distribution and its properties, Counting process & definition of Poisson process, Inter arrival & waiting time distribution, Further properties of Poisson process, Non-homogeneous Poisson process.	**8 Hours**
Module-4	Continuous-time Markov chain, Birth & death process, The transition probability function, Limiting probabilities, Time reversibility, Computing the transition probabilities.	**7 Hours**
Module-5	Terms & notations in Queuing Theory, Steady state probabilities, A single server exponential queuing system (M/M/1), M/M/1 system with finite capacity, An application problem, The system M/G/1, Multiserver queues.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. M. Ross, ***Introduction to Probability Models***, 10th *Ed.*, Academic Press, 2009.

Reference Books:

R1. J. Medhi, ***Stochastic Processes***, 4th *Ed.*, New Age International, 2019.

P.T.O

Online Resources:

1. https://nptel.ac.in/courses/110101141: by Prof. M. Hanawal, IIT Bombay
2. https://nptel.ac.in/courses/111105901: by Prof. S. R. Khare, Prof. A. J. Budkuley, IIT Kharagpur
3. https://nptel.ac.in/courses/111104089: by Prof. J. Dutta, IIT Kanpur
4. https://nptel.ac.in/courses/103101354: by Prof. Y. S. Mayya, IIT Bombay

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

CO1	Apply probability models to real life engineering problems.
CO2	Explain Markov chain and classification of states.
CO3	Solve problems using the concepts of hidden Markov chain and Poisson process.
CO4	Apply Markov chain in problems of different field of engineering.
CO5	Apply Queuing theory in engineering and daily life situations.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Numerical Optimization	L-T-P	Credits	Marks
OEL	MT4003		3-0-0	3	100

Objectives	The objective of this course is to learn how to handle the linear and nonlinear problems of optimization in different fields of engineering.
Pre-Requisites	Knowledge of coordinate geometry, calculus and matrix algebra is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Linear Programming: Graphical Method, Simplex Method, Methods of Artificial Variables, Alternate Optima, Redundancy & Degeneracy.	**8 Hours**
Module-2	Mathematics of Simplex Method (without proof), the Revised Simplex Method, Dual Problem, Construction of Dual, Duality Theorem (without proof), Dual Simplex Method, Post Optimal analysis.	**9 Hours**
Module-3	Integer Linear Programming: Gomory's Cutting Plane Method for All Integer & Mixed Integer Programming, Branch & Bound Method, Convex Function, Convex Programming Problem, Quadratic Programming and Wolfe's Method.	**8 Hours**
Module-4	Optimality Conditions, Lagrangian & Lagrange Multipliers, KKT Necessary/Sufficient Optimality Conditions, Duality in Non-linear Programming, Unconstrained Optimization – Line Search Methods for Uni-modal Functions, Steepest Descent Method, Newton's Method, Modified Newton's Method, Conjugate Gradient Method.	**9 Hours**
Module-5	Constrained Optimization – Frank Wolfe's Method, Rosen's Gradient Projection Method, Penalty function method, Barrier function method.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Chandra, Jayadeva, and A. Mehera, ***Numerical Optimization with Applications***, 1st *Ed.*, Narosa Publisher, 2013.

Reference Books:

R1. D. G. Luenberger and Y. Ye, ***Linear & Nonlinear Programming***, 1st *Ed.*, Springer, 2016.
R2. S. S. Rao, ***Engineering Optimization - Theory and Practice***, 4th *Ed.*, John Wiley & Sons, 2013.
R3. K. Dev, ***Optimization for Engineering Design - Algorithms and Examples***, 2nd *Ed.*, PHI, 2012.

Online Resources:

1. https://nptel.ac.in/courses/111105100: by Prof. A. Goswami and Prof. D. Chakraborty, IIT Kharagpur
2. https://nptel.ac.in/courses/112101298: by Prof. A. A. Kulkarni, IIT Bombay
3. https://nptel.ac.in/courses/111104644: by Prof. D. Thirumulanathan, IIT Kanpur
4. https://nptel.ac.in/courses/108101371: by Prof. D. Mukherjee, IIT Bombay

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

CO1	Apply simplex method to solve linear programming problems.
CO2	Explain the concepts behind simplex method and apply it to sensitivity analysis.
CO3	Apply integer programming and convex programming methods in optimization problems.
CO4	Explain the concepts and conditions of non-linear programming problems and its application.
CO5	Solve constrained optimization problems by applying advanced optimization techniques.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Simulation & Modelling	L-T-P	Credits	Marks
OEL	MT4004		3-0-0	3	100

Objectives	The objective of this course is to learn the basic concepts and steps of statistical simulation along with some modeling problems for engineering, scientific, business, and social science processes in the real life.
Pre-Requisites	Basic knowledge of probability and statistics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Basic concepts of Queue, M/M/1 and M/M/s queues, Queues involving non exponential distributions, Inventory models, Deterministic Continuous review model, Deterministic Periodic review model.	**8 Hours**
Module-2	Random number generation and its application to integration, Estimation of π and other problems, Generating discrete random variable - Inverse transform method, Generating geometric random variable and Bernoulli random variable, Generating Poisson and Binomial random variable, The Acceptance rejection method, The composition Approach, Programming for generation of discrete random variable.	**9 Hours**
Module-3	Generation of Continuous random variable - The Inverse transform method, The rejection Method, Generating normal random variable by different methods, Generating Poisson Process, Simulating a single server queuing system, A queuing system with two servers in series, A queuing system with two servers in parallel, An Inventory Model, An Insurance Risk model.	**10 Hours**
Module-4	Simulation of a repair model, Programming for simulation model, Reduction of variance using antithetic variables, Estimation of system reliability using antithetic variables, Application problems, Reduction of variance using control variates, Application problems, Variance by conditioning, Application problems.	**8 Hours**
Module-5	Stratified sampling, Reduction of variance using stratified sampling, Goodness of fit for discrete data, Kolmogorov-Smirnov test for continuous data, Goodness of fit test when some parameters are unspecified, Two sample problem.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. F. S. Hillier and G. J. Lieberman, ***Introduction to Operations Research***, 8th *Ed.*, McGraw-Hill, 2005.
T2. S. M. Ross, ***Simulation***, 5th *Ed.*, Academic Press, 2012.

Reference Books:

R1. A. M. Law and W. D. Kelton, ***Simulation Modeling and Analysis***, 4th *Ed.*, McGraw-Hill Higher Education, 2005.
R2. H. A. Taha, ***Operations Research***, 8th *Ed.*, Pearson Education, 2006.

Online Resources:

1. https://nptel.ac.in/courses/112107214: by Prof. P. M. Pathak, IIT Roorkee
2. https://nptel.ac.in/courses/103105215: by Prof. S. Mondal, IIT Kharagpur
3. https://nptel.ac.in/courses/103107096: by Prof. V. K. Agrawal, IIT Roorkee

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

CO1	Understand the queue and inventory model and solve related problems.
CO2	Create discrete random variable.
CO3	Generate continuous random variable and simulate queues and inventory models.
CO4	Understand and apply the variance reduction methods in simulation.
CO5	Test the goodness of a simulation by analyzing the simulated data.

Program Outcomes Relevant to the Course:

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

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	2								2	1	1
CO2	3	3	2	2	2								2	1	1
CO3	3	3	2	2	3								2	1	1
CO4	3	3	1	2	2								2	1	1
CO5	3	3	1	1	2								2	1	1

Category	Code	Fluid Mechanics	L-T-P	Credits	Marks
OEL	ME4001		3-0-0	3	100

Objectives	The objective of this course is to study the properties and behavior of fluids including fluid statics, kinematics, dynamics, inviscid flow, flow of viscous fluids, measuring instruments and fluid motive devices.
Pre-Requisites	Basic knowledge of the material properties of solids, liquids and gases and some knowledge of calculus and differential equations are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on engineering applications.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Fluid properties – Density, Specific weight, Specific gravity, Viscosity, Vapor pressure, Compressibility; Pressure at a point, Pascal's law, Pressure variation with temperature, Density with altitude; Pressure measurement - Simple and differential manometers, Piezometer, Pressure gauges; Hydrostatic forces on submerged surfaces, Forces on horizontal and vertical plane surfaces; Buoyancy and flotation, Archimedes' principle, Stability of immersed and floating bodies, Determination of metacentric height.	**9 Hours**
Module-2	Kinematics of fluid flow, Lagrangian and Eulerian descriptions; Conservation of mass-Continuity equation, Flow visualization - Streamlines, Path lines, Streak lines, Stream tubes; Classification of fluid flow - Steady and unsteady, Uniform and non-uniform, Reynold's number, Laminar and turbulent flows, Rotational and irrotational flows, One-, two-, and three-dimensional flows.	**8 Hours**
Module-3	Dynamics of inviscid flows, Surface and body forces, Euler's equation, Bernoulli's equation; Applications - flowmeters and measurement; Momentum balance equation, Control volume approach; Dynamics of viscous fluids, Navier–Stokes equations (explanation only), Navier–Stokes equations in Cartesian form, Applications to simple geometries, Couette and Poiseuille flows.	**9 Hours**
Module-4	Pipe flow, Friction losses, Darcy–Weisbach friction factor, Moody's diagram, Hydraulic diameter; Water level, Velocity and discharge measurement; Notches and weirs; Impact of jet and relevant equations.	**8 Hours**
Module-5	Hydraulic turbines – Impulse turbine, Reaction and mixed flow turbines, Construction and working; Hydraulic pumps – Centrifugal pumps, Positive displacement pumps, hydraulic valves, Construction and working; Principles of dimensional analysis and similarity.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. K. Som, G. Biswas, and S. Chakraborty, ***An Introduction to Fluid Mechanics and Fluid Machines***, 3rd *Ed.*, McGraw-Hill, 2017.

T2. E. Rathakrishnan, ***Fluid Mechanics - An Introduction***, 4th *Ed.*, PHI Learning, 2022.

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Reference Books:

R1. F. M. White and H. Xue, ***Fluid Mechanics***, 9th *Ed.*, McGraw-Hill, 2021.
R2. R. W. Fox, A. T. McDonald, P. J. Pritchard, and J. W. Mitchell, ***Introduction to Fluid Mechanics***, 10th *Ed.*, Wiley Eastern, 2020.
R3. R. K. Bansal, ***A Textbook of Fluid Mechanics and Hydraulic Machines***, 11th *Ed.*, Laxmi Publications, 2023.

Online Resources:

1. https://nptel.ac.in/courses/105103192: by Prof. S. Dutta, IIT Guwahati
2. https://nptel.ac.in/courses/112105269: by Prof. S. Chakraborty, IIT Kharagpur
3. https://ocw.mit.edu/courses/2-06-fluid-dynamics-spring-2013/download: by Prof. Kripa K Varanasi

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

CO1	Explain and apply the principles of fluid mechanics to solve problems in hydro-statics.
CO2	Describe the principles of fluid mechanics to solve problems in fluid kinematics.
CO3	Understand and apply the concepts of fluid dynamics to flow measuring devices.
CO4	Analyze and design free surface and pipe flows for real-world applications.
CO5	Design the working proportions of hydraulic machines.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Power Plant Engineering	L-T-P	Credits	Marks
OEL	EE4001		3-0-0	3	100

Objectives	The objective of this course is to impart a basic understanding of the different types of power plants, site selection criteria, cooling tower operations etc., and basics of hydroelectric, diesel, and nuclear power generation.
Pre-Requisites	Basic knowledge of thermodynamics, fluid mechanics, environmental sciences and engineering chemistry is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Energy sources for the generation of electric power, Types, special features, and applications of power plants; Power tariff types, Load distribution parameters, Load curve, Load factor, Capital & Operating Cost of different power plants.	**8 Hours**
Module-2	**Steam Power Plant**: Selection of sites, General layout of modern steam power plant, Pollution control equipment, High pressure boilers, Super heater and air preheater, Fluidized bed boilers, Fuel and ash handling equipments, Water treatment plant, Spray ponds and cooling towers, Steam condenser type and calculation.	**9 Hours**
Module-3	**Hydroelectric Power Station**: Potential power with reference to rainfall and catchment area, Water storage, Equipment used in hydroelectric power stations, Characteristics of hydraulic turbines; Diesel power stations – Application of Diesel in power sector, Comparison of the factors governing the cost of hydro, steam and diesel power stations.	**8 Hours**
Module-4	**Nuclear Power Plant**: Classifications and essential components of nuclear reactors, Heavy water moderator and cooled reactors, CANDU reactors, Light water reactor, Gas cooled reactors, Liquid metal cooled reactors, Disposal of nuclear waste.	**8 Hours**
Module-5	**Control & Automation in Power Plant**: Role of control and instrumentation in power plant, Recorders and industrial displays, Electrical instruments and metering, Working of meters, Meter calibration, Performance optimization of power plant with integrated controls, Turbine interlock and protection of generators; Power plant automation using PLC, SCADA, Introduction to energy management system (EMS) and EMS framework.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. P. K. Nag, ***Power Plant Engineering***, 2nd *Ed.*, Tata McGraw-Hill, 2019.
T2. M. M. El-Wakil, ***Power Plant Technology***, 2nd *Ed.*, Tata McGraw-Hill, 2010.

Reference Books:

R1. S. Domkundwar and C. Arora, ***Power Plant Technology***, 6th *Ed.*, Dhanapat Rai & Sons, 2011.
R2. M. Verma, ***Power Plant Engineering***, 3rd *Ed.*, Metropolitan Book Company, 1976.

R3. F. D. Petrusella, ***Programmable Logic Controller***, 4th *Ed.*, Tata McGraw-Hill, 2017.
R4. M. S. Thomas and J. D. McDonald, ***Power System - SCADA and Smart Grids***, 1st *Ed.*, CRC Press, 2015.

Online Resources:

1. https://nptel.ac.in/courses/112107216: by Prof. R. Kumar, IIT Roorkee
2. https://nptel.ac.in/courses/112103277: by Dr. V. Kulkarni, IIT Guwahati
3. https://nptel.ac.in/courses/127106135: Prof. T. N. C. Anand, IIT Madras
4. https://www3.nd.edu/~powers/ame.20231/notes.pdf

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

CO1	Describe the concepts of power cycles, sources of energy, their principles and applications.
CO2	Evaluate the different criteria of power plant layout and site selection and be familiar with the working principles of the various components of power plant and their uses.
CO3	Evaluate the design layout and working of hydroelectric & diesel power plants.
CO4	Explain the principles and working of nuclear power plants.
CO5	Apply automation techniques to efficiently operate, monitor, and maintain automated power plant systems.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Project Management	L-T-P	Credits	Marks
OEL	MG4007		3-0-0	3	100

Objectives	The objective of this course is to study the fundamental tools and behavioral skills necessary to successfully launch, lead, and realize benefits, develop the skills for planning and controlling, and understanding key factors to drive successful project outcomes.
Pre-Requisites	General knowledge of any organization and its operations is sufficient.
Teaching Scheme	Regular classroom lectures with use of ICT as needed. Each session is planned to be interactive with real-life examples.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Objective of Project Management, Projects vs Operations, Stakeholders - Clients, Vendors, Regulators, Users, Types of Projects, Project Life Cycle, Project Initiation, Project Planning - Predictive vs Adaptive Planning, Project Execution, Project Closure; Analysis of a Project - Market demand analysis, Technical analysis and financial estimation, Project Success Criteria - Cost, Quality, Value Delivered.	**8 Hours**
Module-2	Commonly used techniques for Project Management, Network techniques - PERT, CPM, Crashing of a project network, Line of balance (LOB): Application area of LOB, Input of LOB, Steps of LOB, Line balancing - Rank Positional weight method; Project Resource Management - Allocation, Leveling and Smoothing methods, Rolling-wave Planning, Managing schedule uncertainty, Trade-offs between time, scope, cost, and quality, HR constraints in real world projects.	**9 Hours**
Module-3	Project Selection technique, Investment criteria (NPV, IRR, Benefit Cost Ratio), Project cash flows, Cost of capital; Risk analysis - Sources, Measures and perspectives of risk, Sensitivity analysis, Scenario analysis, Break-even analysis, Simulation analysis, Decision tree analysis; Managing risk - Project selection under risk, Technical risk vs execution risk, Managing changes during project execution, Risk registers and mitigation tracking.	**8 Hours**
Module-4	Project Financing, Capital structure, Sources of finance, internal accrual, securities, term loans, working capital, Equity and Debt, Venture capital and private equity, Cost overruns and financial risk in projects - Lifecycle costing, Economic vs financial viability, Sustainability and long term project impact.	**8 Hours**
Module-5	Social Cost Benefit Analysis (SCBA): Rationale for SCBA, UNIDO Approach, Net Benefit In terms of Economics (efficiency) Prices; Project Audit - Project failure & reasons for Audit, Phases of Project Audit; Project monitoring & control mechanisms - Performance tracking using simple dashboards, Lessons learned and post project reviews, Ethics, safety, and societal responsibility in projects, Project Management tools - Spredsheet-based dashboards, GanttProject, LibreProject.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. P. Chandra, ***Projects Planning, Analysis, Selection, Financing, Implementation and Review***, 9th *Ed.*, McGraw-Hill Education, 2019.
T2. R. Paneerselvam and P. Senthilkumar, ***Project Management***, 1st *Ed.*, PHI Learning, 2009.

Reference Books:

R1. C. Gray, E. Larson, and G. Desai, ***Project Management The Managerial Process***, 7th *Ed.*, McGraw-Hill Education, 2013.
R2. B. Punmia and K. Khandelwal, ***Project Planning and Control with PERT and CPM***, 4th *Ed.*, Laxmi Publications, 2006.

Online Resources:

1. https://nptel.ac.in/courses/110104073: by Prof. R. Sengupta, IIT Kanpur
2. https://nptel.ac.in/courses/110107081: by Prof. S. K. Gupta & Prof. M. K. Barua, IIT Roorkee
3. https://help.ganttproject.biz/uploads/default/original/1X/ae5fa52935b40a26960ee3c350dbbb311822b542.pdf
4. https://www.projectlibre.com/projectlibre-desktop/

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

CO1	Describe the fundamental project management tools and behavioral skills.
CO2	Explain the basic concept of various network techniques for project management.
CO3	Optimally utilize the resources for successful completion of a project.
CO4	Perform cost-benefit analysis of a project considering various factors involved.
CO5	Plan, monitor, control, and administer projects using computerized PMIS tools.

Program Outcomes Relevant to the Course:

PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

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

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

Category	Code	Organizational Behaviour	L-T-P	Credits	Marks
OEL	HS4001		3-0-0	3	100

Objectives	The objective of this course is to learn the human interactions in an organization and develop the skills required for leadership, conflict resolution and taking rational decisions to attain business goals.
Pre-Requisites	Basic knowledge of standard operations of an established organization is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when needed. Each session is planned to be interactive with real-life examples.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Organizational Behaviour (OB)**: Definition, Importance; Learning – Nature, Learning Cycle, Components; Theories; Personality - Definition, Determinants of Personality, Personality Traits, Personality and OB.	**9 Hours**
Module-2	**Perception**: Definition, Perceptual Process, Importance of Perception in OB; Motivation -– Nature, Importance, Herzberg's Two Factor Theory, Maslow's Need Hierarchy Theory, Alderfer's ERG Theory.	**8 Hours**
Module-3	**Organizational Behaviour Process**: Communication – Importance, Types, Gateways, Barriers, Communication as a tool for improving Interpersonal Effectiveness; Groups in Organizations - Nature, Types, Group Cohesiveness, Group Decision-making, Managerial Implications, Effective Team Building; Leadership: Leadership & Management, Theories of Leadership; Conflict – Nature of Conflict and Conflict Resolution.	**9 Hours**
Module-4	**Organizational Culture**: Definition, Culture and Organizational Effectiveness; Introduction to Human Resource Management - Selection, Orientation, Training and Development, performance Appraisal.	**8 Hours**
Module-5	**Organizational Change**: Importance of Change, Planned Change and OB techniques; International Organizational Behavior – Trends in International Business, Cultural Differences and Similarities, Individual and Interpersonal Behavior in Global Perspective.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. K. Davis, ***Organisational Behaviour***, 9th *Ed.*, McGraw-Hill, 1992.
T2. K. Aswathappa, ***Organisational Behaviour***, 12th *Revised Ed.*, Himalaya Publishing House, 2016.
T3. U. Pareek and S. Khanna, ***Understanding Organizational Behaviour***, 4th *Ed.*, Oxford University Press, 2016.

Reference Books:

R1. S. P. Robbins, ***Organisational Behaviour***, 8th *Ed.*, Prentice Hall of India, 2018.
R2. K. B. L. Srivastava and A. K. Samantaray, ***Organizational Behaviour***, 1st *Ed.*, India Tech, 2009.

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Online Resources:

1. https://nptel.ac.in/courses/110105033: by Dr. S. Mukhopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/110105120: by Prof. K. B. L. Srivastava, IIT Kharagpur
3. https://www.studocu.com/en/search/organizational-behaviour: by different universities

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

CO1	Describe the concepts of OB and the micro approaches inside an organization.
CO2	Explain perception process and analyze motivation theories in organizational behaviour.
CO3	Evaluate communication, group behaviour, leadership approaches, and conflict resolution.
CO4	Examine organizational culture and HRM functions influencing effectiveness.
CO5	Articulate the change processes and cross-cultural behaviour in global organizations.

Program Outcomes Relevant to the Course:

PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

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

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

Category	Code	Entrepreneurship Development	L-T-P	Credits	Marks
OEL	HS4002		3-0-0	3	100

Objectives	The objective of this course is to learn various aspects of becoming an entrepreneur by starting own business and making it successful so as to adopt entrepreneurship as a career option for graduating engineers.
Pre-Requisites	General knowledge of any business and its operations is sufficient.
Teaching Scheme	Regular classroom lectures with use of ICT as needed. Each session is planned to be interactive with real-life examples & case studies.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Concept of Entrepreneurship, Characteristics of successful entrepreneur, Growth of entrepreneurship in India. Role of Entrepreneurship in Economic Development, The Entrepreneurial Process, Entrepreneurial Motivation. Entrepreneurial Competencies. Developing Entrepreneurial Competencies.	**8 Hours**
Module-2	Ideas to Reality, creativity, innovation and Entrepreneurship, Identifying and recognizing Opportunities, Techniques for generating Ideas, Encouraging and Protecting the new ideas and selecting the right project, Ensuring your market, Market survey and Research.	**8 Hours**
Module-3	Business Plan - Meaning, Contents and significance, Formulation, Presentation to the investors, Techno-economic Feasibility Assessment - A preliminary Project Report, Details Project Report, Project Appraisal, Methods of Project Appraisal.	**9 Hours**
Module-4	Creating a successful financial plan, Basic financial statements, Ratio Analysis, Break-even Analysis; Marketing Management of SMEs, Problems of HRM – Relevant Labour – laws, Forms of Business ownership, Institutional Finance to entrepreneurs, Source of financing, Institutional support to entrepreneurs.	**9 Hours**
Module-5	The importance of Intellectual Property, Patents, Trade Mark, Copyrights, Trade secrets, Intellectual property audit, Start up Policy of Centre, State, and MSME sectors, Problems of MSME, Sickness in small scale enterprises, Govt. policies on revival of sickness and remedial measures.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. B. R. Barringer and R. D. Ireland, ***Entrepreneurship***, 2nd *Ed.*, Pearson Education, 2008.

T2. Z. Thomas and S. Norman, ***Essentials of Entrepreneurship and Small Business Management***, 5th *Ed.*, PHI Learning, 2009.

T3. S. S. Khanka, ***Entrepreneurial Development***, 4th *Ed.*, S. Chand & Co., 2010.

Reference Books:

R1. P. Chavantimath, ***Entrepreneurship Development and Small Business Enterprises***, 3rd *Ed.*, Pearson Education, 2018.

R2. P. C. Jain, ***Hand Book for New Entrepreneurs***, 4th *Ed.*, Oxford University Press, 2004.

R3. J. A. Timmons and S. Spinelli Jr., ***New Venture Creation: Entrepreneurship for the 21st Century***, 8th *Rev. Ed.*, Tata McGraw-Hill, 2009.

Online Resources:

1. https://nptel.ac.in/courses/110106141: by Prof. C. B. Rao, IIT Madras
2. https://nptel.ac.in/courses/127105007: by Prof. M. K. Mondal, IIT Kharagpur
3. https://nptel.ac.in/courses/110107094: by Prof. V. Sharma & Prof. R. Agrawal, IIT Roorkee

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

CO1	Describe entrepreneurship concepts, roles in economic development, and competencies.
CO2	Apply creativity and opportunity recognition techniques to identify viable ventures.
CO3	Prepare and evaluate business plans using techno-economic feasibility and appraisal.
CO4	Analyze financial planning, SME marketing, HR issues, and sources of finance.
CO5	Explore intellectual property rights, startup policies, and challenges of MSMEs.

Program Outcomes Relevant to the Course:

PO2	**Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).
PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO4	**Conduct Investigations of Complex Problems**: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions (WK8).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

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

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

Category	Code	Security Analysis, Investment & Trading	L-T-P	Credits	Marks
OEL	MG4001		3-0-0	3	100

Objectives	The objective of this course is to equip the students with the knowledge of analyzing equities, indices, commodities and other securities by the help of advanced technical analysis tools and techniques.
Pre-Requisites	Basic knowledge of mathematics and skill in spreadsheets is required.
Teaching Scheme	Regular classroom lectures with use of ICT as needed; sessions shall be interactive with problem solving activities and real-life examples with demonstration.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Capital Market**: Bonds, Equities, Currencies, Funds, etc., Players in the space – FII, DII, Prop Desk, Retail, Regulatory Bodies - SEBI, Rules and Regulations; Trading Platforms – Trading View, Chart IQ, Multiple Broker Platforms like Zerodha, Fyers, ICICI Direct, Dhan, Alice Blue; Types of Activities – Long Term, Short Term, Swing, Day Trading, Scalping, High Frequency Trading (HFT).	**8 Hours**
Module-2	**Security Analysis**: Fundamental Analysis – Qualitative and Quantitative Analysis; Technical Analysis, Dow Theory, Wycoff Theory, Candlestick Patterns – Single, Double and Tripple candles.	**7 Hours**
Module-3	**Chart Patterns**: Rounding Top & Bottom, Head & Shoulder and Inverse, Price Action Approaches - Gap Up & Down, Price Rejections, Technical Indicators – Pivot, Exponential Moving Average (EMA), Super Trend, Bollinger Band, Parabolic Stop & Reverse (PSAR), Volume Weighted Average Price (VWAP).	**10 Hours**
Module-4	**Oscillators**: Relative Strength Index (RSI), Stochastics, Moving Average Convergence / Divergence (MACD), Commodity Channel Index (CCI), Average True Range (ATR), Average Directional Index (ADX), Trading Strategy Development, Screener Development, Back Testing and Optimization.	**11 Hours**
Module-5	**Advanced Techniques**: Fibonacci Trading Approach, Fundamentals of Options, Option Chain Analysis, Algorithmic Trading and AI in FinTech, Capital Management, Best Practices and Success Factors.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. R. Chakrabarty and S. De, ***Capital Markets in India***, 1st *Ed.*, SAGE Response, 2010.
T2. B. Graham and D. Dodd, ***Security Analysis***, 6th *Ed.*, McGraw-Hill Education, 2008.
T3. M. J. Pring, ***Technical Analysis Explained: The Successful Investor's Guide to Spotting Investment Trends and Turning Points***, 5th *Ed.*, McGraw-Hill Education, 2014.

Reference Books:

R1. J. J. Murphy, ***Technical Analysis of Financial Markets***, New York Institute of Finance, 1999.
R2. B. Graham, ***The Intelligent Investor: The Definitive Book on Value Investing***, 1st *Revised Ed.*, Harper Brothers, 2003.

R3. C. Boroden, ***Fibonacci Trading: How to Master the Time and Price Advantage***, 1st *Ed.*, McGraw-Hill Education, 2008.
R4. A. Damodaran, ***Damodaran on Valuation: Security Analysis for Investment and Corporate Finance***, 2nd *Ed.*, Willey Finance, 2006.

Online Resources:

1. https://in.tradingview.com/
2. https://www.investing.com/
3. https://chartink.com/
4. https://www.valueresearchonline.com/
5. https://www.screener.in/
6. https://www.investopedia.com/terms/t/technicalanalysis.asp
7. https://zerodha.com/varsity/
8. https://www.moneycontrol.com/

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

CO1	Explain the capital market structure and describe the rules and regulations.
CO2	Utilize fundamental analysis tools to screen securities for investment and trading.
CO3	Apply technical analysis tools to identify and evaluate investment and trading opportunities.
CO4	Combine different technical analysis tools and techniques to identify high probability trades.
CO5	Apply technical analysis to create screeners& strategies and back tests for optimization.

Program Outcomes Relevant to the Course:

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

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

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

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

Category	Code	Circular Economy	L-T-P	Credits	Marks
OEL	MG4002		3-0-0	3	100

Objectives	The objective of this course is to provide students with an understanding of circular economy principles, sustainable development and innovative business models, while developing skills in environmental impact assessment, waste reduction and implementation of circular economy strategies within legal and policy frameworks.
Pre-Requisites	Basic understanding of economics, environmental science, and sustainability principles. Familiarity with business or management concepts is helpful for grasping circular business models.
Teaching Scheme	Regular classroom lectures with use of ICT as needed. Each session is planned to be interactive with focus on real-world problem solving.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Environmental Economics**: Institutional Framework for a Circular Economy; Linear Economy and its emergence & disadvantages, Replacing with Circular Economy, Development of Concept, Sustainable Development - Concepts, Theories and Principles of Sustainable Development; Sustainable Development and Waste Management, Global context and relevance for sustainable development goals (SDGs).	**9 Hours**
Module-2	**Circular Economy**: Environmental and social benefits of CE, The 3R, 6R, and 9R frameworks; Public Good; Economic instruments for solving environmental problems, Externalities – Public goods, Market failure, Property rights, Material recovery, Waste reduction, Reducing negative externalities, Explaining Butterfly diagram, Concept of loops, Solid Waste & wasterwater management.	**9 Hours**
Module-3	**Circular Design & Innovation**: Zero waste – Waste Management in context of CE, Circular design, Research and innovation, Life cycle assessment, Measuring environmental performance, Circular business models, Product-as-a-Service (PaaS), Sharing economy & collaborative consumption, Reverse logistics and industrial symbiosis, Design for durability, Disassembly and remanufacturing, Role of innovation, Digitalization and Industry 4.0.	**8 Hours**
Module-4	**Environmental Impact Assessment & Green Startup**: Natural Systems, Green Startup Ecosystems and Opportunities on Global and National Level; Green Business models, Environmental Impact Assessment; Environment Impact Assessment Valuation Techniques – Stated Preference approaches, Surrogate Market approaches, Conventional market approach, Household production Function approach.	**8 Hours**
Module-5	**Environment Policy of India**: Objectives & implementation, Role of Governments & networks, Sharing best practices, Universal CE policy goals, India's CE strategy, ESG, Environmental legislation related to CE, Implementation of CE on macro level.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. G. Bhalla, ***Circular Economy: (Re)Emerging Movement***, 1st *Ed.*, Invincible Publishers, 2020.
T2. K. Webster, ***The Circular Economy: The Future of Sustainable Development***, 2nd *Ed.*, Ellen McArthur Foundation, 2017.
T3. A. M. Hussan, ***Principles of Environmental Economics and Sustainability***, 3rd *Ed.*, Routledge Publication, 2018.

Reference Books:

R1. A. Kumar, ***The Circular Economy: The Future of Sustainable Development***, 1st *Ed.*, AG Publishing House, 2025.
R2. S. K. Ghosh, ***Circular Economy: Recent Trends in Global Perspective***, 1st *Ed.*, Springer Nature, 2021.
R3. S. S. Shukla, M. Jain, and A. Jain, ***The Circular Economy: Changing the Future of India***, —edn1, IGI Global, 2024.
R4. N. Hanley, J. F. Shogren, and B. White, ***Environmental Economics in Theory and Practice***, 1st *Ed.*, Macmillan Press,1997.

Online Resources:

1. https://nptel.ac.in/courses/109107171: by Prof. D. Nayak and S. P. Singh, IIT Roorkee
2. https://nptel.ac.in/courses/105105184: by Prof. B. K. Dubey, IIT Khragpur

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

CO1	Explain environmental & circular economy concepts and their relevance to sustainability.
CO2	Analyze CE principles & economic tools to assess waste reduction and resource recovery.
CO3	Apply circular design, innovation and digitalization to build sustainable models.
CO4	Evaluate impacts using EIA techniques and explore green startup models and opportunities.
CO5	Examine legal & policy frameworks for CE in India to promote sustainable growth.

Program Outcomes Relevant to the Course:

PO3	**Design/Development of Solutions**: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required (WK5).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	**Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

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

Category	Code	Generative AI	L-T-P	Credits	Marks
HNS	CS4027		3-0-1	4	100

Objectives	The objective of this course is to learn the key concepts of Generative AI (Gen-AI) modeling, Large Language Models (LLM), and to design, implement, and fine-tune modern text and vision generation systems using probabilistic principles and parameter-efficient adaptation methods.
Pre-Requisites	Working knowledge of Linear algebra, Probability theory, Machine & Deep learning fundamentals, and Python programming is required.
Teaching Scheme	Regular classroom lectures with the use of ICT as and when required; sessions shall be interactive with focus on problem solving activities, and hands-on sessions.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction, Generative vs. Discriminative Modeling, First Generative Model, Generative Modeling Framework, Representation Learning, Core Probability Theory, Generative Model Taxonomy; Variational Auto-Encoders (VAE), Demonstration on VAE; Generative Adversarial Networks (GANs) - Training Strategy, Evaluating Optimality, Overview of DCGAN, StyleGAN, Implementation of GAN; Introduction to Diffusion Models.	**12 Hours**
Module-2	Language Model (LM), Evolution of LM, NLP pipeline; Tokenization - Word & Sub-word based Tokenization, Byte-pair Encoding, WordPiece, Implementation of Tokenizer; N-gram Model, Evaluating LMs - Perplexity; Word Embedding - Distributional Hypothesis, Vector Semantics, Measuring Semantic Similarity, Word2Vec (CBOW and Skip-grams).	**10 Hours**
Module-3	Recurrent Neural Networks (RNN), RNN LM - Forward Inference, Training; RNNs for Sequence Labelling, Text Generation; Implementation of a Simple RNN LM; Bidirectional RNNs; Encoder-Decoder Model with RNNs - Training and Implementation; Attention.	**11 Hours**
Module-4	Transformer - Self-Attention and its Implementation, Transformer Encoder & Decoder Blocks, Positional Embeddings, LM Head; Sampling for LLM Generation - Top-k, Top-p, and Temperature samplings; LM Pre-training - Evaluation Dataset, Encoder, Decoder, and Encoder-Decoder based Pre-trainings, Limitation; Pre-training to fine-tuning, Implementation of fine-tuning BERT for Classification task; Instruction tuning.	**13 Hours**
Module-5	Prompting Strategies in LLM-Ingredients of a Prompt, Basic Prompting, Manual Prompt Template, Instruction-based Prompting, Hands-on Design of Manual Prompt Templates; Complexity of a Prompt, In-Context Learning, Experiments with Instruction-based Prompting, Compare Role-based vs Direct prompts, Implement in-context Learning, Chain-of-thoughts, Tree-of-thought; Parameter-efficient Fine-tuning - Adapters, Prefix & Prompt tuning, LoRa; Overview of Popular LLM Models.	**10 Hours**
	Total	**56 Hours**

P.T.O

Text Books:

T1. D. Foster, ***Generative Deep Learninge***, 2nd *Ed.*, O'Reilly Media, 2023.
T2. T. Chakraborty, ***Introduction to Large Language Models***, 1st *Ed.*, Wiley India, 2025.
T3. D. Jurafsky and J. H. Martin, ***Speech and Language Processing***, 3rd *Ed.*, 2024.

Reference Books:

R1. J. Alammar and M. Grootendorst, ***Hands-On Large Language Models***, 1st *Ed.*, O'Reilly, 2024.
R2. A. Bahree, ***Generative AI in Action***, 1st *Ed.*, Manning, 2024.
R3. N. Dhamani and M. Engler, ***Introduction to Generative AI***, 2nd *Ed.*, Manning, 2025.

Online Resources:

1. https://nptel.ac.in/courses/106102576: by Prof. T. Chakraborty and Prof. S. Chakraborti, IIT Delhi
2. https://nptel.ac.in/courses/106106224: by Prof. V. Balasubramanian, IIT Hyderabad

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

CO1	Explain the principles of generative modeling and the working of VAE and GAN.
CO2	Analyze language models, tokenization methods, N-gram evaluation, and word embeddings.
CO3	Design and implement RNN-based language models with encoder-decoder and attention.
CO4	Examine transformer architecture, sampling methods, and fine-tuning of pretrained LMs.
CO5	Apply prompting strategies and parameter-efficient fine-tuning techniques in LLMs.

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

Category	Code	Nature Inspired Computing	L-T-P	Credits	Marks
HNS	CS4028		3-0-1	4	100

Objectives	The objective of this course is to learn the ideas and methods of natural computing that are based on biological and physical phenomena. It will help in building and using nature-inspired algorithms to solve complex optimization and the real-world problems.
Pre-Requisites	Basic knowledge of algorithms, mathematics, AI/ML fundamentals, programming in C/Python/Java is required.
Teaching Scheme	Regular classroom lectures with the use of ICT as and when required; sessions shall be interactive with focus on problem solving activities, and hands-on sessions.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: From Nature to Natural Computing, Motivation, Key Ideas, Philosophy of Natural Computing, Computing Inspired by Nature, Usage of Natural Computing Approaches.	**8 Hours**
Module-2	**Evolutionary Computing**: Pillars of Evolutionary Theory, The Genotype, Artificial Evolution, Genetic Representations, Initial Population, Fitness Functions, Selection and Reproduction, Genetic Operators, Evolutionary Measures, Types of Evolutionary Algorithms, Implementation of Genetic Algorithm (GA).	**13 Hours**
Module-3	Nature Inspired Computing for Problem-Solving: Particle Swarm Optimization (PSO) - Concepts, Velocity, Position update rules, Parameter selection, Programming of PSO; Ant Colony Optimization (ACO) - Pheromone model, Probabilistic path selection, Evaporation, Implementation of ACO;	**13 Hours**
Module-4	**Immunocomputing**: Working and constituents of Biological Immune Systems, Lessons for Artificial Immune Systems (AIS), Algorithms, Application of AIS, Shape space, Negative Selection Algorithm (NSA), Clonal Selection Algorithm (CSA), Implementation of NSA and CSA taking Suitable Dataset(s).	**13 Hours**
Module-5	**Hybrid Nature-Inspired Algorithms**: GA-PSO, PSO-ANN, ACO-PSO, Implementation of hybrid algorithms.	**9 Hours**
	Total	**56 Hours**

Text Books:

T1. D. Floreano and C. Mattiussi, ***Bio-Inspired Artificial Intelligence: Theories, Methods, and Technologies***, 1st *Ed.*, MIT Press, 2023.

T2. X. Yang, ***Nature-Inspired Optimization Algorithms***, 1st *Ed.*, Elsevier / Academic Press, 2014.

T3. A. Y. Zomaya, ***Handbook of Nature-Inspired and Innovative Computing***, 1st *Ed.*, Springer, 2006.

Reference Books:

R1. L. N. de Castro, ***Fundamentals of Natural Computing: Basic Concepts, Algorithms, and Applications***, 1st *Ed.*, Chapman and Hall/CRC, 2006.

R2. M. Dorrigo and T. Stützle, ***Ant Colony Optimization***, 1st *Ed.*, Prentice Hall of India, 2005.

Online Resources:

1. https://nptel.ac.in/courses/111104644: By Prof. D. Thirumulanathan, IIT Kanpur
2. https://nptel.ac.in/courses/111105100: By Prof. A. Goswami and D. Chakraborty, IIT Kharagpur
3. https://ocw.mit.edu/courses/ids-338j-multidisciplinary-system-design-optimization-spring-2010/pages/lecture-notes/
4. https://ocw.mit.edu/courses/6-0002-introduction-to-computational-thinking-and-data-science-fall-2016/video_galleries/lecture-videos/

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

CO1	Explain the fundamentals of natural computing and its distinction from traditional methods.
CO2	Analyze genetic algorithms, genetic programming, and evolutionary methods.
CO3	Implement nature-inspired optimization methods to solve real-world problems.
CO4	Apply biological immune systems using the clonal and negative selection methods.
CO5	Utilize advanced hybrid and multi-objective natural computing methods to real-world problems.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	VLSI Chip Design & Verification	L-T-P	Credits	Marks
MNR	EC4001		4-0-0	4	100

Objectives	The objective of this course is to study the Verilog HDL techniques for the design and analysis of digital circuits and systems.
Pre-Requisites	Fundamental knowledge on digital electronic circuits and MOSFETs is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Hierarchical modeling - Modules, Instances, Basic concepts - Lexical conventions, Whitespace, Comments, Operators, Data types – Value set, Nets, Registers, Vectors, Arrays, Parameters, Strings modules and ports - Modules, Port declaration, Port connection rules, Connecting ports to external signals.	**9 Hours**
Module-2	**Combinational Circuit Design - I**: Dataflow modeling – Continuous assignments, Delays, Expressions, Operators and operands, Operator types, Examples; Gate level modeling - Gate types, Gate delays, Rise, Fall and turn-off delays, Min/Typical/Max values; Switch level modeling - Switch-modeling elements, MOS switches, CMOS switches.	**12 Hours**
Module-3	**Combinational Circuit Design - II**: Behavioral modeling - Initial statement, Always statement, Adders, Subtractors, Comparator, MUX and DeMUX (using if...else and case Construct), Loops - While loop, For loop, Repeat loop, Forever loop (with relevant examples), Structural modeling - 4-bit Adders, 2-bit multiplier, 4-bit comparator, 8:1-MUX and 1:8-DeMUX.	**12 Hours**
Module-4	**Multiplexer as Universal Logic**: Design of basic gates, Boolean expressions and other combinational logic circuits using multiplexers; Decoders and Encoders - 1:2 Decoders, 2:4 Decoder, Test bench of decoder, Priority encoders, Test bench of priority encoder; Latches and Flip-Flops - D Latch, Flip-flop, Positive and negative edge-triggered D Flip-Flop.	**12 Hours**
Module-5	**Sequential Circuit Design**: Synchronous and asynchronous reset, Counter design using synthesizable constructs – Synchronous counters, Asynchronous counter, BCD up–down counter; Finite State Machine (FSM) - Melay & Moore machines, Verilog implementation of sequence detector (Overlapping permitted and non-overlapping), Vending machine.	**11 Hours**
	Total	**56 Hours**

Text Books:

T1. S. Palnitkar, ***Verilog HDL: A guide to Digital Design and Synthesis***, 4th *Ed.*, SunSoft Press, 1996.
T2. V. Taraate, ***Digital Logic Design Using Verilog***, 2nd *Ed.*, Springer, 2016.

Reference Books:

R1. S. Ramachandran, ***Digital VLSI Systems Design***, 2nd *Ed.*, Springer, 2006.
R2. C. H. Roth Jr., L. K. John, B. K. Lee, ***Digital Systems Design Using Verilog***, 2nd *Ed.*, Cengage Learning, 2015.

R3. D. E. Thomas, P. R. Moorby, ***The Verilog Hardware Description Language***, 5th *Ed.*, Kluwer Academic Publishers, 2002.
R4. M. D. Ciletti, ***Advanced Digital Design with Verilog HDL***, 2nd *Ed.*, Pearson Education, 2010.

Online Resources:

1. https://nptel.ac.in/courses/108103179: by Prof. S. R. Ahamed, IIT Guwahati
2. https://www.chipverify.com/verilog/verilog-tutorial
3. https://www.edaplayground.com/

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

CO1	Explain fundamentals and syntax of Verilog HDL for digital IC design and verification.
CO2	Design and analyze combinational logic circuits using data flow, gate and switch level modeling.
CO3	Apply structural modeling of Verilog HDL to design combinational logic circuits.
CO4	Design combinational logic circuits using multiplexer as universal logic through Verilog HDL.
CO5	Apply synthesizable constructs of Verilog to design sequential and FSM based circuits.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Analog Integrated Circuit Design	L-T-P	Credits	Marks
MNR	EC4002		4-0-0	4	100

Objectives	The objective of this course is to study analysis & design of analog integrated circuits and systems for various applications including single-stage, differential & operational amplifiers, current mirrors & bandgap reference circuits with different specifications.
Pre-Requisites	Fundamentals of MOSFET, Analog electronics and Network theory are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Review of Circuits & Systems**: Circuit elements and their constitutive relations, Network theory, Superposition (linearity) and time-invariant principle, Design and analysis of LTI systems, KCL, KVL, Node Equation procedure, Thevenin and Norton method, Matrix formulation for CAD solution, Analysis of non-linear circuits - Analytical, Graphical and incremental solution, Dynamic circuit analysis - Solution to a first-order differential equation.	**10 Hours**
Module-2	**Integrated Circuit Devices**: Diodes – Basic operation and large-signal modeling, MOS transistor, Large & small signal (low & high frequency) modeling, Advanced MOS modeling (subthreshold, mobility degradation); SPICE modeling - Introduction, Diode model, MOS transistors, Advanced SPICE models for MOS transistors, Passive devices - Resistors and capacitors, Reading process parameters from foundry documents.	**12 Hours**
Module-3	**CMOS Processing and Layout**: CMOS processing, Layout and design rules, Reading design rules from foundry documents, Analog layout considerations - variability, Mismatch, Matching, Noise consideration; Single-Stage Amplifiers – Common source, Source follower, Common gate, Examples, Impedance matching.	**12 Hours**
Module-4	**Operational Amplifier**: Differential Amplifier, Telescopic, Folded cascode, Two stage amplifier design, Stability - Frequency response, Feedback, Compensation, Current mirrors, Simple current mirror, Cascode current mirror, Wide swing current mirror, Matching.	**12 Hours**
Module-5	**Bandgap References and LNA**: Low power band gap reference design. Low Noise Amplifier (LNA) - Design of low noise amplifier.	**10 Hours**
	Total	**56 Hours**

Text Books:

T1. T. C. Carusone, D. A. Johns, and K. A. Martin, ***Analog Integrated Circuit Design***, 2nd *Ed.*, Wiley India, 2012.

T2. B. Razavi, ***Design of Analog CMOS Integrated Circuits***, Indian Edition, McGraw-Hill Education, 2002.

T3. D. Holberg and P. Allen, ***CMOS Analog Circuit Design***, 3rd *Ed.*, Oxford University Press, 2013.

Reference Books:

R1. P. Gray, P. Hurst, S. Lewis, and R. Meyer, ***Analysis and Design of Analog Integrated Circuits***, 4th *Ed.*, John Wiley & Sons, 2001.
R2. R. J. Baker, ***CMOS Circuit Design, Layout and Simulation***, IEEE Inc., 2008.
R3. A. Agarwal and J. Lang, ***Foundations of Analog and Digital Electronic Circuits***, 1st *Ed.*, Elsevier, 2005.

Online Resources:

1. https://nptel.ac.in/courses/117106030: by Dr. N. Krishnapura, IIT Madras
2. http://cmosedu.com
3. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/
4. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-374-analysis-and-design-of-digital-integrated-circuits-fall-2003/

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

CO1	Analyze linear and nonlinear circuits using network theorems, CAD tools, and dynamics.
CO2	Explain operation and modeling of diodes, MOS devices, and passive components using SPICE.
CO3	Apply CMOS processing, layout design rules, and single-stage amplifier configurations.
CO4	Design & analyze differential, cascode, and 2-stage op-amps with feedback & compensation.
CO5	Design low-power bandgap references and low-noise amplifiers for analog VLSI circuits.

Program Outcomes Relevant to the Course:

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

P.T.O

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

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

Category	Code	Realtime Embedded System Design	L-T-P	Credits	Marks
MNR	EC4003		4-0-0	4	100

Objectives	This course focuses on real-time and embedded system concepts, including task scheduling, synchronization, and inter-process communication to design reliable, responsive, and efficient real-time applications for time-critical embedded systems.
Pre-Requisites	Fundamental knowledge of basic electronics, digigal electronic circuits, microprocessor and microcontrollers, and embedded systems is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving and applications.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Embedded system design and its characteristics, Real-time systems - Characteristics and classification, Hard, Soft and Firm real-time systems, Responsiveness, Latency, CPU utilization, Deadlines and timing requirements, Real-time applications and case overviews.	**12 Hours**
Module-2	**RTOS & Scheduling**: Operating system basics, Types of operating systems, Tasks, Process and threads, Multiprocessing and multitasking, Task scheduling, Non-preemptive scheduling - FIFO, LIFO, Shortest job first (SJF), Priority based scheduling, Preemptive scheduling-Shortest remaining time (SRT), Round robin, Priority based scheduling.	**12 Hours**
Module-3	**RTOS Advanced Scheduling & Services**: Earliest deadline first (EDF) scheduling, Rate monotonic algorithm (RMA), Issues associated with RMA, Issues in using RMA in practical situations threads, Processes and scheduling, Introduction to handling sharing and dependencies among real time tasks and scheduling real time tasks in multiprocessor.	**12 Hours**
Module-4	**Processes, Threads and IPC**: Multiple processes, Threads in an application, Tasks, Task states, Task and data, ISRs, Concept of Semaphores, Introduction to message queue function, Mailbox function, Pipe, Socket and RPC function.	**11 Hours**
Module-5	**Application & Case Studies**: Design process and design examples, Automatic chocolate vending machine, Digital camera, Adaptive Cruise control, Smart card.	**9 Hours**
	Total	**56 Hours**

Text Books:

T1. R. Kamal, ***Embedded Systems : Architecture, Programming and Design***, 12th Reprint, Tata McGraw-Hill, 2007.
T2. K. V. Shibu, ***Introduction to Embedded Systems***, 2nd *Ed.*, McGraw-Hill Education, 2017.
T3. R. Mall, ***Real-Time Systems***, 2nd *Ed.*, Pearson Education, 2010.

Reference Books:

R1. D. E. Simon, ***An Embedded Software Primer***, Addison Wesley, 1999.
R2. C. Baron, J. Geffroy, and G. Motet (Eds), ***Embedded System Applications***, Springer, 1997.
R3. S. Iyer and P. Gupta, ***Embedded Real time Systems Programming***, 1st *Ed.*, McGraw-Hill, 2017.
R4. Q. Li and C. Yao, ***Real-Time Concepts for Embedded Systems***, 1st *Ed.*, CRC Press, 2003.

R5. K. V. K. Prasad, ***Embedded / Real-Time Systems: Concepts, Design and Programming***, 1st *Ed.*, Wiley India, 2003.

Online Resources:

1. https://nptel.ac.in/courses/117105234: by Prof. S. Chattopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/108106176: by Prof. L. S. Jayashree, IIT Madras

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

CO1	Describe components, characteristics, and design metrics of embedded and real-time systems.
CO2	Explain RTOS concepts and analyze task scheduling methods in real-time embedded systems.
CO3	Apply advanced RTOS scheduling and task management for efficient real-time system design.
CO4	Implement IPC and process synchronization in real-time embedded systems.
CO5	Explore modern embedded trends and real-time applications through case studies.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Industrial Internet of Things	L-T-P	Credits	Marks
MNR	EC4004		4-0-0	4	100

Objectives	The objective of this course is to learn the design & implementation of IoT applications for industrial automation by connecting the sensors to the cloud and extracting the data from cloud to the connected devices.
Pre-Requisites	Knowledge of IoT protocols and architecture is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions shall focus on design, programming and applications of IoT.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Background, Key technologies, Use cases of the IIoT; IoT & IIoT - Similarities and differences, IoT Analytics and AI, Industry environments, scenarios covered by IIoT.	**10 Hours**
Module-2	**The Industrial Process**: The CIM Pyramid; The IIoT data flow - MODBUS-TCP, OPC-UA, MQTT, PROFINET, CAN, Edge devices, Gateway with preprocessing and filtering, Enterprise applications, Condition monitoring, Production insights.	**10 Hours**
Module-3	**The IIoT Data Flow**: IIoT data flow in the factory, Measurements and the actuator chain, Controllers, Industrial Protocols, SCADA, ERP & MES.	**11 Hours**
Module-4	**Implementing Industrial IoT**: IoT Data Flow, Discovering OPC, OPC Classic, OPC UA, Understanding the IIoT edge, Implementing the IIoT data flow.	**12 Hours**
Module-5	**Implementing IIoT on Cloud**: AWS Technical requirements - AWS Architecture, Registering for AWS, IoT Core, Storing Data, AWS Analytics, Understanding Diagnostics Maintenance; Predictive Analytics - Technical Requirements, Different classes of analytics, IIoT Analytics Technologies, Building IIoT Analytics, Understanding the role of the Infrastructure, Deploying Analytics.	**13 Hours**
	Total	**56 Hours**

Text Books:

T1. G. V. A. Capasso, ***Hands-On Industrial Internet of Things***, Packt Publishers, 2018.
T2. I. Butun, ***Industrial IoT***, 1st *Ed.*, Springer, 2020.
T3. A. Suresh, M. Nandagopal, P. Raj, E. A. Neeba, and J-W. Lin, ***Industrial IoT: Application, Architectures and Use Cases***, 1st *Ed.*, CRC Press, 2020.

Reference Books:

R1. O. Hersent, D. Boswarthick, and O. Elloumi, ***The Internet of Things: Key Applications and Protocols***, Student Edition, John Wiley & Sons, 2016.
R2. A. Gilchrist, ***Industry 4.0: The Industrial Internet of Things***, 1st *Ed.*, Apress, 2017.

Online Resources:

1. https://nptel.ac.in/courses/106105195: by Prof. S. Misra, IIT, Kharagpur
2. https://nptel.ac.in/courses/106105166: by Prof. S. Misra, IIT, Kharagpur
3. https://nptel.ac.in/courses/108105064: by Prof. A. Barua, IIT, Kharagpur

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

CO1	Explain technical requirements, key technologies, and use cases of Industrial IoT (IIoT).
CO2	Analyze industrial processes, devices, data flow, and communication protocols in IIoT systems.
CO3	Design network protocols and software layers for industrial data flow and device integration.
CO4	Implement IIoT data flow from edge to cloud using OPC UA and Node-RED platforms.
CO5	Develop cloud-based IIoT solutions and perform analytics for real-world industrial applications.

Program Outcomes Relevant to the Course:

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

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

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

Category	Code	Smart Power Systems	L-T-P	Credits	Marks
MNR	EE4006		3-0-1	4	100

Objectives	The objective of the course is to learn fundamental and interdisciplinary knowledge of Smart Power Systems, including smart grid concepts, communication infrastructure, distributed energy resources, energy storage, wide area monitoring, and microgrids, along with hands-on exposure through simulation, programming, and software-based analysis.
Pre-Requisites	Basic understanding of Electrical Power Systems, Basic Electronics, Communication Systems, Simulation and Programming is required.
Teaching Scheme	Regular classroom lectures integrated with practice sessions involving simulation, software tools and programming exercises; sessions are planned to focus on real-world implementation of smart power systems.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Smart Power Systems & Grid Components**: Evolution of electric grid, Basic concepts of conventional power systems, Need for smart power systems, Standard concepts & definitions, Functions, Opportunities, Challenges & benefits, Comparison between conventional grid & smart grid, Basic power system network modelling using software tools; Smart Grid Components - Smart infrastructure, Communication, Management and protection, National & international smart grid initiatives, Case study analysis of Indian smart grid projects.	**10 Hours**
Module-2	**Architecture & Protocols**: Smart grid architecture domains, IEEE/IEC Standards on Smart Grid; Smart metering, Advanced Metering Infrastructure (AMI), Distribution automation, SCADA, Outage Management System (OMS), Plug-in Hybrid Electric Vehicles, Vehicle-to-Grid (V2G); AMI communication simulation, SCADA block diagram implementation using software tools; Communication infrastructure—WAN, NAN, HAN, Communication technologies—Ethernet, WLAN, Bluetooth, ZigBee, WiMAX, Broadband over Power Line; IEC/IEEE communication protocol standards.	**13 Hours**
Module-3	**Distributed Energy & Storage**: Distributed energy resources—Solar PV, Solar thermal, Biomass, Wind, Fuel cells, And Micro-turbines (Working principles and characteristics); PV and Wind system simulation using software tools; Energy storage technologies—Mechanical, Electrical, Electromagnetic, Electrochemical (BESS), And Thermal storage systems; Battery charging–discharging modeling.	**11 Hours**
Module-4	**Wide Area Monitoring & Smart Sensors**: Wide Area Measurement System (WAMS)—Phasor estimation, Synchrophasor concept, PMU structure and operation, Applications of PMU; PMU data visualization using software tools; Smart sensors—Intelligent electronic devices (IEDs), GIS; Basics of Demand Side Management (DSM); DSM optimization using basic programming.	**11 Hours**

Cont'd. . .

Module-#	Topics	Hours
Module-5	**Microgrids**: Introduction and definitions of microgrids, Types of microgrids – AC, DC, Hybrid; Modes of operation, Microgrid control and protection, Structure of AC and DC microgrids, Challenges and value addition, Microgrid simulation in grid-connected and islanded modes, Load sharing simulation in AC microgrids.	**11 Hours**
	Total	**56 Hours**

Text Books:

T1. D. Jayaweera, ***Smart Power Systems and Renewable Energy System Integration***, 1st *Ed.*, Springer, 2018.
T2. J. Ekanayake, N. Jenkins, K. Liyanage, J. Wu, and A. Yokoyama, ***Smart Grid: Technology and Applications***, 1st *Student Ed.*, Wiley, 2012.
T3. C. W. Gellings, ***The Smart Grid: Enabling Energy Efficiency and Demand Response***, 1st *Ed.*, CRC Press, 2009.

Reference Books:

R1. S. Borlase, ***Smart Grid: Infrastructure, Technology and Solutions***, 1st *Ed.*, CRC Press, 2012.
R2. A. G. Phadke and J. S. Thorp, ***Synchronized Phasor Measurement and their Applications***, 1st *Ed.*, Springer, 2008.
R3. J. A. Momoh, ***Smart Grid: Fundamentals of Design and Analysis***, 1st *Ed.*, Wiley-IEEE Press, 2012.
R4. P. F. Schewe, ***The Grid: A Journey through the Heart of our Electrified World***, 1st *Ed.*, Joseph Henry Press, 2007.
R5. S. K. Salman, ***Introduction to the Smart Grid: Concepts, Technologies and Evolution***, 1st *Ed.*, IET, 2017.

Online Resources:

1. https://nptel.ac.in/courses/108107113: by Prof. N.P. Padhy and Prof. P. Jena, IIT Roorkee
2. https://npp.gov.in/dashBoard/cp-map-dashboard
3. https://www.smartgrid.gov/
4. http://www.nsgm.gov.in/

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

CO1	Describe and model smart power systems and their components using software tools.
CO2	Explain architecture, standards, and communication in Smart Power Systems and analyze use.
CO3	Analyze distributed energy resources, storage tech, and model operation using simulation tools.
CO4	Interpret wide area monitoring systems and smart sensor data using software tools.
CO5	Evaluate microgrid operation and control via simulation in grid-connected and islanded modes.

Program Outcomes Relevant to the Course:

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

Cont'd. . .

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

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

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

Category	Code	Intelligent Transportation & E-Mobility	L-T-P	Credits	Marks
MNR	EE4005		3-0-1	4	100

Objectives	The objective of this course is to provide a systems-level understanding of electric, connected, and autonomous mobility technologies, including EV architecture, battery systems, autonomous perception, and connected vehicle communication, with emphasis on embedded systems, AI, control, and sustainability.
Pre-Requisites	Fundamentals of engineering mathematics, signals & systems, control systems, digital/embedded systems, and programming is required.
Teaching Scheme	Regular classroom lectures supported by ICT tools, with interactive discussions, case studies, simulations, and hands-on problem solving related to EVs, autonomous systems, and intelligent mobility.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Electric Vehicle Ecosystem**: Evolution of electric vehicles and global mobility trends; Electric, hybrid, and internal combustion engine (ICE) vehicles – comparison; EV architecture and system integration; EV subsystems – Powertrain architecture, Electric motor and controller, Battery pack and Battery Management System (BMS), Charging systems; Charging infrastructure – AC & DC standards; Government policies, incentives, and EV roadmap in India; EV safety aspects and automotive standards overview; System-level modeling and comparative analysis of electric, hybrid, and ICE vehicles.	**10 Hours**
Module-2	**Battery Technology & Management**: Battery fundamentals and electrochemistry; Battery chemistries – Li-ion, LFP, NMC, Solid-state; Battery performance parameters – SOC, SOH, DOD, C-rate, Energy and power density; Battery pack design and configuration; Thermal management techniques; Battery Management Systems (BMS) – Architecture, Hardware components, Cell balancing, Protection, Monitoring; Charging methods and safety considerations; Battery recycling, Second-life applications, Sustainability; Simulation and analysis of battery and BMS performance.	**12 Hours**
Module-3	**Traction Systems, Power Electronics & Diagnostics**: Electric motors – BLDC, PMSM, Induction motors; Traction motor characteristics and selection criteria; Motor control strategies and speed–torque control; Power electronic converters – Inverters and motor controllers; Regenerative braking and energy recovery; EV traction system fault analysis; Diagnostic tools, fault codes, and condition monitoring; Predictive maintenance in EV systems; Simulation of traction motor drive and regenerative braking performance.	**12 Hours**

Cont'd. . .

Module-#	Topics	Hours
Module-4	**Autonomous Vehicles & Computer Vision**: Levels of vehicle autonomy (SAE L0–L5); Sensor technologies – Cameras, LiDAR, Radar, Ultrasonic sensors; Advanced Driver Assistance Systems (ADAS) – AEB, ACC, LDW, LKA; Localization and mapping fundamentals; Perception, Planning, and Control of autonomous vehicles; Image processing basics – Filtering, Edge detection, Feature extraction; Object and lane detection; Deep learning for computer vision; OpenCV fundamentals with Python demonstrations; Computer vision-based lane and object detection for autonomous driving.	**12 Hours**
Module-5	**Connected & Intelligent Mobility Systems**: Connected vehicle concepts and intelligent transportation systems; V2X communication – V2V, V2I, V2P, V2C; Telematics and IoT in automotive applications; GPS/GNSS navigation and digital mapping; Role of 5G and edge computing in smart mobility; Embedded systems architecture – Microcontrollers, sensors, actuators; Automotive communication protocols – CAN, LIN, FlexRay; Electronic Control Unit (ECU) architecture; Automotive cybersecurity – Threats, Vulnerabilities, ISO 21434 overview; AI and machine learning in mobility – Battery health prediction, Predictive maintenance, Driver monitoring, Traffic prediction, Route optimization; Industry tools – MATLAB, Python, ROS; Connected vehicle data analysis and embedded communication demonstration.	**10 Hours**
	Total	**56 Hours**

Text Books:

T1. J. Larminie and J. Lowry, ***Electric Vehicle Technology Explained***, 2nd *Ed.*, Wiley, 2012.
T2. C. C. Chan and K. T. Chau, ***Electric and Hybrid Vehicles***, 1st *Ed.*, McGraw-Hill, 2001.
T3. G. L. Plett, ***Battery Management Systems, Vol. 1 & 2***, 2nd *Ed.*, Artech House, 2015.

Reference Books:

R1. R. Krishnan, ***Electric Motor Drives***, 1st *Ed.*, Pearson Education, 2001.
R2. N. Mohan, T. M. Undeland, and W. P. Robbins, ***Power Electronics***, 3rd *Ed.*, Wiley, 2003.
R3. R. Szeliski, ***Computer Vision: Algorithms and Applications***, 2nd *Ed.*, Springer, 2022.

Online Resources:

1. nptel.ac.in/courses/108102121: by Prof. A. Jain, IIT Delhi
2. https://nptel.ac.in/courses/108106182: by Prof. A. Jhunjhunwala, et. al., IIT Madras
3. www.sae.org
4. https://e-amrit.niti.gov.in/national-level-policy

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

CO1	Explain EV architecture, subsystems, charging infrastructure, and EV policies in India.
CO2	Analyze EV battery technologies, performance metrics, BMS functions, and safety aspects.
CO3	Apply traction motor control, power electronics, and diagnostics in EV drive systems.
CO4	Explore autonomous driving principles, sensors, ADAS, and computer vision techniques.
CO5	Apply connected vehicle technologies, embedded platforms, and AI applications in mobility.

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).

Cont'd. . .

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

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

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

Category	Code	Financial Management	L-T-P	Credits	Marks
MNR	MG4005		3-1-0	4	100

Objectives	This course introduces the fundamentals of financial management to evaluate technology projects, interpret financial information, and make informed decisions considering cost, risk, and business outcomes.
Pre-Requisites	Basic understanding of mathematics and engineering economics is required.
Teaching Scheme	Regular classroom lectures with the use of ICT tools as and when required; sessions emphasize interactive discussions, real-world examples and spreadsheet-based financial analysis.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Role of finance in Engineering organizations; Objectives and scope of financial management; Interface of finance with engineering, operations, and marketing; Revenue, cost, and profit concepts; Financial statements – Profit and Loss statement, Balance sheet, Cash flow statement; Financial planning and forecasting; Risk–return relationship; Financial vs technical success of projects.	**10 Hours**
Module-2	**Financial Planning & Capital Budgeting**: Financial planning in Engineering and IT projects; Project cost and cash flow estimation; Time value of money; Capital budgeting process; Cash flow techniques – Payback period, Net Present Value (NPV), Internal Rate of Return (IRR); Comparison of alternative engineering projects; Sensitivity analysis, risk evaluation, and capital rationing; Evaluation of new technology and automation investments.	**12 Hours**
Module-3	**Cost of Capital & Investment Decisions**: Sources of long-term finance – equity and debt; Cost of capital – concept and significance; Cost of equity, debt, and retained earnings (basic understanding); Weighted Average Cost of Capital (WACC) in investment decisions; Financial vs technological risk in projects; Decision contexts – Cloud vs on-premise infrastructure, Buy vs build, Outsourcing vs in-house development.	**10 Hours**
Module-4	**Working Capital & Operational Finance**: Working capital in project-driven organizations; Cash budgeting and short-term financial planning; Sources of short-term finance; Inventory management – Economic Order Quantity (EOQ); Receivables and payables management; Monitoring and control of inventory and receivables; Impact of project delays and cost overruns on cash flows; Cost optimization and operational efficiency.	**12 Hours**
Module-5	**Financial Decision Making**: Budgeting and variance analysis for engineering projects; Financial dashboards and performance indicators; Financial KPIs in organizations; Project performance and financial feasibility evaluation; Long-term financial sustainability and impact of engineering decisions; Ethical considerations in financial decisions; Integrated evaluation of projects considering technical feasibility, financial viability, risk, and sustainability.	**12 Hours**
	Total	**56 Hours**

Text Books:

T1. F. Crundwell, ***Finance for Engineers***, 1st *Ed.*, Springer Publications, 2008.
T2. I. M. Pandey, ***Financial Management***, 13th *Ed.*, Vikas Publishing House, 2025.
T3. L. J. Gitman and C. J. Zutter, ***Principles of Managerial Finance***, 13th *Ed.*, Pearson Education, 2017.

Reference Books:

R1. M. Y. Khan and P. K. Jain, ***Financial Management: Text, Problems and Cases***, 8th *Ed.*, McGraw-Hill, 2018.
R2. P. Chandra, ***Financial Management: Theory and Practice***, 11th *Ed.*, McGraw-Hill, 2022.
R3. S. N. Maheshwari and S. K. Maheshwari, ***Financial Management: Principles and Practice***, 13th *Ed.*, S. Chand & Sons, 2021.
R4. R. M. Kishore, ***Financial Management***, 8th *Ed.*, Taxmann Publications, 2022.

Online Resources:

1. https://nptel.ac.in/courses/110107144: by Prof. A. K. Sharma, IIT Roorkee
2. https://nptel.ac.in/courses/110107073: by Prof. A. K. Sharma, IIT Roorkee
3. https://nptel.ac.in/courses/111103126: by Prof. N. Selvaraju and S. P. Chakrabarty, IIT Guwahati
4. https://ocw.mit.edu/courses/15-414-financial-management-summer-2003/pages/lecture-notes/

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

CO1	Explain the role of finance, financial statements, and risk–return concepts in projects.
CO2	Apply capital budgeting techniques to evaluate engineering and technology investments.
CO3	Analyze cost of capital and financial risks in technology investment decisions.
CO4	Apply working capital concepts for short-term financial planning and operations.
CO5	Evaluate engineering projects using financial indicators and feasibility analysis.

Program Outcomes Relevant to the Course:

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

Cont'd. . .

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

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

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

Category	Code	Business Strategy	L-T-P	Credits	Marks
MNR	MG4006		3-1-0	4	100

Objectives	The objective of this course is to equip technical students with strategic thinking skills to analyze markets, develop technology-driven strategies, and manage innovation in engineering and technology enterprises.
Pre-Requisites	Basic understanding of mathematics and business operations in an engineering project environments is required.
Teaching Scheme	Regular classroom lectures with the use of ICT tools as and when required; sessions emphasize interactive discussions, real-world examples and case studies.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Strategy Foundations**: Concept of strategy and strategic management, Strategic thinking vs strategic planning, Levels of strategy – Corporate, Business, Functional, Strategic management process, Vision, Mission, Goals and strategic intent, Stakeholders and corporate governance, Strategy in engineering and technology organizations, Strategy frameworks and analytical tools.	**10 Hours**
Module-2	**Industry Analysis**: External environment analysis, PESTLE analysis, Industry structure and competition, Porter's Five Forces model, Industry life cycle and technology evolution, Competitor analysis and benchmarking, Technology disruption and digital competition, Market positioning in technology industries.	**12 Hours**
Module-3	**Resources & Innovation**: Internal analysis of firms, Resources and capabilities, Core competencies in technology organizations, Value chain analysis in manufacturing and digital firms, VRIO framework, Innovation and R&D strategy, Technology commercialization, Intellectual property and knowledge assets.	**10 Hours**
Module-4	**Strategy Design**: Business strategies – Cost leadership, Differentiation, Focus strategy, Platform and ecosystem strategies, Startup and entrepreneurial strategies, Strategic alliances, Mergers and acquisitions in technology sectors, Strategy implementation, Organizational structure and project-based organizations.	**12 Hours**
Module-5	**Digital & Global Strategy**: Strategic control and evaluation, Balanced scorecard and KPIs, Risk management and governance, Sustainability and responsible innovation, Digital transformation strategies, AI and data-driven strategy, Case studies of global technology companies and engineering enterprises.	**12 Hours**
	Total	**56 Hours**

Text Books:

T1. F. T. Rothaermel, ***Strategic Management***, 6th *Ed.*, McGraw-Hill Education, 2023.
T2. R. M. Grant, ***Contemporary Strategy Analysis***, 11th *Ed.*, Wiley, 2021.
T3. M. A. Hitt, R. D. Ireland, and R. E. Hoskisson, ***Strategic Management: Competitiveness and Globalization***, 13th *Ed.*, Cengage Learning, 2022.

Reference Books:

R1. R. Rumelt, ***Good Strategy/Bad Strategy: The Difference and Why It Matters***, 1st *Ed.*, Crown Business, 2011.
R2. W. C. Kim and R. Mauborgne, ***Blue Ocean Strategy***, Expanded Edition, Harvard Business Review Press, 2015.
R3. C. M. Christensen, ***The Innovator's Dilemma***, Revised Edition, Harvard Business Review Press, 2016.
R4. E. Ries, ***The Lean Startup***, 1st *Ed.*, Crown Business, 2011.

Online Resources:

1. https://nptel.ac.in/courses/110108047: by Prof. R. Srinivasan, IISc Bangalore
2. https://nptel.ac.in/courses/110106157: by Prof. C. B. Rao, IIT Madras
3. https://nptel.ac.in/courses/110105161: by Prof. S. Chowdhury, IIT Kharagpur
4. https://nptel.ac.in/courses/110106164: by Prof. C. B. Rao, IIT Madras

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

CO1	Explain strategy concepts, strategic intent, and decision making in organizations.
CO2	Analyze industry structure and external environment using strategic tools.
CO3	Evaluate resources, capabilities, and innovation for competitive advantage.
CO4	Formulate business and corporate strategies for technology-driven firms.
CO5	Assess strategic performance, risks, and digital transformation initiatives.

Program Outcomes Relevant to the Course:

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

P.T.O

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

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

Category	Code	Business Intelligence & Visualization	L-T-P	Credits	Marks
MNR	MG4003		3-1-0	4	100

Objectives	The objective of this course is to enable students to create dashboards and illustrate data stories effectively using modern BI tools.
Pre-Requisites	Knowledge of statistics with programming and spreadsheet tools is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples, case-studies and latest trends.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Business Intelligence & Data Warehousing**: Introduction to Business Intelligence (BI); Role of BI in organizations; OLTP vs OLAP systems; Data warehousing concepts and architecture; ETL process – Extract, Transform, Load; Data marts; Star and Snowflake schema; Fact and dimension tables; Understanding sample data warehouse schema; Designing simple Star schema for retail or sales dataset.	**8 Hours**
Module-2	**Relational Databases & SQL**: Relational database concepts – Tables, Keys, Relationships; SQL queries – SELECT, WHERE, ORDER BY, GROUP BY, HAVING, Aggregation functions (SUM, AVG, COUNT); Joins – INNER, LEFT/RIGHT; Subqueries; Basic data cleaning using SQL; Writing MySQL queries and extracting KPIs from transactional data.	**10 Hours**
Module-3	**Data Visualization**: Importance of visual communication; Chart types and usage – Bar, Line, Pie, Scatter, Heat map; Avoiding misleading visualizations; Colour theory and perception; Data-ink ratio; Designing for clarity and impact; Visual best practices; Improving poor visualizations; Selecting charts for business scenarios.	**8 Hours**
Module-4	**Dashboard Design & KPIs**: Dashboards and their purpose; Types – Strategic, Operational, Analytical; Key Performance Indicators (KPIs); Designing KPIs for Sales, Finance, Marketing, Operations; Layout & usability principles; Interactive filters & drill-downs; Real-time vs static dashboards; KPI framework design for a case company; Dashboard layout wireframe.	**10 Hours**
Module-5	**Using Power BI / Tableau**: Connecting to data sources; Data transformation using Power Query / Tableau Prep; Calculated fields and measures; Visualizations and dashboards; Filters and slicers; Publishing and sharing reports; Basic DAX (Power BI); Parameters and calculated fields (Tableau); Dashboard development from raw datasets; Industry datasets – Retail, Automobile, Manufacturing, Healthcare; Publishing dashboard.	**12 Hours**
Module-6	**Storytelling with Data**: Data storytelling concepts; Structuring business narratives; Framing business problems; Insight vs information; Executive presentation of dashboards; Business recommendations; Pitfalls in BI reporting; Mini project – Problem definition, Data analysis, Dashboard creation, Presentation to mock management panel.	**8 Hours**
	Total	**56 Hours**

Text Books:

T1. C. N. Knaflic, ***Storytelling With Data: A Data Visualization Guide For Business Professionals***, 1st *Ed.*, Wiley, 2015.
T2. R. Kimball and M. Ross, ***The Data Warehouse Toolkit***, 2nd *Ed.*, Wiley, 2013.

Reference Books:

R1. R. N. Prasad and S. Acharya, ***Fundamentals of Business Analytics***, 2nd *Ed.*, Wiley, 2011.
R2. S. Sringeswara, P. Tiwari, and U. D. Kumar, ***Data Visualization: Storytelling Using Data***, 1st *Ed.*, Wiley, 2022.
R3. B. Dykes, ***Effective Data Storytelling***, 1st *Ed.*, Wiley, 2019.

Online Resources:

1. https://www.youtube.com/watch?v=Jy9tn9iR9Oo: by Prof. S. Quader, NPTEL-NOC IITM
2. https://www.youtube.com/watch?v=JhjpC2tbFxs: by Simplilearn
3. https://www.youtube.com/playlist?list=PLahhVEj9XNTdg4FnhAo_OQ-bSDd86VBcH: by Microsoft Learn

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

CO1	Explain BI concepts, data warehousing architecture, and dimensional modeling.
CO2	Write SQL queries to retrieve, aggregate, and analyze data from relational databases.
CO3	Apply data visualization principles to create clear and effective charts.
CO4	Design dashboards and define KPIs for business performance monitoring.
CO5	Develop interactive dashboards using Power BI or Tableau for data analysis.
CO6	Present business insights using data storytelling and structured narratives.

Program Outcomes Relevant to the Course:

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

P.T.O

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

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

Category	Code	Business Analytics Using Power of AI	L-T-P	Credits	Marks
MNR	MG4004		3-1-0	4	100

Objectives	The objective of this course is to apply business analytics, BI, and AI tools to solve real-world, industry-style problems using structured and unstructured data while considering ethics and governance.
Pre-Requisites	Knowledge of mathematics, statistics and worksheet operations is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required; sessions are planned to be interactive with focus on examples, case-studies and hands-on practice.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**AI in Business & Analytics Landscape**: Evolution from BI to AI-assisted analytics; AI in decision-making; Prompt curation for forecasting models – Descriptive, Diagnostic, Predictive, Prescriptive; AI tools for data analytics; AI technologies in business; Data-driven culture.	**8 Hours**
Module-2	**Sectoral Applications of AI-Assisted Analytics**: Finance – Fraud detection, Credit scoring, Risk analytics, Algorithmic trading basics; Retail – Demand forecasting, Customer segmentation, Recommendation systems, Inventory optimization; Healthcare – Disease prediction models, Patient risk stratification, Medical imaging analytics (conceptual); Automobile – Predictive maintenance, Autonomous systems (conceptual), Supply chain optimization; Manufacturing – Quality control using AI, Production optimization, Smart factory analytics; Sectoral case study analysis.	**12 Hours**
Module-3	**Big Data Concepts**: 5Vs of Big Data – Volume, Velocity, Variety, Veracity, Value; Structured, semi-structured, and unstructured data; Data lakes vs data warehouses; Distributed computing basics; Hadoop & Spark basics (conceptual); Batch vs stream processing.	**8 Hours**
Module-4	**Cloud Platforms for Analytics**: Role of cloud computing in analytics; Google Colab for ML projects; AWS basics – EC2, S3 storage, Overview of analytics services; Cloud deployment basics; Cost awareness in cloud computing; Running ML model in Google Colab; Uploading dataset to cloud storage; Platforms – Google Colab, Amazon Web Services.	**8 Hours**
Module-5	**AI-Assisted Analytics Project**: Problem identification, Data collection, Data cleaning & preprocessing, Feature engineering, Model selection, Evaluation metrics, Business interpretation, Deployment-ready presentation, Technical report, Dashboard or model output, Executive presentation, Ethical assessment.	**12 Hours**
Module-6	**Ethics, Governance & Data Privacy**: Algorithmic bias; Fairness in AI; Responsible AI principles; Data privacy concerns; Data protection regulations – General Data Protection Regulation, Information Technology Act; Data anonymization concepts; Transparency and Explainable AI (XAI); Case studies – AI bias incidents, Data breaches, Ethical failures in analytics projects.	**8 Hours**
	Total	**56 Hours**

Text Books:

T1. R. Sharda, D. Delen, and E. Turban, ***Business Intelligence, Analytics, Data Science, and AI***, 5th *Ed.*, Pearson Education, 2024.
T2. P. C. Bruce, et. al., ***Machine Learning for Business Analytics***, 2nd *Ed.*, Wiley, 2023.

Reference Books:

R1. S. G. Yaseen, ***Applied Artificial Intelligence in Business***, 1st *Ed.*, Springer Nature, 2025.
R2. J. Boffa, ***AI Assisted Business Analytics***, 1st *Ed.*, Springer, 2023.
R3. A. H. Gandomi, F. Chen, and L. Abualigah, ***Big Data Analytics Using Artificial Intelligence***, 1st *Ed.*, John MDPI Books, 2023.

Online Resources:

1. https://www.youtube.com/watch?v=J5WnKMIOQuY: Google Data Analytics
2. https://www.youtube.com/watch?v=JhjpC2tbFxs: by Simplilearn
3. https://www.youtube.com/watch?v=yuIMWWMWN4A: by TechCanvas

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

CO1	Identify and formulate real-world business problems suitable for AI-assisted analytics solutions.
CO2	Apply analytics techniques across key sectoral domains such as Finance, Retail, and Healthcare.
CO3	Apply big data concepts and tools in handling large-scale structured & semi-structured datasets.
CO4	Explore & utilize popular cloud-based platforms for scalable analytics implementation.
CO5	Develop end-to-end AI-assisted analytics solutions for real-world business problems.
CO6	Evaluate ethical, legal, and privacy implications in AI-driven business analytics applications.

Program Outcomes Relevant to the Course:

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

P.T.O

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

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

Category	Code	Skill Lab & Project-I	L-T-P	Credits	Marks
PRJ	IP4007		0-0-4	2	100

Objectives	This laboratory course focuses on overall skill development of through problem formulation, designing, development and implementation of models as solution for the identified problem. Students will be introduced to different open source tools to carry out the assigned project, finishing with project demonstration, report, presentation, viva, and evaluation.
Pre-Requisites	Knowledge on programming languages like C, C++, Java, Python, RDBMS tools such as PostreSQL, front-end tools and Scientific Document preparation tools are required.
Teaching Scheme	Regular laboratory classes conducted under supervision of the teacher, comprising of programming assignments leading to a complete project.

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	Problem Identification – I.
2	Problem Identification – II.
3	Problem Formulation.
4	Designing the Model – I.
5	Designing the Model – II.
6	Database Design – I.
7	Database Design – II.
8	Development and Implementation of Model – I.
9	Development and Implementation of Model – II.
10	Development and Implementation of Model – III.
11	Development and Implementation of Model – IV.
12	Interim Project Presentation & Viva.
13	Development and Implementation of Model – V.
14	Development and Implementation of Model – VI.
15	Development and Implementation of Model – VII.
16	Development and Implementation of Model – VIII.
17	Development and Implementation of Model – IX.
18	Development and Implementation of Model – X.
19	GUI Development – I.
20	GUI Development – II.
21	GUI Development – III.
22	Performance Analysis and Testing – I.
23	Performance Analysis and Testing – II.

Cont'd. . .

Experiment-#	Assignment/Experiment
24	Project Report Preparation – I.
25	Project Report Preparation – II.
26	Project Report Preparation – III.
27	Project Report Preparation – IV.
28	Final Project Presentation & Viva.

Text Books:

T1. B. W. Kernighan and D. M. Ritchie, ***The C Programming Language***, 2nd *Ed.*, Pearson Education, 2015.
T2. H. Schildt, ***The Complete Reference C++***, 5th *Ed.*, McGraw-Hill, 2015.
T3. H. Schildt, ***Java - The Complete Reference***, 13th *Ed.*, McGraw-Hill, 2024.
T4. R. Sedgewick, K. Wayne, and R. Dondero, ***Introduction to Programming in Python : An Interdisciplinary Approach***, 2nd *Ed.*, Pearson Education, 2024.

Reference Books:

R1. Z. A. Shaw, ***Learn C the Hard Way: Practical Exercises on the Computational Subjects You Keep Avoiding (Like C)***, 1st *Ed.*, Addison Wesley, 2016.
R2. B. Stroustrup, ***The C++ Programming Language***, 4th *Ed.*, Addison-Wesley, 2013.
R3. E. Matthes, ***Python Crash Course: A Hands on Project-based Introduction to Programming***, 3rd *Ed.*, William Pollock, 2023.

Online Resources: *There are a number of online resources available for this course. The student is advised to search on the Internet and locate the required study materials as per advise of the teacher.*

Note: Additional course/reference materials, research publications, manuals/API, tools, libraries, or other software may be suggested by the teacher as per requirement of the skills needed for the project.

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

CO1	Identify different real-life problems from a given situation or environment.
CO2	Design and develop mathematical models for the existing problems.
CO3	Implement the proposed models by selected programming languages or tools.
CO4	Validate the model using test cases for practical implementation in real-life as a product.
CO5	Deploy the model and contribute it as a product to the society.

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

Cont'd. . .

PO5	**Engineering Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems (WK2 and WK6).
PO6	**The Engineer and The World**: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment (WK1, WK5, and WK7).
PO7	**Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO9	**Communication**: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO11	**Life-Long Learning**: Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

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

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



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