

St. Francis Institute of Technology

(Engineering College)

(An Autonomous Institute, Affiliated to University of Mumbai)

S.V.P. Road, Borivli (W), Mumbai



Bachelor of Engineering in Computer Engineering

Third Year Scheme and Syllabus

w.e.f. Academic Year 2026– 2027

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Preamble

Engineering education plays a pivotal role in today's world by equipping individuals with the knowledge, skills, and mindset needed to drive technological advancements, tackle complex global challenges, and foster societal progress.

St. Francis Institute of Technology (SFIT) in Borivali, Mumbai, stands as a renowned engineering institute offering both undergraduate and postgraduate degree programs in engineering. Acknowledging its commitment to quality education, SFIT has earned autonomous status from the UGC with institute vide letter no. F.2-10/2023 (AC-Policy) dated 24th April 2024 with effect from the academic year 2024-25. In light of this achievement, SFIT is unveiling a distinctive new curriculum for its undergraduate engineering degree program. Aligned with SFIT's vision, this curriculum aims to nurture bright young minds into technological entrepreneurs and innovative leaders of tomorrow's world, while upholding the Franciscan values of integrity, peace, and love.

Quality assurance in higher education primarily relies on accreditation, focusing on evaluating program outcomes. The introduction of the newly developed autonomy curriculum for undergraduate engineering degrees enhances quality assurance through several measures. These include well-defined learning outcomes for each course, rigorous assessment methodologies, feedback mechanisms to monitor student progress and program effectiveness and adherence to the Outcome-based education (OBE) framework, emphasizing critical thinking and holistic skill development.

Reflecting the transformative vision of the National Education Policy (NEP) 2020, the updated curriculum prioritizes multidisciplinary learning, flexibility, research, and innovation, integrating soft skills cultivation and ethical principles while leveraging technology for enhanced learning experiences.

The revised curriculum adopts a Choice Based Credit and grading system, promoting continuous evaluation, and enabling credit transferability. Skill-based laboratories and mini projects are integral components, fostering experiential learning across engineering disciplines.

The undergraduate degree program will consist of a total of approximately **175** credits. Course credits are allocated based on a 15-week teaching-learning process, with course content delivered over 13 weeks, allowing the remaining 2 weeks for revision, guest lectures, and coverage of additional content beyond the syllabus. The overall credit distribution and curriculum approach in this revision align with the AICTE model curriculum.

The Computer Engineering syllabus is designed to focused on fundamental and core computer engineering courses along with the other multifaceted attributes like vocational skill courses, ability enhancement courses, multidisciplinary aspect and Co-curricular courses. It introduces the some EEM courses which can be learned on NPTEL/MOOC courses to develop the self- learning approach among students. Field project and course mini projects have been introduced to imbibe the problem identification and problem-solving skills among students.

This curriculum will be implemented sequentially for First Year Engineering from the academic year 2024-25, followed by subsequent years until the academic year 2027-28, aligning with the AICTE model curriculum.

Abbreviations

AEC	Ability Enhancement Courses
AIML	Artificial Intelligence and Machine Learning Engineering
BE	Fourth Year Engineering
BEE	Basic Electrical and Electronics Engineering
BSC	Basic Science Courses
CA	Continuous Assessment
CC	Co-curricular Courses
CEP	Community engagement project:
CMPN/CE	Computer Engineering
DAIML	Department of Artificial Intelligence and Machine Learning
DCMPN	Department of Computer Engineering
DECS	Department of Electronics and Computer Science
DEE	Department of Electrical Engineering
DEXTC	Department of Electronics and Telecommunication Engineering
DINFT	Department of Information Technology
DME	Department of Mechanical Engineering
ECS	Electronics and Computer Science
EE	Electrical Engineering
EEM	Entrepreneurship/Economics/Management
ELC	Experiential Learning Courses
ESC	Engineering Science Courses
ESE	End Semester Examination
EXTC	Electronics and Telecommunication Engineering
FBT	First Year B.Tech.
FP	Field Projects
HSSM	Humanities Social Sciences and Management
IKS	Indian Knowledge System
INFT	Information Technology
ISE	In Semester Evaluation
LLC	Liberal Learning Courses
MDC	Multidisciplinary Courses
MDM	Multidisciplinary Minor
ME	Mechanical Engineering
MSE	Mid Semester Examination
OE	Generic/ Open Electives (other than a particular program)
OrE	Oral Examination
OEC	Open Elective Courses

1 Course Structure and Curriculum

1.1 Definition of Credit

Table 1.1 Credit Allocation

Schedule	Score
1 Hour Lecture (L) per week	1 Credit
1 Hour Tutorial (T) per week	1 Credit
1 Hour Practical (P) per week	0.5 Credit
2 Hours Practical (P) per week	1 Credit

1.2 Range of Credits

Table 1.2 Options for 4 years Bachelor's Engg. / Tech. Degree

Level	Course Name	Total Credit Assigned
6	Bachelor's degree (B.E. / B.Tech.) in Computer Engineering	160-176
6	Bachelor's degree (B.E. / B.Tech.) in Computer Engineering with Honors	180-194
6	Bachelor's degree (B.E. / B.Tech.) in Computer Engineering with Honors with Research	180-194
6	Bachelor's degree (B.E. / B.Tech.) in Computer Engineering with Double Minor (Multidisciplinary and Specialization Minor)	180-194

1.3 Total Credits and Marks of B.E. / B.Tech. in CMPN Engineering

Table 1.3: Total Credits and Marks of Four-year CMPN Engineering Degree Program

S. No.	Academic Year	Total Credits	Total Marks
1	First Year	43	1450
2	Second Year	44	1450
3	Third Year	42	1475
4	Final Year (Tentative)	40	1375
	Total Credits of Program	169	5750

1.4 Semester-wise Credit Distribution Structure

Table 1.4 Credit distribution of verticals as per NEP-2020 in Third Year of B.Tech. in CMPN Engineering

Sr. No.	Course Type	Course Code	Courses	Credits	Total
Semester-V					
1	PCC	CE5PC_CR1	Data Warehousing and Mining	2	9
2		CE5PC_LR1	Data Warehousing and Mining Lab	1	
3		CE5PC_CR2	Computer Network & system Security	3	
4		CE5PC_LR2	Computer Network & System Security Lab	1	
5		CE5PC_CR3	Theory of Computer Science	2	
6	PEC	CE5PE_CX1	Programme Elective Course – I*	3	4
7		CE5PE_LX1	Programme Elective Course Lab - I *	1	
8	MDM	-	MDM-II *	4	4
9	OEC	-	OEC-II \$	4	4
Total					21
Semester-VI					
1	PCC	CE6PC_CR1	System Programming and Compiler Construction	3	11
2		CE6PC_LR1	System Programming and Compiler Construction Lab	1	
3		CE6PC_CR2	Artificial Intelligence	3	
4		CE6PC_LR2	Artificial Intelligence Lab	1	
5		CE6PC_CR3	Mobile Computing	2	
6		CE6PC_LR3	Mobile Computing Lab	1	
7	VS	CE6VS_LR4	Software Product Development Tools and Techniques	2	2
8	PEC	CE6PE_CR4	Programme Elective Course – II	3	4
9		CE6PE_LR4	Programme Elective Course Lab – II	1	
10	MDM	-	MDM-III *	4	4
Total					21

C-Course, L-Laboratory, T-Tutorial, P-Project

* Refer Table No. 1.5.2

\$Refer Table No. 1.5.3

1.5 Third Year Scheme of the Syllabus

1.5.1 Contact Hours and Credit Distribution of Courses

Table 1.5.1: Contact Hours and Credit Distribution of Courses

Semester V											
Sr. No.	Course Code	Course	Contact Hours				Credits Assigned				
			Theory (C)	Practical (L)	Tutorial (T)	Project (P)	C	L	T	P	Total
1	CE5PC_CR1	Data Warehousing and Mining	2	-	-	-	2	-	-	-	2
2	CE5PC_LR1	Data Warehousing and Mining Lab	-	2	-	-	-	1	-	-	1
3	CE5PC_CR2	Computer Network & system Security	3	-	-	-	3	-	-	-	3
4	CE5PC_LR2	Computer Network & System Security Lab	-	2	-	-	-	1	-	-	1
5	CE5PC_CR3	Theory of Computer Science	2	-	-	-	2	-	-	-	2
6	CE5PE_CX1	Programme Elective Course – I*	3	-	-	-	3	-	-	-	3
7	CE5PE_LX1	Programme Elective Course Lab - I *	-	2	-	-	-	1	-	-	1
8	-	MDM-II *	3	2	-	-	3	1	-	-	4
9	-	OEC-II \$	3	-	1	-	3	-	1	-	4
TOTAL			16	8	1	-	16	4	1	-	21
Semester VI											
Sr. No.	Course Code	Course	Contact Hours				Credits Assigned				
			Theory (C)	Practical (L)	Tutorial (T)	Project (P)	C	L	T	P	Total
1	CE6PC_CR1	System Programming and Compiler Construction	3	-	-	-	3	-	-	-	3
2	CE6PC_LR1	System Programming and Compiler Construction Lab	-	2	-	-	-	1	-	-	1
3	CE6PC_CR2	Artificial Intelligence	3	-	-	-	3	-	-	-	3
4	CE6PC_LR2	Artificial Intelligence Lab	-	2	-	-	-	1	-	-	1
5	CE6PC_CR3	Mobile Computing	2	-	-	-	2	-	-	-	2
6	CE6PC_LR3	Mobile Computing Lab	-	2	-	-	-	1	-	-	1
7	CE6VS_LR4	Software Product Development Tools and Techniques	-	4*	-	-	-	2	-	-	2
8	CE6PE_CX2	Programme Elective Course–II	3	-	-	-	3	-	-	-	3
9	CE6PE_LX2	Programme Elective Course Lab – II	-	2	-	-	-	1	-	-	1
10	-	MDM-III *	3	2	-	-	3	1	-	-	4
TOTAL			14	14	-	-	14	7	-	-	21

* Refer Table No. 1.5.3

\$ Refer Table No. 1.5.4

1.5.2 Programme Elective Courses –I (PEC-I) Offered in Third Year

Table: List of Programme Elective Courses - I with Credits

Sr. No	PEC Bucket Name	PEC-1 (SEM V) (4 credits)		PEC-2 (SEM VI) (4 credits)	
1	Machine Intelligence and Data Analytics	Machine Learning	Machine Learning Lab	Deep Learning	Deep Learning Lab
2	Cyber Security and Blockchain Technology	Ethical hacking and Digital Forensics	Ethical hacking and Digital Forensics Lab	Advanced Networks and System Security	Advanced Networks and System Security Lab
3	Immersive Technologies and Visual Computing	Computer Graphics	Computer Graphics Lab	Design Principles of UI/UX	Design Principles of UI/UX Lab
4	Full Stack Web Engineering	Internet Programming	Internet Programming Lab	Advanced web technology	Advanced web technology Lab

1.5.3 (MDM) Courses Offered in CMPN Program

Table 1.5.3: Semester-wise Credit Distribution of Multi-Disciplinary Minor Courses (MDM)

Sr No.	Minor Title	Sem IV (2 credits)	Sem V (4 credits)		Sem VI (4 credits)		Sem VII (4 credits)
1	Image Processing and computer Vision	Signals and Systems	Discrete Time Signal Processing	Discrete Time Signal Processing Lab	Digital Image Processing	Digital Image Processing Lab	Computer Vision and Machine Learning
	Course Codes	ET4MM_CX1	ET5MM_CX1	ET5MM_LX1	ET6MM_CX1	ET6MM_LX1	ET7MM_CX1
2	Embedded Systems	Digital System Design	Microprocessors and Microcontrollers	Microprocessors and Microcontrollers Lab	Advanced Microcontroller & Interfacing	Advanced Microcontroller & Interfacing Lab	Embedded Systems Applications
	Course Codes:	ET4MM_CX2	ET5MM_CX2	ET5MM_LX2	ET6MM_CX2	ET6MM_LX2	ET7MM_CX2
3	Electric Vehicles	Introduction to EV	Electric Vehicle Systems and Control	Vehicle Dynamics and EV Simulation Lab	Energy Systems and Charging Infrastructure	Energy Systems and Charging Infrastructure Lab	Advanced Topic in EV
	Course Codes:	EE4MM_CX1	EE5MM_CX1	EE5MM_LX1	EE6MM_CX1	EE6MM_LX1	ET7MM_CX1
4	IoT	Introduction to IoT and Core Technologies	Data Management, Cloud Integration, and Analytics	IoT Programming and Interfacing Lab	IoT System Design, Development, and Security	IoT Prototyping and Cloud Integration Lab	Advanced IoT Applications
	Course Codes:	EC4MM_CX1	EC5MM_CX1	EC5MM_LX1	EC6MM_CX1	EC6MM_LX1	EC7MM_CX1
5	Additive Manufacturing	Introduction to Additive Manufacturing	CAD for Additive Manufacturing	CAD Lab	Additive Manufacturing for Industrial Applications	Additive Manufacturing Lab	3D Printing for Medical Tech
	Course Codes:	ME4MM_CX1	ME5MM_CX1	ME5MM_LX1	ME6MM_CX1	ME6MM_LX1	ME7MM_CX1
6	Robotics	Introduction to Robotics	Mobile Robotics and Path Planning	Mobile Robotics and Path Planning Lab	Robot Perception and Control	Robot Perception and Control Lab	Industrial and Service Robots
	Course Codes:	ME4MM_CX2	ME5MM_CX2	ME5MM_CX2	ME6MM_CX2	ME6MM_LX2	ME7MM_CX1

1.5.4 Open Elective Courses-II (OEC-II) Offered in Semester-V

Table 1.5.4: List of Open Elective-II Courses with Credits

Course Code	List of OEC-II Courses
IL5OE_CX1	Project Management Practices
IL5OE_CX2	Digital Product Development
IL5OE_CX3	Systems Reliability Engineering
IL5OE_CX4	Decision Science & Business Optimization
IL5OE_CX5	Smart Business Information Systems
IL5OE_CX6	Design of Experiments and Data Analytics
IL5OE_CX7	Energy Audit and Management
IL5OE_CX8	Climate Change and Disaster Management

1.6 Evaluation and Examination Scheme of Third Year Syllabus

Table 1.6.1: Marks Distribution of Courses

Semester V							
S. No.	Course Code	Course	ISE		ESE		Total Marks
			CA	MSE	Theory	Practical	
1	CE5PC_CR1	Data Warehousing and Mining	15	15	45	-	75
2	CE5PC_LR1	Data Warehousing and Mining Lab	25	-	-	25	50
3	CE5PC_CR2	Computer Network & System Security	20	20	60	-	100
4	CE5PC_LR2	Computer Network & System Security Lab	25	-	-	25	50
5	CE5PC_CR3	Theory of Computer Science	15	15	45	-	75
6	CE5PE_CX1	Programme Elective Course – I*	20	20	60	-	100
7	CE5PE_LX1	Programme Elective Course Lab - I *	25	-	-	25	50
8	-	MDM-II *	20	20	60	-	100
			25	-	-	-	25
9	-	OEC-II \$	20	20	60	-	100
Total			210	110	330	100	725
Semester VI							
S. No.	Course Code	Course	ISE		ESE		Total Marks
			CA	MSE	Theory	Practical	
1	CE6PC_CR1	System Programming and Compiler Construction	20	20	60	-	100
2	CE6PC_LR1	System Programming and Compiler Construction Lab	25	-	-	25	50
3	CE6PC_CR2	Artificial Intelligence	20	20	60	-	100
4	CE6PC_LR2	Artificial Intelligence Lab	25	-	-	25	50
5	CE6PC_CR3	Mobile Computing	15	15	45	-	75
6	CE6PC_LR3	Mobile Computing Lab	25	-	-	25	50
7	CE6VS_LR4	Software Product Development Tools and Techniques	25	-	-	25	50
8	CE6PE_CR4	Programme Elective Course – II	20	20	60	-	100
9	CE6PE_LR4	Programme Elective Course Lab – II	25	-	-	25	50
10	-	MDM-III *	20	20	60	-	100
			25	-	-	-	25
Total			245	95	285	125	750

* Refer Table No. 1.5.3

\$ Refer Table No. 1.5.4

Evaluation Pattern:

Evaluations consist of the following –

1. **In Semester Evaluation (ISE)** which comprises of two components - Continuous assessment (CA) and Mid-Semester Examination (MSE)
 - CA - Includes home assignments, group assignments, quizzes, presentations, experiments, mock tests, tutorials, etc.
 - MSE - A written assessment covering up to 50% of the syllabus, conducted at mid-semester.
2. **End Semester Examination (ESE)** - A written assessment covering 100% of the syllabus, conducted at the end of the semester. Modules covered in the mid-semester exam will have a 30-40 % weightage, with the remaining 60 -70% weightage assigned to the rest of the modules.
3. **Practical Examination (PE), Oral Examination (OrE) and Project Examination (PrE)** – wherever applicable. These are conducted by a pair of internal and external examiner at the end of the semester.

Table 1.6.2: Components of evaluations with weightage

Components	Sub- Components	Weightage	Marks
Theory Course			
ISE	CA	20% [@]	20/15*
	MSE	20%	20/15*
ESE		60%	60/45*
Lab Course			
ISE	CA	60% #	15/30 ^{&}
	Mock Test	40%	10/20 ^{&}
ESE ^{\$}	PE/OrE	100%	25/50 ^{&}
Mini Project			
ISE	CA	100% • Internal mid Sem evaluation (includes partial demo[#]): 20% • Internal end Sem evaluation (full demo[#]): 40% • Report: 20% • Attendance: 20%	25/50 ^{&}
ESE ^{\$}	PrE	100%	25/50 ^{&}

Note: Duration of MSE is 1 hour and ESE is 2.5/2 hours*

[@] Includes – (CA1 of 10 marks conducted before MSE) + (CA2 of 10 marks conducted after MSE)

* For 3 credit course/2 credit course

[&] For marks 25/50/100 as per scheme

[#] Rubrics can be defined by the faculty with approval from HOD

^{\$} Pair of internal and external examiner should conduct Practical/Oral/Project exams

1.7 Third Year Exit Courses

Certification after completion of Third Year exit courses: Diploma in Network Engineering and Full Stack Development

Table 1.7.1: Contact Hours and Credit Distribution for Exit Courses after Third Year

Sr. No.	Course Code	Course	Contact Hours				Credits Assigned				
			Theory (C)	Practical (L)	Tutorial (T)	Project (P)	C	L	T	P	Total
1	CE6EX_CR1	CCNA	3	-	-	-	3	-	-	-	3
	CE6EX_LR1	CCNA Lab	-	2	-	-	-	1	-	-	1
2	CE6EX_CR2	Web Product Development	3	-	-	-	3	-	-	-	3
	CE6EX_LR2	Web Product Development Lab	-	2	-	-	-	1	-	-	1
	OR										
	CE6EX_LR2	Internship in Networking/ Full Stack development	-	-	-	8	-	-	-	4	4
TOTAL											8

Table 1.7.2 : Marks distribution of exit courses after Third Year

Sr. No.	Course Code	Course	ISE		ESE		Total Marks
			CA	MSE	Theory	Practical	
1	CE6EX_CR1	CCNA	20	20	60	-	100
	CE6EX_LR1	CCNA Lab	25	-	-	25	50
2	CE6EX_CR2	Web Product Development	20	20	60	-	100
	CE6EX_LR2	Web Product Development Lab	25	-	-	25	50
	OR						
	CE6EX_LR2	Internship in Networking/ Full Stack development	50	-	-	100	150
TOTAL							300

Guidelines for Exit:

- The NEP 2020 Four Year Multidisciplinary Engineering Curriculum Framework offers multiple entry and exit options with the award of UG certificate/ UG diploma/ or three-year degree depending upon the number of credits secured.
- Multiple Exits: Students will have the flexibility to enter a programme in odd semesters and exit a programme after the successful completion of even semesters as per their future career needs.
- Eligibility for Exit:**
 - Students exiting the Third Year Programme after securing minimum 80 credits will be awarded UG Diploma in the relevant Discipline /Subject provided they secure additional 8 credits in skill-based vocational courses (skill-based courses, internship, mini projects etc) offered during summer vacation after the second year.

- **Breakdown of the 8 Additional Credits:**
 - **Option 1:** Two 4-credit (2+2) courses from the PCC/VSEC category.
 - **Option 2:** One 4-credit (2+2) course from the PCC/VSEC category OR a certified industry internship worth 4 credits (minimum 60 hours).
- Exit options shall be provided with Diploma degree to the students exiting at the end of the sixth semester.
- **Re-entry or Lateral Entry:** Students, opting for exits at any level, will have the option to re-enter the programme from where they had left off, in the same or in a different higher education institution within four years of exit and complete the degree programme within the stipulated maximum period of eight years from the date of admission to first year UG. Re-entry at various levels for lateral entrants in academic programmes shall be based on the earned and valid credits as-deposited and accumulated in the Academic Bank of Credits (ABC) through Registered Higher & Technical Education Institutions (RHTEI) and proficiency test records. Lateral entry into the programme of study leading to the UG Diploma/ B. Vocational/ UG Bachelor's Degree with single minor/ UG Bachelor's Degree with Double Minor/ Honours /Research will be based on the validation of prior learning outcomes achieved and subject to availability based on intake capacity.

2 Semester-V Course Syllabus

2.1 Data warehousing and Mining (CE5PC_CR1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE5PC_CR1	Data warehousing and Mining	02	02

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
15	Continuous	15	1	45	2	75

Course Objectives

Sr. No.	Objectives
1	To <i>identify</i> the significance of Data Warehousing and OLAP operations.
2	To <i>understand</i> the importance of supervised and unsupervised learning in data mining.
3	To <i>analyze</i> data, choose relevant models and algorithms for respective applications.
4	To <i>develop</i> research interest towards advances in data mining.
5	To <i>discover</i> meaningful patterns and associations in data using frequent pattern mining techniques.

Course Outcomes

The student will be able to	
CO1	<i>design</i> data warehouse with dimensional modeling and apply OLAP operations to solve real business problems.
CO2	<i>analyze</i> data mining principles and perform preprocessing and visualization to enhance data analysis.
CO3	<i>apply</i> classification techniques and evaluate performance using accuracy measures and validation methods.
CO4	<i>apply</i> clustering techniques such as k-Means, k-Medoids, and hierarchical methods to group data, and evaluate clustering results using appropriate validation measures.
CO5	<i>apply</i> the fundamentals of frequent pattern and association rule mining and illustrate the basic concepts and techniques used in web mining.

Course Contents

Module	Unit	Detailed Contents	Hours
	Pre-requisite		
	Database Concepts		

1.0	Data Warehousing Fundamentals		06
	1.1	Introduction to Data Warehouse, Data warehouse architecture, Data warehouse versus Data Marts, E-R Modeling versus Dimensional Modeling	
	1.2	Data Warehouse Schemas; Star Schema, Snowflake Schema, Factless Fact Table, Fact Constellation Schema, Update to the dimension tables.	
	1.3	Major steps in ETL process, OLTP versus OLAP, OLAP operations: Slice, Dice, Rollup, Drilldown and Pivot.	
2.0	Introduction to Data Mining and Exploration		05
	2.1	Data Mining Task Primitives, Architecture, KDD process, Issues in Data Mining, Applications of Data Mining	
	2.2	Data Exploration: Types of Attributes, Statistical Description of Data, Data Preprocessing Techniques.	
3.0	Classification		05
	3.1	Basic Concepts, Decision Tree, Naïve Bayes	
	3.2	Accuracy and Error measures, Evaluating the Accuracy of a Classifier.	
	3.3	Holdout & Random Subsampling, Cross Validation, Bootstrap.	
4.0	Clustering		05
	4.1	Types of data in Cluster analysis, Partitioning Methods (k-Means, k-Medoids).	
	4.2	Hierarchical Methods (Agglomerative).	
5.0	Mining frequent patterns and associations		05
	5.1	Market Basket Analysis, Frequent Item sets, Closed Item sets and Association Rule, Apriori Algorithm, Association Rule Generation, Frequent Pattern Mining.	
	5.2	Introduction to Web Mining (Content, Structure. Usage Mining), Page Rank.	
Total Hours			26

Suggested Learning Resources

Textbooks

1. Data Warehousing: Fundamentals for IT Professionals, II Ed., Paulraj Ponniah, Wiley India, 2010.
2. Data Mining Concepts and Techniques, II Ed., Han, Kamber, Morgan Kaufmann, 2006
3. Data Mining Introductory and Advanced Topics, II Ed., M.H. Dunham, Pearson Education, 2006.

Reference Books

1. Data warehousing, I Ed., Reema Theraja, Oxford University Press 2009.
2. Introduction to Data Mining, II Ed., Pang-Ning Tan, Michael Steinbach and Vipin Kumar. 2018.
3. Data Mining, III Ed., Morgan Kaufmann, Ian H. Witten, Eibe Frank and Mark A. Hall, 2011.

Web Resources

1. Coursera online course: Data Mining Specialization by Prof. John C. Hart.
<https://www.coursera.org/specializations/data-mining>
2. NPTEL online course: Data Mining by Prof. Pabitra Mitra IIT Kharagpur.
https://onlinecourses.nptel.ac.in/noc20_cs12/preview

2.2 Data Warehousing and Mining Lab (CE5PC_LR1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE5PC_LR1	Data Warehousing and Mining Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	-	25	-	50

Course Objectives

Sr. No.	Objectives
1	To <i>learn</i> how to build a data warehouse and query it.
2	To <i>learn</i> about the data sets and data preprocessing.
3	To <i>demonstrate</i> the working of algorithms for data mining tasks such Classification, Clustering, Association rule mining & Web mining.
4	To <i>apply</i> the data mining techniques with varied input values for different parameters.
5	To <i>explore</i> open-source software (like WEKA) to perform data mining tasks.

Course Outcomes

The student will be able to	
LO1	<i>design</i> data warehouses and perform various OLAP operations.
LO2	<i>analyze</i> data using various tools.
LO3	<i>implement</i> data mining algorithms like classification.
LO4	<i>implement</i> clustering algorithms on a given set of data samples.
LO5	<i>implement</i> Association rule mining & web mining algorithm.

Course Contents

Sr. No.	Suggested List of Experiments
1	To implement Data Warehouse using Dimensional Modeling.
2	To implement OLAP operations: Slice, Dice, Rollup, Drilldown and Pivot.
3	To implement Data Visualization techniques (any five).
4	To implement Naive Bayes Classifier algorithm.
5	To implement K-Means Clustering Algorithm.
6	To implement Agglomerative Hierarchical Clustering Algorithm.
7	To implement Apriori Association Rule Mining algorithm.
8	To implement Page Rank Algorithm.
9	To demonstrate data Pre-processing, Classification, Clustering, Association Mining and Visualization on data sets using WEKA tool.
10	To implement Decision Tree Classifier Algorithm.

11	To implement Hierarchical Clustering Algorithm –Agglomerative Clustering.
12	Case study on Power BI tool.

Note: Lab course shall consist of minimum 10 experiments covering all the topics but not limited to the suggested list.

Suggested Learning Resources

Textbooks

1. Data Mining: Concepts and Techniques, IV Ed., Jiawei Han, Jian Pei, and Hanghang Tong, Morgan Kaufmann / Elsevier, 2022.
2. The Data Warehouse Toolkit: The Definitive Guide to Dimensional Modeling, III Ed., Ralph Kimball and Margy Ross, John Wiley & Sons, 2013.
3. Data Mining: Practical Machine Learning Tools and Techniques, IV Ed., Ian H. Witten, Eibe Frank, Mark A. Hall, and Christopher J. Pal, Morgan Kaufmann / Elsevier, 2016.

Reference Books

1. The Data Warehouse Toolkit: The Definitive Guide to Dimensional Modeling, III Ed., Ralph Kimball and Margy Ross, John Wiley & Sons, 2013.
2. Data Mining: Concepts and Techniques, III Ed., Jiawei Han, Micheline Kamber and Jian Pei, Morgan Kaufmann Publishers, 2011.
3. Data Mining: Practical Machine Learning Tools and Techniques, IV Ed., Ian H. Witten, Eibe Frank, Mark A. Hall and Christopher J. Pal, Morgan Kaufmann Publishers, 2016.

Web Resources

1. Official software, guides, and .arff datasets for data preprocessing and mining tasks.
<https://www.waikato.ac.nz/research/institutes-centres-entities/institutes/artificial-intelligence-institute/research/software/>
2. Microsoft documentation for building interactive dashboards and business intelligence case studies.
<https://learn.microsoft.com/en-us/power-bi/>
3. Code examples and structural math logic for Naive Bayes, Decision Trees, K-Means, and Hierarchical clustering.
<https://scikit-learn.org/stable/>
4. Open-source datasets for testing classification, clustering, and association rule algorithms.
<https://www.kaggle.com/datasets>
5. MHRD platform providing simulated environments for interactive data mining experiments.
<https://vlabs.iitkgp.ac.in/vlt/>

2.3 Computer Network & System Security (CE5PC_CR2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE5PC_CR2	Computer Network & System Security	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

S. No.	Objectives
1	To <i>introduce</i> concepts and fundamentals of computer networks.
2	To <i>explore</i> the interworking of various layers of ISO-OSI.
3	To <i>understand</i> various protocols on each layer.
4	To <i>understand</i> the Fundamentals of Cryptography and explore Symmetric and Asymmetric Cryptographic Systems.
5	To <i>examine</i> cryptographic hash functions and learn various authentication mechanisms.

Course Outcomes

The student will be able to	
CO1	<i>understand</i> the ISO-OSI, TCP/IP model, and <i>demonstrate</i> the concepts of data communication at the physical layer
CO2	<i>understand</i> design issues, services provided by the data link layer, and <i>design</i> the network using IP addressing.
CO3	<i>analyze</i> transport layer protocols and <i>explore</i> application layer protocols.
CO4	<i>comprehend</i> the principles of cryptography and <i>analyze</i> modern symmetric encryption techniques.
CO5	<i>apply</i> mathematical principles in public key cryptography, <i>analyze</i> and <i>implement</i> cryptographic hash functions to ensure data integrity and authentication.

Course Contents

Course Contents			
Module	Unit	Detailed Contents	Hours
	Prerequisites: Operating System, Digital logic		
1.0	Introduction to Computer Network and Physical Layer		07
	1.1	Introduction to Computer Network: Network application, Network software and hardware components (Interconnection networking devices), Network topology, protocol hierarchies, design issues for the layers, connection-oriented and connectionless services.	
	1.2	Reference models: Layer details of the OSI, TCP/IP models and Communication between layers.	
	1.3	Physical Layer: Guided Transmission Media- Twisted pair, Coaxial, Fiber optics.	
2.0	Data Link Layer and Network Layer		08

	2.1	Data Link Layer: Design Issues (Services, Framing, Error Control, Flow Control), Error Detection and Correction (Hamming Code, CRC, Checksum), Elementary Data Link protocols.	
	2.2	Medium Access Control sublayer Channel Allocation problem, Multiple Access Protocol (Aloha, Carrier Sense Multiple Access (CSMA/CD))	
	2.3	Network Layer: Design issues, IPv4 Addressing (classful and classless), Subnetting, Super netting. Routing algorithms: Shortest Path (Dijkstra 's), Introduction to IPv6.	
3.0	Transport and Application Layer		08
	3.1	Transport Service: Transport service primitives, Berkeley Sockets, Connection management (Handshake), UDP, TCP.	
	3.2	DNS: Name Space, Resource Record and Types of Name Servers.	
	3.3	Application Layer: HTTP, SMTP, Telnet, FTP.	
4.0	Introduction to Cryptography and Symmetric Key Cryptography		08
	4.1	Introduction to Cryptography: Introduction to security attacks, services and mechanisms, classical encryption techniques: substitution ciphers and transposition ciphers, cryptanalysis.	
	4.2	Modern Block Ciphers: Stream and block ciphers, Block ciphers principles, block cipher modes of operation, Data Encryption Standard (DES) & Advanced Encryption Standard (AES), Introduction to steganography.	
5.0	Public Key Cryptography and Cryptographic Hash Function		08
	5.1	Euler's totient function, Fermat's and Euler's Theorem, Chinese Remainder Theorem. Asymmetric key ciphers: RSA algorithm.	
	5.2	Symmetric Key Distribution: KDC, Kerberos: Kerberos Authentication protocol, Symmetric key agreement: Diffie-Hellman key exchange.	
	5.3	Cryptographic hash functions and their properties: MD5, SHA-1. Secure hash functions and their properties: MAC, HMAC, CMAC.	
Total Hours			39

Suggested Learning Resources

Textbooks

1. Computer Networks, IV Ed., A.S. Tanenbaum, Pearson Education, 2018.
2. Data Communications and Networking, V Ed., B.A. Forouzan, Tata Mc Graw Hill, 2017.
3. Cryptography and Network security Principles and Practices, IV Ed., William Stallings, Pearson Education, 2005.
4. Cryptography & Network Security, III Ed., Behrouz A. Ferouzan, Tata Mc Graw Hill, 2015.

Reference Books

1. Computer Networks: An Engineering Approach To Computer Networking, II Ed, S. Keshav, Pearson, 2007.
2. Computer Networks: A Systems Approach, II Ed., Larry L. Peterson, Bruce S. Davie, The Morgan Kaufmann Series in Networking, 1999.
3. Cryptography and Network Security, IV Ed., Atul Kahate, Tata McGraw-Hill Education, 2003.

Web Resources

1. Networking essentials by Cisco Networking Academy.
<https://www.netacad.com/courses/networking/networking-essentials>

2. TakeUForward: Types of Encryption.
<https://takeuforward.org/computer-network/types-of-encryption>
3. Cryptography I (Coursera) by Dan Boneh.
<https://www.coursera.org/learn/crypto>

2.4 Computer Network & System Security Lab (CE5PC_LR2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE5PC_LR2	Computer Network & System Security Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	25	-	-	50

Course Objectives

Sr. No.	Objectives
1	To <i>practically</i> explore OSI layers and <i>understand</i> the usage of simulation tools.
2	To <i>analyze, specify and design</i> the topological and routing strategies for an IP based networking infrastructure.
3	To <i>understand</i> protocols of each layer.
4	To <i>implement and analyze</i> traditional ciphers along with various encryption algorithms.
5	To <i>implement and understand</i> key exchange algorithms and different hash function.

Course Outcomes

The student will be able to	
LO1	<i>understand and design</i> networking environment in Linux/windows.
LO2	<i>explore</i> working of various inter networking components by designing network configuration.
LO3	<i>implement</i> programs using core programming APIs for understanding networking concepts and analyze network using tools.
LO4	<i>apply</i> the knowledge of symmetric cryptography to implement simple ciphers.
LO5	<i>analyze and implement</i> public key algorithms like DES and RSA.

Course Contents

S. No.	Suggested List of Experiments
1	To study and demonstrate RJ45 and CAT6 Cabling and connection using crimping tools.
2	To study Networking Devices and use basic networking commands in Linux/Windows (ping, tracert, nslookup, netstat, ARP, RARP, ip, ifconfig, dig).
3	To study various internetworking devices (hub, router, bridges, gateway, switches).
4	To implement various framing methods in the data link layer.
5	To compare working of hub, switch and router using simple network topology.
6	To connect two networks using one router (static and default).
7	To implement DHCP using Cisco packet tracer.

8	To use Wireshark to understand the operation of TCP/IP layers. • Ethernet Layer: Frame header, Frame size etc. • Data Link Layer: MAC address, ARP (IP and MAC address binding) • Network Layer: IP Packet (header, fragmentation), ICMP (Query and Echo)
9	To implement Socket programming using TCP or UDP.
10	To perform File Transfer and Access using FTP.
11	To implement a program for password cracking using Brute Force.
12	To design and implement menu driven program on following cipher techniques: a. Ceaser cipher b. Playfair Cipher c. Rail Fence Cipher
13	To implement DES algorithm.
14	To implement AES algorithm.
15	To implement and analyse RSA cryptosystem.
16	To implement Diffie Hellman Key Exchange Algorithm.
17	To implement MD5 algorithm.

Note: Lab course shall consist of minimum 10 experiments covering all the topics but not limited to the suggested list.

Suggested Learning Resources

Textbooks

1. An Engineering Approach To Computer Networks-S.Keshav,II Ed.,Pearson Education .
2. Computer Networks - Andrew S Tanenbaum, IV Ed., Pearson Education. .
3. Network Security and Cryptography, I Ed., Bernard Menezes, Cengage Learning.

Reference Books

1. Computer Networking:Atop Down Approach Featuring The Internet, James F.Kurose,K.W.Ross, III Ed, Pearson Education.
2. Network Security Essentials, VI Ed., William Stallings, Pearson Education.
3. Practical Cryptography for Developers Free online book with code examples (AES, RSA, DH, hash)

Web Resources

1. Networking Essentials by Cisco Networking Academy
<https://www.netacad.com/courses/networking/networking-essentials>
2. TakeUForward: Types of Encryption,
<https://takeuforward.org/computer-network/types-of-encryption>
3. Kali Linux tools (Hydra, John the Ripper)
<https://www.kali.org/tools/john/>
4. CryptoJS(Powerd by Git Book
<https://cryptojs.gitbook.io/docs>

2.5 Theory of Computer Science (CE5PC_CR3)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE5PC_CR3	Theory of Computer Science	02	02

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
15	Continuous	15	1	45	2	75

Course Objectives

Sr. No.	Objectives
1	To <i>introduce</i> fundamental concepts of formal languages, automata, and computation models.
2	To <i>develop</i> the ability to design and analyze finite automata, regular expressions, and grammars for language representation.
3	To <i>provide</i> understanding of context-free grammars, their simplification, and normal forms for structured language design.
4	To <i>familiarize</i> students with advanced computational models such as Pushdown Automata and Turing Machines, and their role in language recognition.
5	To <i>strengthen</i> problem-solving, abstraction, and theoretical foundations required for compiler design, language processing, and complexity analysis.

Course Outcomes

The student will be able to	
CO1	<i>construct</i> finite automata to solve given computational problems.
CO2	<i>apply</i> methods to <i>analyze</i> regular expressions and <i>construct</i> equivalent finite automata.
CO3	<i>design</i> and <i>transform</i> context-free grammars into equivalent normal forms.
CO4	<i>design</i> pushdown automata to recognize a given language through acceptance by the final state and the empty stack techniques.
CO5	<i>construct</i> a Turing machine to solve computational problems.

Course Contents

Course Contents			
Module	Unit	Detailed Contents	Hours
	Pre-requisite		
	Data Structure and Algorithms, Discrete Structure		
1.0	Finite Automata		06
	1.1	Introduction to Alphabets, Strings, Languages, Closure Properties, Finite Automata.	

	1.2	FA with final state: Deterministic Finite Automata (DFA), Non-Deterministic Finite Automata (NFA), Epsilon-NFA, NFA to DFA Conversion, Minimization of DFA.	
	1.3	FA without Final State: Moore Machine, Mealy Machine, Moore to Mealy conversion, Mealy to Moore Conversion. Applications and limitations of Finite Automata.	
2.0	Regular Expression		05
	2.1	Regular Expression, closure properties, of RL, Equivalence of RE and Finite Automata.	
	2.2	Arden's Theorem, Applications of Regular Expressions. Methods for Determining Language Regularity and Non-Regularity .	
3.0	Grammar		06
	3.1	Context Free Grammars (CFG): Definition and designing CFGs, Leftmost and Rightmost derivations, Parse tree, Ambiguity	
	3.2	Simplification and Applications, Normal Forms: Chomsky Normal Forms (CNF) and Greibach Normal Forms (GNF), Context Free language (CFL)-Closure properties. Applications of grammar.	
4.0	Pushdown Automata (PDA)		05
	4.1	Definition, Model of PDA, PDA as generator, Acceptance by Final State and Acceptance by Empty stack and its Equivalence, Deterministic PDA, Non-Deterministic PDA, decider, and acceptor of CFG. Applications of PDA.	
5.0	Turing Machine (TM)		04
	5.1	Definition of Turing Machine, Design of TM as a generator, decider and acceptor.	
	Total Hours		26

Suggested Learning Resources

Textbooks

1. Introduction to Automata Theory, Languages, and Computation, III Ed., John E. Hopcroft, Rajeev Motwani, Jeffery D. Ullman, Pearson Education, 2008.
2. Theory of Computation, Michael Sipser, III Ed., Cengage learning. 2013.
3. Theory of Computation, Vivek Kulkarni, Illustrated Edition, Oxford University Press.

Reference Books

1. Introduction to Languages and the Theory of Computation, IV Ed., J. C. Martin, Tata McGraw-Hill Publication, 2013.
2. Theory of Computation: A Problem-Solving Approach, Kavi Mahesh, Kindle Edition, Wiley-India, 2011.

Web Resources

1. Jflap tool.
www.jflap.org
2. Udemy Course on The Complete Theory of Computation.
<https://www.udemy.com/course/the-complete-theory-of-computation/>

2.6 Program Elective Course-I

2.6.1 Machine Learning (CE5PE_CX1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE5PE_CX1	Machine Learning	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

S. No.	Objectives
1	To <i>understand</i> basic concepts and techniques of Machine Learning.
2	To <i>acquire</i> an in-depth understanding of various supervised and unsupervised algorithms.
3	To <i>be able</i> to apply various ensemble techniques for combining ML models.
4	To <i>understand</i> the fundamental concepts of Classification Algorithm and Analyze and design the Support Vector Machine algorithm for optimization problems.
5	To <i>identify</i> Clustering techniques for grouping of data points and to demonstrate dimensionality reduction techniques.

Course Outcomes

The student will be able to	
CO1	<i>understand</i> basic concepts and techniques of Machine Learning.
CO2	<i>acquire</i> in depth understanding of various supervised and unsupervised algorithms.
CO3	<i>apply</i> various ensemble techniques for combining ML models.
CO4	<i>understand</i> the fundamental concepts of Classification Algorithm and analyze and design the Support Vector Machine algorithm for optimization problems.
CO5	<i>identify</i> Clustering techniques for grouping of data points and demonstrate dimensionality reduction techniques.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites: Engineering Mathematics, Data Structures, Algorithms		
1.0	Introduction to Machine Learning and Regression		07

	1.1	Machine Learning, Types of Machine Learning, Issues in Machine Learning, Application of Machine Learning, Steps in developing a Machine Learning Application	
	1.2	Training Error, Generalization error, Overfitting, Underfitting, Bias- Variance trade-off.	
	1.3	Learning with Regression: Linear Regression, Multivariate Linear Regression, Logistic Regression.	
2.0	Learning with Trees		07
	2.1	Learning with Trees: Decision Trees, Classification and Regression Trees (CART)	
	2.2	Performance Metrics: Confusion Matrix, [Kappa Statistics], Sensitivity, Specificity, Precision, Recall, F-measure, ROC curve	
3.0	Ensemble Learning and Dimensionality Reduction		09
	3.1	Understanding Ensembles, K-fold cross validation, Boosting, Stumping, XGBoost	
	3.2	Bagging, Sub-bagging, Random Forest, Comparison with Boosting.	
	3.3	Dimensionality Reduction Techniques, Principal Component Analysis, Linear Discriminant Analysis, Singular Valued Decomposition.	
4.0	Learning with Classification		08
	4.1	Support Vector Machine Constrained Optimization, Optimal decision boundary, Margins and support vectors, Quadratic Programming, SVM for linear and nonlinear classification, Basics of Kernel trick.	
	4.2	Support Vector Regression, Multiclass Classification	
5.0	Learning with Clustering		08
	5.1	Introduction to clustering, overview of distance metrics and major clustering approaches.	
	5.2	Graph Based Clustering, Model based Clustering and Density Based Clustering.	
	Total Hours		39

Suggested Learning Resources

Textbooks

1. Machine Learning in Action, I Ed., Peter Harrington, DreamTech Press, 2012.
2. Introduction to Machine Learning, IV Ed., Ethem Alpaydın, MIT Press, 2020.
3. Machine Learning, I Ed., Tom M. Mitchell, McGraw Hill, 1997.
4. Machine Learning: An Algorithmic Perspective, II Ed., Stephen Marsland, CRC Press, 2014.

Reference Books

1. Kevin P. Murphy, "Machine Learning: A Probabilistic Perspective", I Ed, MIT Press, 2012.
2. Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar, "Foundations of Machine", II Ed, MIT Press, 2018.

Web Resources

NPTEL Lecture Series:

1. Introduction to Machine Learning by Prof. Sudeshna Sarkar, IIT Kharagpur.

https://onlinecourses.nptel.ac.in/noc21_cs85/preview

2. Data sets for Machine Learning algorithms:

<https://www.kaggle.com/datasets>

2.6.2 Machine Learning Lab (CE5PE_LX1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE5PE_LX1	Machine Learning Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	25	-	-	50

Lab Objectives

S. No.	Objectives
1	To <i>understand</i> the fundamental concepts, terminologies, and workflow of Machine Learning.
2	To <i>implement</i> and evaluate supervised and unsupervised machine learning algorithms using real-world datasets.
3	To <i>apply</i> ensemble learning techniques to improve model performance and predictive accuracy.
4	To <i>develop</i> and <i>analyze</i> classification and regression models using Support Vector Machines and other machine learning techniques.
5	To <i>perform</i> clustering, dimensionality reduction, and feature extraction for effective data analysis and visualization.

Course Outcomes

The student will be able to	
LO1	<i>demonstrate</i> the fundamental concepts, techniques, and applications of Machine Learning.
LO2	<i>implement</i> and evaluate supervised and unsupervised learning algorithms for solving real-world problems.
LO3	<i>apply</i> ensemble learning methods such as bagging and boosting to enhance model performance.
LO4	<i>develop</i> , <i>analyze</i> , and optimize classification and regression models using Support Vector Machines and decision tree-based techniques.
LO5	<i>perform</i> clustering, dimensionality reduction, and feature extraction using appropriate machine learning algorithms for data-driven decision making.

Course Contents

Sr. No.	Suggested List of Experiments
1	To implement Linear Regression for Predictive Modeling.
2	To implement Logistic Regression for Classification Tasks.

3	To implement Ensemble Learning Techniques Using Bagging and Boosting Algorithms.
4	To implement Multivariate Linear Regression for Multiple Feature Analysis.
5	To implement Support Vector Machine (SVM) for Classification and Regression.
6	To implement Dimensionality Reduction Techniques Using PCA/ SVD/LDA.
7	To implement Graph-Based Clustering Algorithms for Data Segmentation.
8	To implement Density-Based Spatial Clustering (DBSCAN) for Unsupervised Learning.
9	To implement CART algorithm for Classification Tree Modeling.
10	To implement CART algorithm for Regression Tree Modeling.
11	To implement Linear Discriminant Analysis (LDA) for Classification and Feature Extraction.
12	Mini Project: Development and Evaluation of a Machine Learning-Based Predictive Analytics System.

Note: Lab course shall consist of minimum 10 experiments covering all the topics but not limited to the suggested list and one mini project/case study on any machine learning application.

Suggested Learning Resources

Textbooks

1. Introduction to Machine Learning with Python: A Guide for Data Scientists, I Ed., Andreas C, Müller and Sarah Guido, O'Reilly, 2016.
2. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, II Ed., Aurélien Géron, O'Reilly, 2019.

Reference Books

1. Mark Lutz, "Learning Python", V Ed., O'Reilly Media, 2013.
2. Aurélien Géron, "Concepts, Tools, and Techniques to Build Intelligent Systems", III Ed., O'Reilly Media, 2022.

Web Resources

1. Machine Learning Hands-on courses by Google.
<https://cloud.google.com/learn/training/machinelearning-ai>
2. Machine Learning Crash Course by Google.
<https://developers.google.com/machine-learning/crash-course>

2.6.3 Ethical Hacking and Digital Forensics (CE5PE_CX2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE5PE_CX2	Ethical Hacking and Digital Forensics	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

S. No.	Objectives
1	To <i>build</i> a strong conceptual base of digital forensics.
2	To <i>address</i> forensic challenges in distributed environments.
3	To <i>leverage</i> machine learning for smarter investigations.
4	To <i>explore</i> non-traditional evidence sources.
5	To <i>prepare</i> students for real-world scenarios.

Course Outcomes

The student will be able to	
CO1	<i>explain</i> the history and evolution of digital forensics and its role in modern cyber investigations.
CO2	<i>analyze</i> the cloud architectures and <i>utilize</i> tools such as Wireshark, Splunk, and cloud log analysis platforms (AWS/GCP/Azure) for forensic investigation and intrusion detection.
CO3	<i>implement</i> various Natural Language Processing (NLP) methods to <i>analyze</i> emails, chats, and textual communication for forensic purposes.
CO4	<i>examine</i> different forensic approaches for wearables, smart home systems, and connected vehicles.
CO5	<i>evaluate</i> the issues of privacy, consent, and ethical dilemmas in digital forensic investigations.

Course Contents

Module	Unit	Detailed Contents	Hours
		Pre-requisite- Computer network and system security	
1.0	Foundations of Digital Forensics		08
	1.1	Introduction to Ethical Hacking: Concept of ethical	

		hacking, types of hackers, phases of ethical hacking, cyber threats and attack, Reconnaissance and information gathering techniques.	
	1.2	History and evolution of digital forensics, types of digital evidence and crime scenarios, Forensic process: identification, preservation, analysis, and presentation, Reverse engineering, social engineering, Vulnerability assessment and penetration testing.	
	1.3	File systems and data recovery basics: File system fundamentals in forensics, Role of file systems in digital evidence, File system architecture: metadata, allocation tables, inodes, Common forensic-relevant file systems.	
2.0	Cloud and Network Forensics		08
	2.1	Cloud architecture and evidence acquisition, Jurisdiction, and legal issues in cloud forensics.	
	2.2	Network traffic analysis and packet inspection, Log analysis and intrusion detection.	
	2.3	Service level agreements (SLAs) & Evidence access: Role of SLAs in defining CSP responsibilities, Evidence availability and cooperation clauses, Limitations on investigator access without CSP authorization.	
3.0	Mobile, IoT & Embedded Device Forensics		07
	3.1	Mobile OS architecture and data extraction, IoT device data acquisition, and challenges.	
	3.2	Wearables and smart home systems forensics, vehicle forensics.	
	3.3	Fundamentals of Chain of Custody, Chain of custody for volatile data, Integrity & Authenticity.	
4.0	AI & Automation in Forensics		08
	4.1	Role of AI in evidence sorting and anomaly detection, Facial recognition, and video forensics.	
	4.2	Natural language processing for email/chat analysis, and ethical implications of AI in investigations.	
	4.3	Bias & fairness in AI, transparency & privacy, accountability, predictive policing, and global perspectives, future ethical frameworks.	
5.0	Legal, Ethical & Case-Based Forensics		08
	5.1	Cyber laws and digital evidence admissibility, Privacy, consent, and ethical dilemmas.	
	5.2	Digital evidence under Indian Law, Sections of Indian Evidence Act (IEA) relevant to electronic evidence, Section 65A & 65B – admissibility of electronic records, IT Act provisions on cybercrimes and digital evidence, Landmark Indian cases involving electronic evidence.	
	5.3	Case studies: corporate espionage, ransomware, insider	

	threats, Report writing, and courtroom presentation.	
		39

Suggested Learning Resources

Textbooks

1. Digital Forensics and Internet of Things, I Ed., Anita Gehlot, Rajesh Singh, Jaskaran Singh, Neeta Raj Sharma, Wiley, April 2022.
2. Security, Privacy, and Digital Forensics in the Cloud, I Ed., Lei Chen, Hassan Takabi, Nhien-An Le-Khac, John Wiley & Sons, April 2019.
3. Artificial Intelligence Driven Forensics, S. S. Iyengar et al., Springer Nature, May 2026.
4. Cyber Laws and IT Protection, II Ed., Harish Chander, Gagandeep Kaur, PHI, January 2022.
5. Electronic Evidence with Cross References to New Criminal Laws, II Ed., Nayan Joshi, Coat Pocket Ed., 2015.

Reference Books

1. Handbook of Big Data and IoT Security, I Ed., by Levan Agniashvili, Springer, 2019.
2. Network Forensics: Tracking Hackers through Cyberspace, Sherri Davidoff, Jonathan Ham, Pearson Education, 2012.
3. Practical Mobile Forensics, IV Ed, Heather Mahalik, Rohit Tamma, Satish Bommisetty, Packt Publishing, April 2020.
4. Artificial Intelligence in Forensic Sciences, Zeno Geradts, Katrin Franke, Wiley, October 2023.
5. Cyber Law in India, I Ed., Pavan Duggal, KBI Publication, January 2023.
6. Information Technology Act Commentary, IX Ed., Vakul Sharma ad Seema Sharma, Universal 2025.

Web Resources

1. NPTEL course: Digital Forensics by Dr. Jitendra Pande.
https://onlinecourses.swayam2.ac.in/nou25_cs19/preview
2. SANS Institute Whitepapers on Cloud Forensics:
<https://www.sans.org/white-papers>
3. ScienceDirect – Network Forensics Survey:
<https://www.sciencedirect.com/journal/journal-of-network-and-computer-applications>
4. Indian Evidence Act (Sections 65A & 65B) – Ministry of Law & Justice official site:
https://www.indiacode.nic.in/bitstream/123456789/15351/1/iea_1872.pdf

2.6.4 Ethical Hacking and Digital Forensics Lab (CE5PE_LX2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE5PE_LX2	Ethical Hacking and Digital Forensics Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	25	-	-	50

Course Objectives

S. No.	Objectives
1	To <i>document</i> the imaging process thoroughly (tool, command/options, timestamps, operator, hash values, storage location) and produce an audit-ready evidence record.
2	To <i>correlate</i> Wireshark packet captures with Splunk log events to investigate security incidents.
3	To <i>implement</i> supervised and unsupervised ML algorithms for classification and anomaly detection in forensics.
4	To <i>recover and analyze</i> deleted data such as SMS, call records, contacts, and app artifacts.
5	To <i>analyze</i> acquired evidence to reconstruct events and identify relevant artifacts.

Course Outcomes

The student will be able to	
LO1	<i>explain</i> the principles of disk imaging, integrity verification, and data carving in digital forensics.
LO2	<i>analyze</i> common network protocols to identify anomalies or malicious activities.
LO3	<i>identify and evaluate</i> limitations, potential biases, false positives/negatives, and ethical implications of AI/ML applications in digital forensics.
LO4	<i>perform</i> parsing and reverse-engineering of IoT firmware to identify anomalies, hidden functionalities, or vulnerabilities.
LO5	<i>plan and execute</i> a complete mock digital forensic investigation using proper methodology and tools.

Course Contents

S. No.	Suggestive List of Experiments
1	To implement forensic disk imaging for acquiring a bit-by-bit copy of digital storage media, perform integrity verification using hash algorithms, and recover deleted or hidden files through file carving techniques for forensic analysis.
2	To Perform reconnaissance using tools like Nmap and Maltego . Recover deleted files from NTFS/FAT file systems using Autopsy or FTK Imager and Analyze metadata and allocation tables in forensic-relevant file systems.

3	To implement network traffic monitoring through Wireshark and log correlation using Splunk for identifying security threats and anomalous behavior.
4	To implement cloud security monitoring by analyzing logs from AWS, GCP, or Azure platforms to detect anomalies and assess security incidents.
5	To implement a machine learning model in Python for identifying suspicious patterns and detecting anomalies in forensic datasets.
6	To implement AI-based plugins in Autopsy for automated forensic evidence analysis and compare their performance with traditional forensic investigation methods.
7	To implement forensic techniques for recovering deleted messages, call logs, and application data from Android and iOS devices.
8	To implement IoT log and firmware image analysis using parsing and reverse engineering techniques for identifying anomalies and security vulnerabilities.
9	To implement a mock forensic investigation by analyzing digital evidence and generating a structured forensic investigation report.
10	To implement a courtroom evidence presentation simulation that demonstrates forensic findings while adhering to proper communication and evidence admissibility standards.
11	Study and implement Basic Penetration Testing Using Vulnerability Scanning Tools.
12	Real-Time Case Study and Application.

Note: Lab course shall consist of minimum 10 experiments covering all the topics but not limited to the suggested list.

Suggested Learning Resources

Textbooks

1. OWASP Top 10: The Ten Most Critical Web Application Security Risks ,Open Worldwide Application Security Project (OWASP), OWASP Foundation, Latest Edition.
2. Damn Vulnerable Web Application (DVWA): Web Application Security Training Platform , DVWA Project Contributors, Latest Version.
3. Kali Linux Documentation and Tutorials: Penetration Testing and Security Assessment Guide ,Kali Linux Team, Offensive Security, Latest Edition.
4. Forensic Toolkit (FTK): Digital Forensics and Evidence Analysis Software, AccessData LLC, Exterro, Latest Version.
5. SANS Digital Forensics Resources: Case Studies and Laboratory Exercises, SANS Institute, Latest Edition.

Reference Books

1. Hands-On Ethical Hacking and Network Defense, II Ed., Michael T. Simpson, Kent Backman and James Corley, Cengage Learning, 2010.
2. Penetration Testing: A Hands-On Introduction to Hacking, Georgia Weidman, No Starch Press, 2014.
3. The Basics of Hacking and Penetration Testing, Patrick Engebretson, Syngress, 2013.
4. Guide to Computer Forensics and Investigations, Bill Nelson, Amelia Phillips and Christopher Steuart, Cengage Learning, 2019.

5. The Art of Memory Forensics, Michael Hale Ligh, Andrew Case, Jamie Levy and Aaron Walters, Wiley, 2014.

Web Resources

1. OWASP Web Security Academy / OWASP Labs – Practice web application vulnerabilities and secure coding exercises, OWASP Foundation.
<https://owasp.org/www-project-web-security-academy/>
2. DVWA (Damn Vulnerable Web Application) – Safe environment for web exploitation and security testing labs.
<https://github.com/digininja/DVWA>
3. Kali Linux Documentation – Official tutorials and guides for penetration testing tools and ethical hacking.
<https://www.kali.org/docs/>
4. Autopsy / The Sleuth Kit – Open-source digital forensics platform for investigation and lab exercises.
<https://www.sleuthkit.org/autopsy/>
5. SANS DFIR Resources – Digital Forensics and Incident Response case studies, training materials, and research resources, SANS Institute.
<https://www.sans.org/digital-forensics-incident-response/>

2.6.5 Computer Graphics (CE5PE_CX3)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE5PE_CX3	Computer Graphics	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

S. No.	Objectives
1	To <i>introduce</i> the fundamental concepts of computer graphics and its applications.
2	To <i>study</i> algorithms for raster graphics, line, circle, and polygon drawing.
3	To <i>understand</i> the mathematical foundations for 2D and 3D transformations.
4	To <i>understand</i> viewing, clipping, and projection concepts for realistic image generation.
5	To <i>explore</i> shading, animation, and interaction techniques used in modern graphics systems.

Course Outcomes

The student will be able to	
CO1	<i>understand</i> the basic principles, components, and applications of computer graphics.
CO2	<i>implement</i> and <i>analyze</i> fundamental graphics algorithms for drawing primitives.
CO3	<i>implement</i> and <i>analyze</i> fundamental graphics algorithms for area filling and clipping.
CO4	<i>apply</i> 2D and 3D transformation techniques for image manipulation and modeling.
CO5	<i>understand</i> illumination, shading, and animation techniques for realistic rendering.

Course Contents

Module	Unit	Detailed Contents	Hours
1.0	Pre-requisite		
	Basic programming knowledge: C / C++/ Java		
	Introduction to Computer Graphics		07
1.1	Overview of Computer Graphics: Applications in engineering, entertainment, design, and visualization.		
1.2	Graphics Systems: Raster and Vector displays, frame buffer, color models (RGB, CMY, HSV).		

	1.3	Input and Output Devices: Keyboard, mouse, light pen, digitizer, and graphical display devices.	
2.0	Graphics Primitives and Algorithms		08
	2.1	Scan conversion and line drawing algorithms – DDA, Bresenham’s line algorithm.	
	2.2	Circle and Ellipse drawing algorithms, Polygon representation, and basic polygon drawing algorithm.	
	2.3	Curve generation - Cubic Bezier and B-spline, Fractals.	
3.0	Area Filling and Clipping Algorithms		08
	3.1	Area filling algorithms (Seed fill and scan-line fill).	
	3.2	Window, viewport, Window to viewport transformation.	
	3.3	Line clipping algorithms – Cohen-Sutherland, Liang–Barsky, Polygon Clipping - Sutherland–Hodgman.	
4.0	2D and 3D Transformations and Viewing		08
	4.1	2D transformations: Translation, rotation, scaling, reflection, shear, homogeneous coordinates, and matrix representation.	
	4.2	3D transformations: Translation, scaling, and rotation (about any one axis).	
	4.3	3D Projection (parallel and perspective).	
5.0	Visible Surface Detection and Animation		08
	5.1	Visible Surface Detection: Back Surface detection method, Depth Buffer method, Area Subdivision method.	
	5.2	Illumination models, Shading models – Flat, Gouraud, and Phong shading.	
	5.3	Basics of animation – Keyframe, tweening, morphing, motion paths.	
Total Hours			39

Suggested Learning Resources

Textbooks

1. Computer Graphics – C Version, II Ed, Donald D. Hearn and M. Pauline Baker, Prentice Hall / Pearson Education, 1997.
2. Computer Graphics Using OpenGL, III Ed, Francis S. Hill Jr. and Stephen M. Kelley, Pearson Education, 2015.

Reference Books

1. Computer Graphics: Principles and Practice, II Ed in C, James D. Foley, Andries van Dam, Steven K. Feiner, and John Hughes, Addison-Wesley, 1995.
2. Principles of Interactive Computer Graphics, II Ed., William M. Newman and Robert F. Sproull, McGraw-Hill.
3. Fundamentals of Computer Graphics and Multimedia, I Ed, D. P. Mukherjee, Prentice-Hall of India / PHI Learning, 2004.

Web Resources

1. NPTEL Course: *Computer Graphics* by Prof. Sukhendu Das (IIT Madras).
<https://nptel.ac.in/courses/106106090>

2.6.6 Computer Graphics Lab (CE5PE_LX3)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE5PE_LX3	Computer Graphics Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	25	-	-	50

Course Objectives

S. No.	Objectives
1	To <i>understand</i> the need of developing graphics application.
2	To <i>use the</i> algorithmic development of graphics primitives.
3	To <i>learn</i> the representation and transformation of graphical images.
4	To <i>understand the</i> basics of curves and fractals.
5	To <i>develop</i> the ability to create interactive graphical applications.

Course Outcomes

The student will be able to	
LO1	<i>implement</i> various output primitive algorithms.
LO2	<i>implement</i> various filled area primitive algorithms.
LO3	<i>apply</i> transformation, projection, and clipping algorithms on graphical objects.
LO4	<i>perform</i> curve and fractal generation methods.
LO5	<i>develop</i> a Graphical application/Animation based on learned concepts.

Course Contents

S. No.	Suggestive List of Experiments
1	To implement the DDA Line Drawing Algorithm, and generate graphical shapes including polygons, an X-Mas tree, and other geometric figures.
2	To implement Bresenham's line drawing algorithm and generate dotted, dashed and thick line.
3	To implement a Midpoint Circle algorithm and generate various shapes, like a dartboard, Olympic symbol, etc.
4	To implement the Midpoint Ellipse algorithm for conditions such as $R_x > R_y$ and $R_x < R_y$.
5	To implement any one curve generation technique and draw various shapes like a heart, a spade, a wave, etc.

6	To implement any one of the line clipping algorithms.
7	To implement any one polygon fill algorithm.
8	To implement 2D Transformations such as Translation, Scaling, Rotation, Reflection, and shearing on various polygons.
9	To implement 3D Transformations such as Translation, Scaling, and Rotation on various polygons.
10	To implement parallel and perspective projection.
11	To generate the basic primitives and Sierpinski gasket using OpenGL.
12	To create a polyline using mouse interaction using OpenGL.
13	To implement shading using OpenGL/ Blender.
14	Mini project (e.g., any one application: Animation, game design, Paint simulator, etc.)

Note: The lab course shall consist of a minimum of 10 experiments covering all the topics, but not limited to the suggested list.

Suggested Learning Resources

Textbooks

1. Computer Graphics and Multimedia, I Ed., N. Krishna Murthy, Universities Press.
2. Computer Graphics and Virtual Reality Systems, III Ed., Rajesh K. Maurya, Wiley India.

Reference Books

1. Computer Graphics, II Ed, Zhigang Xiang and Roy A. Plastock, McGraw-Hill Education, 2000.
2. Computer Graphics: A Programming Approach, II Ed., Steven Harrington, McGraw-Hill.
3. Procedural Elements for Computer Graphics, II Ed., David F. Rogers, McGraw-Hill.

Web Resources

1. NPTEL Course: Computer Graphics by Prof. Sukhendu Das (IIT Madras).
<https://nptel.ac.in/courses/106106090>
2. edX Course: Computer Graphics.
<https://www.edx.org/learn/computer-graphics/the-university-of-california-san-diego-computer-graphics>
3. Interactive Computer Graphics (Class Central listing).
<https://www.classcentral.com/course/interactivegraphics-2067>
4. SWAYAM Course: Graphics and Animation Development by Er. Shano Solanki.
https://swayam.gov.in/nd2_ntr20_ed15/preview
5. IIT BombayX: Basic 3D Modeling using Blender.
<https://www.edx.org/learn/blender/iitbombay-basic-3d-modeling-using-blender>

2.6.7 Internet Programming (CE5PE_CX4)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE5PE_CX4	Internet Programming	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

S. No.	Objectives
1	To <i>understand</i> web architecture, internet protocols, and client–server communication.
2	To <i>learn</i> front-end development using HTML5, CSS3, JavaScript, and Bootstrap.
3	To <i>gain</i> knowledge of back-end development using Servlets, JSP, and JDBC.
4	To <i>understand</i> Rich Internet Applications using AJAX and jQuery.
5	To <i>learn</i> XML and PHP for dynamic web application development.

Course Outcomes

The student will be able to	
CO1	<i>explain</i> web fundamentals and HTTP communication.
CO2	<i>design</i> interactive web pages using HTML5, CSS3, and JavaScript.
CO3	<i>apply</i> JavaScript for DOM manipulation, validation, and event handling.
CO4	<i>develop</i> server-side applications using Servlets, JSP, and JDBC.
CO5	<i>build</i> dynamic web applications using AJAX, XML, and PHP.

Course Contents

Course Contents			
Module	Unit	Detailed Contents	Hours
	Prerequisites		
	Basic of HTML		
1.0	Introduction to Web Technology		08
	1.1	Web Essentials: Clients, Servers and Communication, The Internet, Basic Internet protocols, World wide web, HTTP Request Message, HTTP Response Message, Web Clients, Web Servers.	

	1.2	HTML5 – fundamental syntax and semantics, Tables, Lists, Image, HTML5 control elements, Semantic elements, Drag and Drop, Audio – Video controls.	
	1.3	CSS3 – Inline, embedded and external style sheets – Rule cascading, Inheritance, Backgrounds, Border Images, Colors, Shadows, Text, Transformations, Transitions, Animation, Basics of Bootstrap, Responsive Web Design, CSS Flexbox, CSS Grid.	
2.0	Front End Development		08
	2.1	Java Script: An introduction to JavaScript–JavaScript DOM Model–Date and Objects–Regular Expressions– Exception Handling.	
	2.2	Validation–Built-in objects–Event Handling, DHTML with JavaScript–JSON introduction – Syntax – Function Files – Http Request –SQL, Local Storage and Session Storage and Fetch API .	
3.0	Back End Development		08
	3.1	Servlets: Java Servlet Architecture, Servlet Life Cycle, Form GET and POST actions, Session Handling, Understanding Cookies, Installing and Configuring Apache Tomcat Web Server.	
	3.2	Database Connectivity: JDBC perspectives, JDBC program example.	
	3.3	JSP: Understanding Java Server Pages, JSP Standard Tag Library (JSTL), Creating HTML forms by embedding JSP code.	
4.0	Rich Internet Application (RIA)		07
	4.1	Characteristics of RIA, Introduction to AJAX: AJAX design basics, AJAX vs Traditional Approach, Rich User Interface using Ajax, jQuery framework with AJAX.	
5.0	Web Extension: PHP and XML		08
	5.1	XML –DTD (Document Type Definition), XML Schema, Document Object Model, Presenting XML, Using XML Parsers: DOM and SAX, XSL-eXtensible Stylesheet Language.	
	5.2	Introduction to PHP- Data types, control structures, built in functions,building web applications using PHP- tracking users, PHP and MySQLdatabase connectivity with example.	
	Total Hours		39

Suggested Learning Resources

Textbooks

1. Web Programming with HTML5, CSS, and JavaScript by John Dean 2018.
2. Web Application Security: Exploitation and Countermeasures for JavaScript Apps– Andrew Hoffman.
3. Web Technology Black Book, I Ed., Dreamtech Press, 978-7722-997
4. Learning PHP, MySQL, JavaScript, CSS & HTML5, III Ed., Robin Nixon O'REILLY, 2014.
5. Professional Rich Internet applications, Dana Moore, Raymond Budd, Edward Benson, AJAX and Beyond Wiley publications
6. The Web Application Hacker's Handbook — Finding and Exploiting Security Flaws, II Ed., Dafydd Stuttard & Marcus Pinto, John Wiley & Sons.

Reference Books

1. Internet and World Wide Web - How To Program, V Ed., Harvey & Paul Deitel& Associates, Harvey Deitel and Abbey Deitel, Pearson Education, 2011.
2. Web Technologies, II Ed., Achyut S Godbole and Atul Kahate, Tata McGraw Hill, 2012.
3. JavaScript: The Complete Reference, III Ed., Thomas A Powell, Fritz Schneider, Tata McGraw Hill, 2013.
4. JavaScript: The Definitive Guide, VI Ed., David Flanagan, O'Reilly Media, 2011.
5. The Complete Reference - PHP, Steven Holzner, Tata McGraw Hill, 2008.
6. PHP & MySQL in easy Steps, Mike Mcgrath Tata McGraw Hill, 2012.

Web Resources

1. NPTEL Video on WEB Technology By Dr. Nitin Deepak.
www.nptelvideos.in
2. HTML, Javascript, XML, PHP, MYSQL Tutorial.
www.w3schools.com

2.6.8 Internet Programming Lab (CE5PE_LX4)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE5PC_LX4	Internet Programming Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	25	-	-	50

Course Objectives

Sr. No.	Objectives
1	To <i>understand</i> the fundamentals of web development and client-server communication.
2	To <i>design</i> web pages using HTML5, CSS3, and Bootstrap.
3	To <i>implement</i> client-side scripting using JavaScript and DOM.
4	To <i>develop</i> server-side applications using Servlets, JSP, and JDBC.
5	To <i>build</i> dynamic and interactive web applications using AJAX, XML, and PHP.

Course Outcomes

The student will be able to	
LO1	<i>create</i> structured and styled web pages using HTML5 and CSS3.
LO2	<i>implement</i> JavaScript for form validation, event handling, and DOM manipulation.
LO3	<i>develop</i> and <i>deploy</i> servlet and JSP-based web applications.
LO4	<i>perform</i> database operations using JDBC and MySQL.
LO5	<i>build</i> dynamic web applications using AJAX, XML, and PHP.

Course Contents

S. No.	Suggestive List of Experiments
1	To implement the installation and configuration of a web browser, code editor, and Apache Tomcat server, and observe HTTP request-response communication using browser developer tools.
2	To implement a web page using HTML elements such as headings, paragraphs, lists, images, tables, and semantic tags.
3	To implement HTML5 form controls and multimedia features in a web application.
4	To implement CSS3 styling techniques using inline, internal, and external stylesheets, including backgrounds, borders, colors, text formatting, and shadow effects.
5	To implement responsive web page designs using CSS3 and Bootstrap with transformations, transitions, animations, and responsive layout components.
6	To implement JavaScript programs using variables, functions, objects, and event handling mechanisms such as click and mouse events.

7	To implement client-side form validation, dynamic content manipulation, and exception handling using JavaScript.
8	To implement an AJAX-based application that retrieves and displays JSON data without reloading the web page
9	To implement a Java Servlet for handling HTTP GET and POST requests and deploy it on the Apache Tomcat server.
10	To implement a Servlet/JSP-based web application demonstrating cookies and HTTP session tracking mechanisms.
11	To implement a JSP application for inserting, retrieving, and displaying data from a MySQL database.
12	To implement an XML document using DTD/XSD and develop a PHP application for XML data processing and MySQL database connectivity.

Note: Lab course shall consist of minimum 10 experiments covering all the topics but not limited to the suggested list.

Suggested Learning Resources

Textbooks

1. Web Technology Black Book, I Ed., Dreamtech Press, 978-7722-997.
2. Professional Rich Internet applications, Dana Moore, Raymond Budd, Edward Benson, AJAX and Beyond Wiley publications .
3. The Web Application Hacker's Handbook — Finding and Exploiting Security Flaws, II Ed., Dafydd Stuttard & Marcus Pinto, John Wiley & Sons.

Reference Books

1. HTML5 Black Book: Covers CSS3, JavaScript, XML, XHTML, AJAX, PHP and jQuery, II Ed., Kogent Learning Solutions Inc., Dreamtech Press, 2016.
2. Murach's Java Servlets and JSP, III Ed., Joel Murach and Michael Urban, Murach Books, 2014.
3. Learning PHP, MySQL & JavaScript: With jQuery, CSS & HTML5, V Ed., Robin Nixon, O'Reilly Media, 2018.

Web Resources

1. NPTEL Video on WEB Technology By Dr. Nitin Deepak.
www.nptelvideos.in
2. HTML, Javascript, XML, PHP, MYSQL Tutorial.
www.w3schools.com

2.7 Multi-Disciplinary Minor Course

2.7.1 Discrete Time Signal Processing (ET5MM_CX1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
ET5MM_CX1	Discrete Time Signal Processing	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

S. No.	Objectives
1	To <i>understand</i> the fundamentals of Digital Signal Processing and discrete-time signal analysis.
2	To <i>analyze</i> discrete-time signals using DFT and FFT for frequency-domain analysis.
3	To <i>design</i> and <i>realize</i> IIR and FIR digital filters.
4	To <i>apply</i> DSP concepts to practical engineering applications.
5	To <i>understand</i> the fundamentals of Digital Signal Processing and discrete-time signal.

Course Outcomes

The student will be able to	
CO1	<i>explain</i> the basic concepts of DSP, convolution, DFT and FFT.
CO2	<i>analyze</i> discrete-time signals using DFT/FFT and <i>implement</i> frequency-domain algorithms.
CO3	<i>design</i> and <i>realize</i> FIR and IIR digital filters.
CO4	<i>analyze</i> transfer functions, frequency response, pole-zero plots and realization structures.
CO5	<i>compare</i> FIR and IIR filters for different applications.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites		
	Signals and Systems.		
	1.0	Introduction to Digital Signal Processing	
1.1		Frequency Domain Analysis of Discrete-Time Signals:	

		Introduction to DSP, Need for DSP, Advantages of DSP over Analog Processing, LTI Systems, Linear Convolution, Circular Convolution, Filtering of Long Data Sequences using Overlap-Add and Overlap-Save Methods, Discrete Fourier Transform (DFT), DFT as Linear Transformation and Properties.	
	1.2	Fast Fourier Transform (FFT): Need for FFT, Radix-2 FFT, Decimation-in-Time (DIT) FFT, Decimation-in-Frequency (DIF) FFT.	
2.0	Filter Realization		07
	2.1	Filter Realization: Transfer Function, Frequency Response, Magnitude and Phase Response, Pole-Zero Plot, Stability of Systems, Direct Form-I, Direct Form-II, Cascade and Parallel Structures, FIR Linear Structure.	
3.0	IIR Filter Design		08
	3.1	IIR Filter Design: LTI Systems as Frequency Selective Filters, LPF and HPF Characteristics of Ideal Filters, Butterworth Approximation, Butterworth Filter Design, Design of Digital IIR Filters using Impulse Invariant Transformation and Bilinear Transformation Techniques.	
4.0	FIR Filter Design		08
	4.1	FIR Filter Design: Characteristics of Linear Phase FIR Filters, Symmetric and Antisymmetric FIR Filters, Location of Zeros, Minimum, Maximum and Mixed Phase FIR Systems, FIR Filter Design using Window Techniques (Rectangular, Hamming, Hanning), Comparison of FIR and IIR Filters.	
5.0	DSP Applications		07
	5.1	DSP Applications: Introduction to DSP Applications, Noise Reduction in Audio Signals using Digital Filters, Echo Cancellation, Sub-band Coding of Speech Signals, ECG & EEG Signal Analysis, DTMF (Dual Tone Multi-Frequency).	
Total Hours			39

Suggested Learning Resources

Textbooks

1. Digital Signal Processing: Principles, Algorithms and Applications, IV Ed., John G. Proakis and Dimitris G. Manolakis, Pearson Education, 2007.
2. Digital Signal Processing: A Practical Approach, II Ed., Emmanuel C. Ifeachor and Barrie W. Jervis, Pearson Education, 2002.
3. Digital Signal Processing, II Ed., A. Nagoor Kani, McGraw Hill Education India Pvt. Ltd., 2012.

Reference Books

1. Digital Signal Processing: A Computer-Based Approach, IV Ed., Sanjit K. Mitra, McGraw Hill Education India, 2013.
2. Discrete-Time Signal Processing, III Ed., Alan V. Oppenheim, Ronald W. Schaffer and John R. Buck, Pearson Education, 2010.

3. Theory and Applications of Digital Signal Processing, I Ed., Lawrence R. Rabiner and Bernard Gold, Prentice Hall of India, 2006.
4. Digital Signal Processing, IV Ed., S. Salivahanan and C. Gnanapriya, McGraw Hill Education India, 2015.
5. Digital Signal Processing, Schaum's Outline Series, II Ed., Monson H. Hayes, McGraw Hill, 2011.
6. Biomedical Signal Analysis: A Case Study Approach, I Ed., Rangaraj M. Rangayyan, Wiley-IEEE Press, 2002.

Web Resources

1. NPTEL course on Digital Signal Processing and its Applications by Prof. V. M. Gadre, IIT Bombay.
<https://nptel.ac.in/courses/108101174>
2. NPTEL course on Digital Signal Processing by Prof. T. K. Basu, IIT Kharagpur.
<https://nptel.ac.in/courses/108105055>
3. NPTEL course on Discrete Time Signal Processing by Prof. Mrityunjay Chakraborty, IIT Kharagpur.
<https://nptel.ac.in/courses/117105134>

2.7.2 Discrete Time Signal Processing Lab (ET5MM_LX1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
ET5MM_LX1	Discrete Time Signal Processing Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	-	-	-	25

Course Objectives

S. No.	Objectives
1	To <i>carry out</i> basic discrete time signal processing operations.
2	To <i>analyze</i> discrete-time signals in the frequency domain using DFT and FFT algorithm
3	To <i>implement</i> and <i>design</i> FIR filters and IIR filters.
4	To <i>evaluate</i> the performance of digital filters using frequency response, phase response, and pole-zero plots
5	To <i>implement</i> applications related to the field of biomedical signal processing and audio signal processing.

Course Outcomes

The student will be able to	
LO1	<i>perform</i> basic discrete time signal processing operations such as Linear Convolution, Circular Convolution, Auto Correlation, Cross Correlation, etc. and <i>interpret</i> the results.
LO2	<i>demonstrate</i> their ability towards <i>interpreting</i> and <i>performing</i> frequency analysis of different discrete time sequences and systems.
LO3	<i>design</i> and <i>implement</i> the FIR and IIR Filters for given specifications.
LO4	<i>implement</i> multirate digital signal processing techniques such as interpolation, decimation, and sampling rate conversion, and <i>analyze</i> their performance in signal processing applications.
LO5	<i>implement</i> and <i>analyse</i> applications related to the field of biomedical signal processing and audio signal processing.

Suggested List of Experiments

S. No.	Suggestive List of Experiments
1	Generate the following standard discrete time signals. i) Unit Impulse ii) Unit step iii) Ramp iv) Exponential
2	Implementation of Linear Convolution between two finite length sequences

3	Implementation of Circular Convolution between two finite length sequences.
4	To perform block convolution using overlap - add method and overlap-save method.
5	To determine impulse, magnitude, phase response and pole-zero plot of given transfer functions.
6	To study the effect of frequency resolution and zero padding.
7	To compute and implement the N-point DFT of a discrete-time signal and study its power spectral density.
8	Verification of the Properties of Discrete Fourier Transform (DFT)
9	Design digital FIR LPF, HPF, BPF, BRF using window techniques
10	Design of IIR Butterworth filter and Chebyshev filter.
11	Implementation of Decimation Process
12	Implementation of Interpolation Process
13	Design of minimum phase, maximum phase and mixed phase systems.
14	Implementation of I/D sampling rate converters
15	Design a comb filter to suppress 50Hz hum in biomedical signals.
16	Design of FIR filter using windowing method and use the designed filter to filter an input signal which has both low and high frequency components or real-world signal like ECG/EEG, speech signal etc.
17	To reconstruct DT signals contaminated with sinusoidal interference using FIR filters.
18	Echo cancellation

Note: Lab course shall consist of minimum 10 experiments covering all the topics but not limited to the suggested list. Include an application based mini-project groupwise.

Suggested Learning Resources

Textbooks

1. Digital Signal Processing: Principles, Algorithms and Applications, IV Ed., John G. Proakis and Dimitris G. Manolakis, Pearson Education, 2007.
2. Digital Signal Processing: A Practical Approach, II Ed., Emmanuel C. Ifeachor and Barrie W. Jervis, Pearson Education, 2002.
3. Digital Signal Processing, II Ed., A. Nagoor Kani, McGraw Hill Education India Pvt. Ltd., 2012.

Reference Books

1. Digital Signal Processing: A Computer-Based Approach, IV Ed., Sanjit K. Mitra, McGraw Hill Education India, 2013.
2. Discrete-Time Signal Processing, III Ed., Alan V. Oppenheim, Ronald W. Schaffer and John R. Buck, Pearson Education, 2010.
3. Theory and Applications of Digital Signal Processing, I Ed., Lawrence R. Rabiner and Bernard Gold, Prentice Hall of India, 2006.
4. Digital Signal Processing, IV Ed., S. Salivahanan and C. Gnanapriya, McGraw Hill Education

India, 2015.

5. Digital Signal Processing, Schaum's Outline Series, II Ed., Monson H. Hayes, McGraw Hill, 2011.
6. Biomedical Signal Analysis: A Case Study Approach, I Ed., Rangaraj M. Rangayyan, Wiley-IEEE Press, 2002.

Web Resources

1. NPTEL course on Digital Signal Processing and its Applications by Prof. V. M. Gadre, IIT Bombay
<https://nptel.ac.in/courses/108101174>
2. NPTEL course on Digital Signal Processing by Prof. T. K. Basu, IIT Kharagpur
<https://nptel.ac.in/courses/108105055>
3. NPTEL course on Discrete Time Signal Processing by Prof. Mrityunjoy Chakraborty, IIT Kharagpur
<https://nptel.ac.in/courses/117105134>
4. Virtual Laboratory
<http://vlabs.iitkgp.ernet.in/dsp/#>

2.7.3 Microprocessor & Microcontrollers(ET5MM_CX2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
ET5MM_CX2	Microprocessor & Microcontrollers	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

S. No.	Objective
1	To <i>learn</i> fundamentals of Microprocessor and Microcontrollers.
2	To <i>write</i> Assembly Language Programming for 8051 microcontroller I/O Interfacing.
3	To <i>learn</i> Interrupts, Timers and counters.
4	To <i>develop</i> an application using 8051 microcontroller.
5.	To <i>study</i> basics of 32 bit Microcontroller.

Course Outcomes

The student will be able to	
CO1	<i>understand</i> fundamentals of microprocessor and Microcontrollers, 8086 architecture.
CO2	<i>develop</i> the basic knowledge and core expertise in 8051 microcontroller.
CO3	<i>write</i> assembly language program to Interface various peripheral devices with 8051 microcontroller .
CO4	<i>design</i> an applications in 8051 Microcontrollers.
CO5	<i>develop</i> the basic knowledge and core expertise in ARM7 microcontroller.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites		
		Digital System Design.	
1.0	Introduction to Microprocessor		08
	1.1	Block diagram of microprocessor based system: CPU, I/O Devices, Memory, Concept of Address, Data and Control Bus	
	1.2	Introduction to 8085 microprocessor.	
	1.3	Introduction to 8086 microprocessor. Overview of 8086 CPU Architecture & Organization, Registers, Instruction Prefetch, ALU, Control unit.	
2.0	Introduction to 8051 Microcontroller		08

	2.1	Comparison between Microprocessor and Microcontroller, Features, Architecture of 8051, Pin Configuration	
	2.2	Machine Cycle, 8051 flag bits and the PSW register, 8051 register banks Program counter, data pointer registers, stack and stack pointer, Special function registers, Memory Organization, Data & Program Memory	
	2.3	Machine Cycle, Timers and counters, Timers Modes & Operations, , Basic of Interrupts, 8051 Interrupt structure, hardware interrupts, Interrupt Programming	
	2.4	Basics of Serial Communication, Modes of Serial Communication.	
3.0	8051 Assembly Language Programming:		08
	3.1	Addressing Modes ,Data types and Assembler directives	
	3.2	Overview of 8051 Instruction set: Data Transfer Instructions, Arithmetic and Logic Instructions, Loop & Jump instructions, Call instructions, Bit manipulation Instructions,	
	3.3	Software development Tools for 8051: Assembler, Simulator, Compiler & Debugger , Programming I/O Port, Timer, Serial communication	
4.0	8051 Interfacing & Practical Applications		08
	4.1	Relay Interfacing ,LED, Seven Segment, LCD Display Stepper Motor	
	4.2	Case studies & hands-on projects involving real world applications,Ex: Digital Thermometer Electronic Voting Machine Note- Students are encouraged to implement Mini-Projects in 8051 as a part of termwork.	
5.0	ARM7: A 32-bit Core Architecture		07
	5.1	Comparison between CISC & RISC, Features of ARM core architecture	
	5.2	Data Flow Model, 3 Stage Pipeline	
	5.3	Registers, operating modes. Introduction to exceptions and interrupts handling	
		Total Hours	39

Suggested Learning Resources

Textbooks

1. Douglas V Hall, SSSP Rao “Microprocessors & Interfacing”, McGraw Hill
2. Ajay Deshmukh, Microcontrollers: Theory and Applications, VI Ed., Tata McGraw Hill Publication.
3. M. A. Mazidi, J. G. Mazidi and R. D. Mckinlay, The 8051 Microcontroller & Embedded systems, II Ed., Pearson Publication.
4. Lyla Das, Embedded Systems: An Integrated Approach, I Ed., Pearson Publication Power Electronics Mohan Ned, John Wiley & Sons Inc.

Reference Books

1. Microprocessors and Interfacing 8085, Douglas V Hall, Tata Mc Gram Hill.
2. Ayala, 8051 Microcontroller , Cengage (Thomson).

3. The 8086/8088 Family, John Uffenbuck, Pearson Media,LPE.
4. ARM System Developer's Guide, Andrew N Sloss, Domnic SYMES.

Web Resources

1. NPTEL Course "Microcontroller and Applications"
<https://nptel.ac.in/courses/117/104/117104072/>

2.7.4 Microprocessor & Microcontrollers Lab(ET5MM_LX2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
ET5MM_LX2	Microprocessor & Microcontrollers Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	-	-	-	25

Course Objectives

S. No.	Objective
1	To <i>learn</i> fundamentals of Microprocessor and Microcontrollers.
2	To <i>write</i> Assembly Language Programming for 8051 microcontroller I/O Interfacing.
3	To <i>learn</i> Interrupts, Timers and counters, applications.
4.	To <i>interface</i> peripheral devices with 8051 microcontrollers.
5.	To <i>design</i> a real time applications using 8051 Microcontrollers programming concepts.

Course Outcomes

The student will be able to	
LO1	<i>explain</i> the architecture, instruction set, arithmetic operations, and internal memory organization of the 8051 microcontroller to solve basic embedded programming problems.
LO2	<i>develop</i> and test Assembly language programs using internal RAM for arithmetic operations, sorting techniques (ascending order), and data manipulation.
LO3	<i>design</i> and <i>implement</i> timer-based and serial communication applications using the 8051
LO4	<i>interface</i> peripheral devices such as LEDs, relays, seven-segment displays, LCDs, and stepper motors with the 8051 microcontroller using hardware and simulation platforms.
LO5	<i>design, develop, and demonstrate</i> a real-time embedded system application integrating multiple peripherals and 8051 programming concepts to meet specified functional requirements.

Suggested List of Experiments

S. No	Suggestive List of Experiments
1	Arithmetic Operations in 8051 Microcontroller
2	Operations on Internal memory (RAM) block of 8051
3	Ascending Order
4	Timer Programming(LED Interfacing) H\W
5	Serial Communication (Proteus Simulation)
6	Rel Relay Interfacing H\W
7	Seven Segment Interfacing H\W

8	LCD interfacing (Proteus Simulation)
9	Stepper Motor interfacing (Proteus Simulation)
10	Design an application using 8051 Microcontrollers

Note: Lab course shall consist of minimum 10 experiments covering all the topics but not limited to the suggested list.

Suggested Learning Resources

Textbooks

1. Douglas V Hall, SSSP Rao “Microprocessors & Interfacing”, McGraw Hill
2. Ajay Deshmukh, Microcontrollers: Theory and Applications, VI Ed., Tata McGraw Hill Publication.
3. M. A. Mazidi, J. G. Mazidi and R. D. Mckinlay, The 8051 Microcontroller & Embedded systems, II Ed., Pearson Publication.
4. Lyla Das, Embedded Systems: An Integrated Approach, I Ed., Pearson Publication Power Electronics Mohan Ned, John Wiley & Sons Inc

Reference Books

1. Microprocessors and Interfacing 8085, Douglas V Hall, Tata Mc Gram Hill
2. Ayala, 8051 Microcontroller , Cengage (Thomson)
3. The 8086/8088 Family, John Uffenbuck, Pearson Media,LPE
4. ARM System Developer’s Guide, Andrew N Sloss, Domnic SYMES

Web Resources

1. NPTEL Course “Microcontroller and Applications”
<https://nptel.ac.in/courses/117/104/117104072/>

2.7.5 Electric Vehicle Systems and Control (EE5MM_CX1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
EE5MM_CX1	Electric Vehicle Systems and Control	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

S. No.	Objectives
1	To <i>develop</i> the ability to <i>analyze</i> , <i>mathematically model</i> , and <i>simulate</i> vehicle parameters.
2	To <i>provide</i> fundamental knowledge of electric vehicle components and operating principles of DC, induction, BLDC, PM, and SRM motor drives with control techniques.
3	To <i>introduce</i> the fundamentals of drive cycles and <i>develop</i> understanding of their role in energy consumption analysis and electric vehicle drivetrain design.
4	To <i>provide</i> an understanding of major power electronic converters and motor drive components used in electric vehicle drivetrains.
5	To <i>introduce</i> fundamental control strategies used in electric vehicles, including traction, regenerative braking, battery, energy management, protection, and charging control.

Course Outcomes

The student will be able to	
CO1	<i>evaluate</i> vehicle performance by modeling rolling, aerodynamic, and grade resistances, and <i>simulate</i> acceleration, maximum speed, and transmission system behavior.
CO2	<i>understand</i> , <i>analyze</i> , and <i>select</i> appropriate electric motor drive systems and control strategies for electric vehicle applications.
CO3	<i>analyze</i> different drive cycles, <i>estimate</i> EV energy consumption per kilometer, and <i>apply</i> drive cycle data in the design of an electric vehicle drivetrain.
CO4	<i>explain</i> the operation and integration of AC–DC, DC–DC, DC–AC converters and <i>analyze</i> the structure and function of electric motor drive systems in EVs.
CO5	<i>understand</i> and <i>analyze</i> basic EV control functions and <i>apply</i> suitable control strategies for safe, efficient, and reliable electric vehicle operation.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites		
	Knowledge of basic concepts of force, motors and electronics.		
1.0	Vehicle Dynamics: Modelling and Simulation		08
	1.1	Vehicle resistance (rolling, aerodynamic drag, grading), Vehicle performance characteristics, Acceleration force and maximum speed.	
	1.2	Transmission systems, including gearboxes and clutches- Mathematical modeling and Simulation.	
2.0	Fundamentals of Electric Motors for EVs		08
	2.1	Introduction to electric components for EVs. DC motor drives (chopper control, multi-quadrant control).	
	2.2	Introduction to Induction motor drives, Permanent Magnet BLDC and SRM motor drives.	
3.0	Drive Cycle and Design of EV Drive Train		07
	3.1	Fundamentals of Drive Cycles: Definition and Purpose of Drive Cycles.	
	3.2	Types of Driving Cycles, Drive Cycles and Energy used per km of an EV. (Numerical)	
4.0	Power Electronics and Motor Control		08
	4.1	Major Power Electronics Blocks in EV Drivetrain, AC-DC, DC-DC, DC-AC(Traction inverter) converters.	
	4.2	Motor Drive / Motor Controller- Concept of an electric drive & components of a drive: Power converter, controller, motor, sensors	
5.0	Electric vehicle control strategy		08
	5.1	Introduction to EV Control- Basic Traction Control, Regenerative Braking Control.	
	5.2	Battery and Energy Control, Vehicle Protection Control and Charging Control.	
	Total Hours		39

Suggested Learning Resources

Textbooks

1. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, II Ed., Mehrdad Ehsani, Yimin Gao, Stefano Longo and Kambiz Ebrahimi, CRC Press, 2018.
2. Electric Vehicle Technology Explained, II Ed., John Lowry and James Larminie, John Wiley and Sons, 2012.
3. Electric and Hybrid Vehicles: Design Fundamentals, I Ed., Iqbal Hussein, CRC Press, 2003.

Reference Books

1. Hybrid Electric Vehicles Principles and Applications with Practical Perspectives, II Ed., Chris

Mi, M. Abul Masrur John Wiley & Sons, Inc., 2018.

Web Resources

1. NPTEL Course on Introduction to Hybrid and Electric Vehicles by Dr. Praveen Kumar and Prof. S. Majhi, IIT Guwahati

<https://nptel.ac.in/courses/108/103/108103009/>

2.7.6 Vehicle Dynamics and EV Simulation Lab (EE5MM_LX1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
EE5MM_LX1	Vehicle Dynamics and EV Simulation Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	-	-	-	25

Course Objectives

S. No.	Objectives
1	To <i>develop</i> the ability to <i>model, simulate, and analyze</i> electric vehicle performance parameters such as rolling resistance, aerodynamic drag, acceleration, and energy consumption using modern software tools.
2	To <i>provide</i> hands-on experience in the study of electric vehicle subsystems including batteries, electric motors, sensors, power converters, and control systems through hardware and simulation-based experiments.
3	To <i>enable</i> students to <i>investigate and evaluate</i> drive cycles, battery State-of-Charge (SOC), regenerative braking, and energy management strategies used in electric vehicles.
4	To <i>familiarize</i> students with open-source software tools and virtual platforms for electric vehicle modeling, route optimization, data analysis, and smart mobility applications.
5	To <i>develop</i> problem-solving, analytical, and experimental skills for designing, testing, and monitoring electric vehicle systems and sustainable transportation technologies.

Course Outcomes

The student will be able to	
LO1	<i>model and analyze</i> vehicle dynamics parameters, including rolling resistance, aerodynamic drag, acceleration, and gradeability, using simulation tools.
LO2	<i>perform</i> experiments on electric vehicle subsystems and evaluate the performance of batteries, motors, sensors, and energy storage systems.
LO3	<i>analyze</i> drive cycle data, <i>estimate</i> energy consumption, battery State-of-Charge (SOC), and <i>assess</i> the effectiveness of regenerative braking techniques.
LO4	<i>utilize</i> open-source software tools for electric vehicle simulation, route optimization, battery modeling, and data visualization applications.

LO5	<i>design, implement, and interpret</i> solutions for electric mobility problems using hardware prototypes, simulation platforms, and modern engineering tools.
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Suggested List of Experiments

S. No.	Suggestive List of Experiments
1	Simulation and Analysis of Aerodynamic Drag on EV Energy Consumption.
2	Development of a Mathematical Model for EV Acceleration Performance.
3	Comparative Analysis of Standard Driving Cycles and Their Effect on EV Range.
4	Simulation of Regenerative Braking and Energy Recovery in Electric Vehicles.
5	Speed Control of DC Shunt Motor.
6	Speed-Torque Characteristics of DC Series Motor.
7	Regenerative Braking of DC motor.
8	Speed control of Induction motor.
9	Torque-Speed Characteristics of Induction Motor.
10	Battery Charging Characteristics.
11	Estimation of Energy Consumption per Kilometer for an Electric Vehicle.
12	Microcontroller Based DC Motor Control.
13	Comparative Analysis of Various Braking Methods.
14	Route Optimization for Electric Vehicles Using Python and OpenStreetMap.

Note: Lab course shall consist of minimum 08 experiments covering all the topics but not limited to the suggested list.

Suggested Learning Resources

Textbooks

1. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, II Ed., M. Ehsani, Y. Gao, S. Longo and K. Ebrahimi, CRC Press, 2018.
2. Electric Vehicle Technology Explained, II Ed., James Larminie and John Lowry, John Wiley & Sons, 2012.
3. Electric and Hybrid Vehicles: Design Fundamentals, II Ed., Iqbal Husain, CRC Press, 2011.

Reference Books

1. Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, II Ed., Chris Mi and M. Abul Masrur, John Wiley & Sons, 2018.
2. Electric Vehicle Machines and Drives: Design, Analysis and Application, I Ed., K. T. Chau, Wiley-IEEE Press, 2015.
3. Fundamentals of Vehicle Dynamics, I Ed., Thomas D. Gillespie, SAE International, 1992.
4. Vehicle Dynamics: Theory and Application, III Ed., Reza N. Jazar, Springer, 2021.
5. Power Electronics: Converters, Applications and Design, III Ed., Ned Mohan, Tore M. Undeland and William P. Robbins, John Wiley & Sons, 2003.

Web Resources

1. Virtual Labs, Ministry of Education, Government of India

- <https://www.vlab.co.in>
2. Electrical Machines Virtual Lab, IIT Roorkee
<https://em-iitr.vlabs.ac.in>
 3. Power Electronics Virtual Laboratory, IIT Kharagpur
<https://virtual-labs.github.io/exp-power-electronics-iitkgp>
 4. Control Engineering Virtual Laboratory, IIT Delhi
<https://coep.vlab.co.in>
 5. OpenModelicaDocumentationandTutorials
<https://openmodelica.org>

2.7.7 Data Management, Cloud Integration and Analytics (EC5MM_CX1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
EC5MM_CX1	Data Management, Cloud Integration and Analytics	03	03

Examination and Evaluation Scheme

Examination and Evaluation Scheme						
ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

S. No.	Objectives
1	To <i>understand</i> the principles of IoT data generation, acquisition, preprocessing, representation, and management.
2	To <i>explain</i> database technologies, data storage systems, and big data processing frameworks used for managing IoT data.
3	To <i>understand</i> cloud computing concepts and IoT cloud integration using modern cloud platforms and services.
4	To <i>apply</i> statistical analysis and basic machine learning techniques to analyze IoT data and support data-driven decision making.
5	To <i>develop</i> an understanding of real-time IoT data processing, visualization techniques for intelligent systems.

Course Outcomes

The student will be able to	
CO1	<i>explain</i> the characteristics, acquisition, preprocessing, representation, and management of IoT data.
CO2	<i>analyze</i> and <i>compare</i> database technologies, distributed storage systems, and big data frameworks for IoT applications.
CO3	<i>describe</i> cloud computing architectures and integrate IoT devices with cloud-based platforms and services.
CO4	<i>apply</i> statistical analysis and basic machine learning techniques to extract meaningful insights from IoT data.
CO5	<i>demonstrate</i> the use of real-time data processing and visualization tools to support monitoring and decision-making in IoT applications.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites:		
	Fundamentals of IoT, Basic concepts of DBMS, Probability and statistics		

1.0	IoT Data Generation, Acquisition and Management		8
	1.1	IoT Data Generation and Characteristics: Introduction to IoT data and its lifecycle; Characteristics of IoT data- Volume, Velocity, Variety, Veracity; IoT data sources: Sensors, Actuators, RFID, Embedded Systems and Smart Devices; Types of IoT data- Structured, Semi-structured, Unstructured, Streaming and Time-series.	
	1.2	IoT Data Acquisition and Pre-processing: IoT data acquisition architecture; Device communication; IoT gateways; Edge, Fog and Cloud data flow; Data cleaning, filtering, validation and aggregation; Data transformation, compression and data quality (Accuracy, Completeness and Consistency).	
	1.3	IoT Data Representation and Management: JSON and XML data formats; Data storage formats and repositories ; Challenges in IoT data management; Overview of IoT data processing architecture.	
2.0	Database Technologies and Big Data Processing		8
	2.1	Database Fundamentals: Database concepts and architecture; Relational Database Management Systems (RDBMS) ; Tables, Attributes, Primary Keys and Foreign Keys; ACID properties.	
	2.2	IoT Database Technologies: SQL and NoSQL databases; Key-value, Document, Column-family and Graph databases; Time-series databases; Distributed databases and CAP theorem.	
	2.3	IoT Data Storage and Big Data Processing: Data warehouse and Data lake; Distributed storage systems; Introduction to Big Data; Hadoop ecosystem, HDFS and MapReduce.	
3.0	Cloud Computing and IoT Cloud Integration		8
	3.1	Cloud Computing Fundamentals: Characteristics of cloud computing; Cloud service models: IaaS, PaaS and SaaS ; Public, Private and Hybrid deployment models.	
	3.2	Cloud Infrastructure and IoT Integration: Virtualization, Resource management, Scalability and elasticity, Device-to-cloud communication, IoT gateways and data ingestion services.	
	3.3	IoT Cloud Platforms: Cloud-based IoT architecture; AWS IoT architecture, Microsoft Azure IoT architecture, Google Cloud IoT architecture; Comparison of IoT cloud platforms.	
4.0	IoT Analytics and Machine Learning		8
	4.1	Fundamentals of IoT Analytics: Analytics pipeline; Data-driven decision making; Descriptive, Predictive and Prescriptive analytics.	
	4.2	Statistical Analysis and Machine Learning: Data summarization; Correlation, Regression and Trend analysis; Machine learning workflow; Supervised learning- Classification and Regression; Unsupervised learning- Clustering; Model evaluation.	
	4.3	IoT Analytics Applications: Smart healthcare; Smart agriculture; Smart cities; Industrial IoT applications.	
5.0	Real-Time Analytics and Data Visualization		7
	5.1	Real-Time Data Processing: Batch and Stream processing; Event-driven architecture; Complex Event Processing (CEP); Apache Kafka overview; Apache Spark Streaming overview.	
	5.2	Data Visualization: Visualization principles; Dashboards and monitoring systems; Visualization tools- Grafana, Power BI and Tableau.	

	Total Hours	39
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Suggested Learning Resources

Textbooks

1. Internet of Things: Principles and Paradigms, I Ed., Rajkumar Buyya, Amir Vahid Dastjerdi, Morgan Kauffman, 2016.
2. Internet of Things – Architecture and Design Principles, I Ed., Kamal, R., Mcgraw Hill, 2017.
3. Internet of Things: A Hands-On Approach, II Ed., Arshdeep Bahga, Vijay Madisetti, Universities Press, 2015.
4. IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, I Ed., David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton, Jerome Henry, Cisco Press, 2017.
5. Thomas Erl, Ricardo Puttini, Zaigham Mahmood, Cloud Computing: Concepts, Technology & Architecture, 1st Edition, Pearson India, 2014

Reference Books

1. The Internet of Things: A Guide to the Connected World, II Ed., Samuel Greengard, The MIT Press, 2021.
2. Designing the Internet of Things, I Ed., Adrian McEwen, Hakim Cassimally, Wiley, 2013.
3. Big Data: Principles and Best Practices of Scalable Real-Time Data Systems, I Ed., Marz, N., Warren, J., Manning Publications, 2015.
4. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, I Ed., EMC Education Services, John Wiley & Sons, 2015.

Web Resources

1. NPTEL course on Introduction to IoT by Prof. Sudip Misra, IIT Kharagpur
<https://archive.nptel.ac.in/courses/106/105/106105166/>
2. NPTEL course on Cloud Computing by Prof. Soumya Kanti Ghosh, IIT Kharagpur
<https://nptel.ac.in/courses/106105167>

2.7.8 IoT Programming and Interfacing Lab (EC5MM_LX1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
EC5MM_LX1	IoT Programming and Interfacing Laboratory	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	-	-	-	25

Course Objectives

S. No.	Objectives
1	To <i>familiarize</i> students with IoT hardware platforms, development tools, and basic programming techniques.
2	To <i>develop</i> skills in interfacing sensors, actuators, and peripheral devices with IoT controllers.
3	To <i>enable</i> students to acquire, process, and communicate sensor data using wired and wireless interfaces.
4	To <i>provide</i> hands-on experience in designing IoT-based monitoring and automation applications.
5	To <i>introduce</i> cloud-based data logging, visualization, and mobile-enabled IoT systems.

Course Outcomes

The student will be able to	
LO1	<i>demonstrate</i> the use of IoT hardware platforms, programming environments, and basic interfacing techniques
LO2	interface sensors, actuators, and display devices to <i>develop</i> basic embedded IoT applications.
LO3	<i>acquire</i> , process, and communicate data between IoT devices and external systems.
LO4	<i>design</i> and <i>implement</i> IoT-based monitoring and automation solutions for real-world applications.
LO5	<i>develop</i> IoT applications with cloud connectivity, remote monitoring, and data visualization capabilities.

Suggested List of Experiments

S. No.	Suggestive List of Experiments
1	Introduction to essential components of IoT.
2	Interfacing of LED and its control using push button, potentiometer and LDR.
3	Design and implementation of temperature and humidity monitoring system using DHT11/ LM35 and LCD.

4	Design and implementation of motion-controlled lights using PIR sensor.
5	Design and implementation of level detection using ultrasonic sensor.
6	Design and implementation of a smoke/gas detection system using MQ series sensor and buzzer.
7	Design and implementation of an automated irrigation system.
8	Design and implementation of noise pollution monitoring system.
9	Design and implementation of obstacle detection system.
10	Design and implementation of traffic management system.
11	Design and implementation of health monitoring system.
12	Design and implementation of RFID-based door access system.
13	Design and implementation of a home automation system using mobile App.
14	Implementation of data transfer and its analysis using Teraterm.
15	Implementation of a live monitoring dashboard on ThingSpeak.

Note:

1. Lab course shall consist of minimum 10 experiments covering all the topics but not limited to the suggested list.
2. Various types of sensors, actuators, microcontrollers and wired and wireless communication technologies must be used.

Suggested Learning Resources

Textbooks

1. Internet of Things: A Hands-On Approach, II Ed., Arshdeep Bahga, Vijay Madiseti, Universities Press, 2015.
2. Internet of Things: Principles and Paradigms, I Ed., Rajkumar Buyya, Amir Vahid Dastjerdi, Morgan Kauffman, 2016.
3. Internet of Things – Architecture and Design Principles, I Ed., Kamal, R., Mcgraw Hill, 2017.

Reference Books

1. The Internet of Things: A Guide to the Connected World, II Ed., Samuel Greengard, The MIT Press, 2021.
2. IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, I Ed., David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton, Jerome Henry, Cisco Press, 2017.

Web Resources

1. NPTEL course on Introduction to IoT by Prof. Sudip Misra, IIT Kharagpur.
<https://archive.nptel.ac.in/courses/106/105/106105166/>
2. Arduino Documentation.
<https://docs.arduino.cc/?utm>
3. ESP-IDF Programming Guide.

[https://docs.espressif.com/projects/esp-idf/en/latest/esp32/?utm_ =](https://docs.espressif.com/projects/esp-idf/en/latest/esp32/?utm_=)

4. Raspberry Pi Documentation.

<https://www.raspberrypi.com/documentation/?utm>

5. Get Started with ThingSpeak.

<https://www.mathworks.com/help/thingspeak/getting-started-with-thingspeak.html>

2.7.9 CAD for Additive Manufacturing (ME5MM_CX1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
ME5MM_CX1	CAD for Additive Manufacturing	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

S. No.	Objectives
1	To <i>introduce</i> students to the fundamentals of CAD/CAM, including hardware, software, and geometric model mapping used in product life cycle management.
2	To <i>develop</i> the ability to <i>create</i> and <i>analyze</i> solid models, using CSG, B-Rep, wireframe, surface, and parametric modeling techniques.
3	To <i>enable</i> students to <i>understand</i> and <i>construct</i> parametric curves and surfaces, including Bezier, Hermite, and B-spline formulations.
4	To <i>equip</i> students with knowledge of geometric transformations in 2D and 3D using matrix and homogeneous coordinate systems.
5	To <i>familiarize</i> students with CAD data exchange formats and additive manufacturing integration, including STL issues, AMF, 3MF, and STEP AP standards.

Course Outcomes

The student will be able to	
CO1	<i>explain</i> the role and scope of CAD/CAM in product development and identify key hardware/software components.
CO2	<i>create</i> and <i>manipulate</i> 3D solid models using parametric, feature-based, and constraint-based modeling approaches.
CO3	<i>construct and analyze</i> parametric curves and surfaces, such as Bezier, Hermite, and B-spline curves for engineering design.
CO4	<i>apply</i> geometric transformations (translation, scaling, rotation, reflection, shearing) using matrix and homogeneous coordinate systems in 2D and 3D.
CO5	<i>use</i> appropriate CAD data exchange formats and identify STL file errors, corrections, and formats used in additive manufacturing applications.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites		
	Engineering Graphics & Design		
1.0	Introduction to CAD		08
	1.1	Scope of CAD/CAM in product life cycle, CAD/CAM hardware and software, 2D and 3D computer graphics representation, Mapping of Geometric Models.	
2.0	Solid Modeling		08
	2.1	Constructive solid geometry (CSG), Boundary Representation (Brep), Wire Frame Modeling, Solid Modeling, Surface Modeling, Parametric Modeling, Feature-based modeling, Constraint-based modeling.	
3.0	Design of Curves		08
	3.1	Parametric representation of curves and surfaces: Synthetic Curves - Bezier curves, Hermite Curves, B-spline curves. Surface representation.	
4.0	Geometric Transformation		08
	4.1	Homogeneous Coordinate system, Matrix representation, Concatenations, 2D and 3D geometric transformation (Translation, Scaling, Rotation, Reflection and Shearing).	
5.0	Exchange Formats and Applications		07
	5.1	CAD Data exchange formats, 3D digitizing: Reengineering for Additive Manufacturing (AM). AM Data Formats: Tessellated Models, STL Format, STL File Problems, STL File Manipulation and Repair Algorithms, AMF files, 3MF, XML, Meta Data, PLY, STEP for AM Application Protocols (AP).	
Total Hours			39

Suggested Learning Resources

Textbooks

1. CAD/ CAM, Theory & Practice, II Ed., Ibrahim Zeid, R. Sivasubramanian, Tata McGraw-Hill Publications, 2009.
2. CAD/CAM Principles and Applications, III Ed., P. N. Rao, Tata McGraw-Hill Publications, 2010.

Reference Books

1. CAD/CAM: Computer-Aided Design and Manufacturing , I Ed., Groover, M. P., & E. W. Zimmers, Pearson Education India, 2003.
2. CAD/CAM: Principles, Practice and Manufacturing Management, II Ed., Chris McMahon & Jimmie Browne, Addison-Wesley Longman Ltd., 1998.

Web Resources

1. NPTEL course on Computer Integrated Manufacturing by Prof. J. Ramkumar & Prof.

Amandeep Singh, IIT Kanpur

<https://nptel.ac.in/courses/112104289>

2. NPTEL course on Computer Aided Design and Manufacturing by Prof. Anoop Chawla,
Prof. P.V. Madhusudan Rao, IIT Delhi

<https://nptel.ac.in/courses/112102101>

2.7.10 CAD Lab (ME5MM_LX1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
ME5MM_LX1	CAD Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	-	-	-	25

Course Objectives

S. No.	Objectives
1	To <i>understand</i> the fundamentals of CAD systems, solid modeling concepts, and types of CAD models used in engineering applications.
2	To <i>develop</i> competency in 2D sketching and geometric modeling using standard creation, modification, and viewing tools.
3	To <i>create</i> accurate 3D solid models of engineering components using feature-based modeling techniques.
4	To <i>apply</i> surface modeling and feature manipulation methods to develop complex and free-form geometries.
5	To <i>perform</i> assembly modeling, drafting, detailing, and CAD data exchange using appropriate standards and formats.

Course Outcomes

The student will be able to	
CO1	<i>explain</i> the principles of CAD, solid modeling, and applications of CAD models in engineering design and manufacturing.
CO2	<i>generate</i> precise 2D sketches of engineering components using appropriate sketching, modification, and viewing commands.
CO3	<i>develop</i> 3D solid and surface models of engineering components using feature-based and surface modeling tools.
CO4	<i>create</i> and <i>analyze</i> assembly models, including constraints, exploded views, interference checks, and engineering drawings.
CO5	<i>select</i> and <i>apply</i> suitable CAD data exchange formats (IGES, STEP/PDES, Parasolid, DXF, STL) for interoperability and manufacturing use.

Suggested List of Experiments

S. No.	Suggestive List of Experiments
1	CAD Introduction- Introduction to Solid Modeling Packages, CAD models Creation, Types and uses of models from different perspectives.
2	2D Modeling – Sketching- Geometric modeling of an Engineering component, demonstrating skills in sketching commands of creation (line, arc, circle etc.) modification (Trim, move, rotate etc.) and viewing using (Pan, Zoom, Rotate etc.).
3	Solid Modeling – Part Modelling- 3D Geometric modeling of an Engineering component, demonstrating modeling skills using commands like Extrude, Revolve, Sweep, Blend, Loft etc.
4	Surface Modelling- Extrude, Sweep, Trim etc and Mesh of curves, free form surfaces etc. Feature manipulation using Copy, Edit, Pattern, Suppress, History operations etc.
5	Assembly Modelling- Assembly modeling using appropriate assembly constraints, Exploded views, interference check. Drafting (Layouts, Standard & Sectional Views, Detailing & Plotting).
6	Data Exchange- CAD data exchange formats like IGES, PDES, PARASOLID, DXF and STL along with their comparison and applicability.

Suggested Learning Resources

Textbooks

1. CAD/ CAM, Theory & Practice, II Ed., Ibrahim Zeid, R. Sivasubramanian, Tata McGraw-Hill Publications, 2009.
2. CAD/CAM Principles and Applications, III Ed., P. N. Rao, Tata McGraw-Hill Publications, 2010.
3. CAD/CAM: Computer-Aided Design and Manufacturing , I Ed., Groover, M. P., & E. W. Zimmers, Pearson Education India, 2003.

Reference Books

1. CAD/CAM: Principles, Practice and Manufacturing Management, II Ed., Chris McMahon & Jimmie Browne, Addison-Wesley Longman Ltd., 1998
2. Theory and Design for Mechanical Measurements, VI Ed., D. H. Figliola & A. Beasley, Wiley, 2015.

Web Resources

1. Introduction to SOLIDWORKS tutorials,
<https://www.solidprofessor.com/tutorials/solidworks/introduction-to-solidworks-tutorials-2025/52184>
2. 3D Printing Training Video for Flashforge.
https://www.youtube.com/watch?v=17RMY_5ncIQ

2.7.11 Mobile Robotics and Path Planning (ME5MM_CX2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
ME5MM_CX2	Mobile Robotics and Path Planning	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

S. No.	Objectives
1	To <i>introduce</i> mobile robot structures and pose representation methods.
2	To <i>develop</i> understanding of robot mobility constraints and motion generation methods.
3	To <i>familiarize</i> with robot actuation, dynamics and motion feasibility issues.
4	To <i>illustrate</i> methods for robot navigation and autonomous path planning.
5	To <i>acquaint</i> with advanced mobility and motion planning concepts.

Course Outcomes

The student will be able to	
CO1	<i>explain</i> mobile robot pose mathematically using coordinate transformations.
CO2	<i>analyze</i> robot mobility and generate robot kinematics and feasible trajectories.
CO3	<i>estimate</i> motion feasibility, torque and power requirements for mobile robots.
CO4	<i>apply</i> path planning and obstacle avoidance methods for robot navigation.
CO5	<i>compare</i> spatial and emerging mobility systems as well as modern motion strategies.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites		
	Coordinate geometry, Trigonometry, Vectors, Matrices, Equations of motion, Rotational motion.		
1.0	Introduction and Robot and Pose Representation		07
	1.1	Introduction: Mobile robotics vs fixed robotics; Anatomy of mobile robots; Locomotion categories; Wheeled vs legged	

		locomotion overview.	
	1.2	Concept of pose: Coordinate frames, points and vectors; Fixed and moving reference frames; Global and local frames; Relative motion.	
	1.3	Pose representation: Rotation in 2 dimensions; Rotation matrix; Planar translations; Planar rigid-body transformations; Homogeneous coordinates; Homogeneous transform matrix; Composition and chaining of transforms; Pre-multiplication and post-multiplication issues.	
2.0	Mobility Kinematics and Motion Generation		08
	2.1	Mobile robot maneuverability: Locomotion constraints; Degrees of mobility and steerability; Holonomic and non-holonomic constraints; Maneuverability; Reachability; Motion feasibility; Minimum turning radius and wheel saturation.	
	2.2	Kinematic models: Coordinate frames in mobile robots; Wheel kinematic constraints; Study of fixed, steered, castor and mecanum wheels; Kinematics of differential-drive, steered and omnidirectional robots; Wheel constraints and slip.	
	2.3	Time-parameterized motion: Trajectory vs path; Straight-line, circular and polynomial motion; Velocity profiles; Motion smoothing and interpolation under kinematic constraints; Motion constraints for trajectory feasibility.	
3.0	Actuation, Dynamics and Motion Feasibility		08
	3.1	Basic rigid-body dynamics: Newton's 2nd law for translation and rotation; Linear acceleration and force; Angular acceleration and torque; Wheel inertia; Simple rolling friction; Acceleration limits.	
	3.2	Motion feasibility and power limits: Torque estimation; Turn radius and tip-over constraints; Velocity and acceleration limits; Wheel slip and traction limits; Incline motion; Power consumption and battery capacity; Thermal considerations.	
	3.3	Actuation and drivetrain mechanics: DC motor basics; Torque-speed curves; Gearbox effects; Actuator selection; Wheel torque transmission; Efficiency losses.	
4.0	Robot Navigation and Path-Planning		08
	4.1	Navigation foundations: The navigation stack; Need for path planning; Workspace and C-space; Free space and obstacle space; Offline vs online planning; Global and local planning; Static vs dynamic maps.	
	4.2	Global path planning: Occupancy grid representation and methods; Graph search and traversal algorithms; Sampling-based planning; Potential field based navigation.	
	4.3	Local path planning: Need for reactive methods; Workspace vs C-space obstacles; Sensor-based vs map-based motion; Path smoothing; Bug algorithms for obstacle avoidance; Geometry-	

		based collision avoidance techniques.	
5.0	Emerging Mobility Systems		08
	5.1	Beyond Planar motion: Rotation in 3 dimensions; 3x3 rotation matrix; Euler angles utility and limitation; Basics of angle-axis and related representations; 3D homogeneous transformations.	
	5.2	Beyond wheeled robots: Wheeled vs legged mobility; Terrain perception, foothold selection and gait stability; Rocker-bogie robots and passive suspension systems; Aerial and aquatic robot configurations; Propulsion and steering issues; Energy and control tradeoffs.	
	5.3	Beyond shortest path: Shortest path versus feasible path; Constraint-aware motion; Trajectory smoothing; Jerk minimization and passenger comfort; Time-optimal and energy-aware trajectories.	
	Total Hours		39

Suggested Learning Resources

Textbooks

1. Robotics, Vision and Control: Fundamental Algorithms in Python, III Ed., Peter Corke, Springer, 2023.
2. Introduction to Autonomous Mobile Robots, II Ed., Ronald Siegwart, Illah. Reza Nourbakhsh, Davide Scaramuzza, The MIT Press, 2011.
3. Robotics: Fundamental Concepts and Analysis, I Ed., Ashitava Ghosal, Oxford University Press, 2019.
4. Robotics Modelling, Planning and Control, I Ed., Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo, Springer, 2009.
5. Introduction to Autonomous Robots: Mechanisms, Sensors, Actuators, and Algorithms, II Ed., Nikolaus Correll, Bradley Hayes, Christoffer Heckman and Alessandro Roncone, The MIT Press, 2022.

Reference Books

1. Embedded Robotics: From Mobile Robots to Autonomous Vehicles with Raspberry Pi and Arduino, IV Ed., Thomas Bräunl, Springer, 2022.
2. Theory of Applied Robotics: Kinematics, Dynamics, and Control, II Ed., Reza N. Jazar, Springer, 2010.
3. Modern Robotics: Mechanics, Planning, and Control, I Ed., Kevin M. Lynch and Frank C. Park, Cambridge University Press, 2017.
4. Introduction to Robotics: Analysis, Control, Applications, II Ed., Saeed B. Niku, Wiley, 2010.
5. Fundamentals of Robotics, I Ed., D. K. Pratihar, Narosa, 2023.

Web Resources

1. NPTEL course on Wheeled Mobile Robots by Prof. Asokan Thondiyath & Prof. Santhakumar, Mohan, IIT Madra & IIT Palakkad

- <https://nptel.ac.in/courses/112106298>
2. NPTEL course on Robot Motion Planning by Prof. Ashish Dutta, IIT Kanpur
<https://nptel.ac.in/courses/112104308>
 3. NPTEL course on Drone Systems and Control by Prof. Suresh Sundaram, Prof. Rudrashis Majumder, IISc Bangalore
<https://nptel.ac.in/courses/101108661>
 4. NPTEL course on Introduction To Robotics by Prof. Asokan T, Prof. Krishna Vasudevan, and Prof. Balaraman Ravindran, IIT Madras
<https://nptel.ac.in/courses/107106090>

2.7.12 Mobile Robotics and Path Planning Lab (ME5MM_LX2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
ME5MM_LX2	Mobile Robotics and Path Planning Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	-	-	-	25

Course Objectives

S. No.	Objectives
1	To <i>develop</i> computational workflows to represent, parameterize, and visualize robot motion using time-based trajectories.
2	To <i>model</i> the kinematics of common mobile robot configurations and <i>relate</i> robot motion to wheel velocities.
3	To <i>analyze</i> the physical feasibility of robot motion by estimating wheel forces, torques, and power requirements.
4	To <i>validate</i> analytically generated robot motion using physics-based simulation environments.

Course Outcomes

The student will be able to	
CO1	<i>estimate</i> motion parameters and interpolated profiles for mobile robots.
CO2	<i>implement</i> kinematic models of mobile robots to compute wheel angular velocities.
CO3	<i>estimate</i> wheel forces, torques and power requirements for mobile robots.
CO4	<i>evaluate</i> the consistency between analytical motion models and simulated robot behaviour using a virtual robotics simulator.

Suggested List of Experiments

S. No.	Suggestive List of Experiments
1	Study of microcontroller development board.
2	Study of serial communication interfaces in microcontroller.
3	Integration of microcontroller with mobile robot actuators.
4	Assembly of physical mobile robot from given components.
5	Development of virtual robot and world models in simulation software.
6	Modelling of mobile robot kinematics using object-oriented programming.
7	Generation, visualization and simulation of time-parameterized motion.
8	Study of velocity profiling, motion constraints and turning constraints.

9	Differential-drive dynamics, torque estimation and motion feasibility.
10	Implementation and testing of robot path planning algorithms.
11	Evaluation of physical and simulated planned path execution.

Note:

1. Journal submission shall include minimum 8 Laboratory Experiments.
2. Recommended hardware: ESP32 microcontroller board, DC motors, L298N motor driver.
3. Recommended software tools: Webots simulator, Python language.

Suggested Learning Resources

Textbooks

1. Robotics, Vision and Control: Fundamental Algorithms in Python, III Ed., Peter Corke, Springer, 2023.
2. ROS Robotics Projects, II Ed., Ramkumar Gandhinathan, Lentin Joseph, Packt, 2019.
3. Mastering ROS 2 for Robotics Programming, IV Ed., Lentin Joseph and Jonathan Cacace, Packt, 2025.
4. Robotics Modelling, Planning and Control, I Ed., Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo, Springer, 2009.
5. Introduction to Autonomous Robots: Mechanisms, Sensors, Actuators, and Algorithms, II Ed., Nikolaus Correll, Bradley Hayes, Christoffer Heckman and Alessandro Roncone, The MIT Press, 2022.

Reference Books

1. Embedded Robotics: From Mobile Robots to Autonomous Vehicles with Raspberry Pi and Arduino, IV Ed., Thomas Bräunl, Springer, 2022.
2. Introduction to Autonomous Mobile Robots, II Ed., Ronald Siegwart, Illah. Reza Nourbakhsh, Davide Scaramuzza, The MIT Press, 2011.
3. Ultimate Robotics Programming with ROS 2 and Python, I Ed., Jonathan Cacace, Orange Education, 2024.
4. ROS Programming: Building Powerful Robots, I Ed., Anil Maahtani, Louis Sanchez, Enrique Fernandez, Aaron Martinez and Lentin Joseph, Packt, 2018.
5. Modern Robotics: Mechanics, Planning, and Control, I Ed., Kevin M. Lynch and Frank C. Park, Cambridge University Press, 2017.
6. Introduction to Robotics: Analysis, Control, Applications, II Ed., Saeed B. Niku, Wiley, 2010.

Web Resources

1. NPTEL course on Wheeled Mobile Robots by Prof. Asokan Thondiyath & Prof. Santhakumar, Mohan, IIT Madra & IIT Palakkad
<https://nptel.ac.in/courses/112106298>
2. NPTEL course on Robot Motion Planning by Prof. Ashish Dutta, IIT Kanpur
<https://nptel.ac.in/courses/112104308>
3. NPTEL course on Drone Systems and Control by Prof. Suresh Sundaram, Prof. Rudrashis Majumder, IISc Bangalore

<https://nptel.ac.in/courses/101108661>

4. NPTEL course on Introduction To Robotics by Prof. Asokan T, Prof. Krishna Vasudevan, and Prof. Balaraman Ravindran, IIT Madras

<https://nptel.ac.in/courses/107106090>

2.8 Open Elective Courses

2.8.1 Project Management Practices (IL5OE_CX1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
IL5OE_CX1	Project Management Practices	03+01*	04

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

S. No.	Objectives
1	To <i>understand</i> the fundamental concepts, principles, and life cycle of project management.
2	To <i>explain</i> the processes involved in project initiation, project selection, and team formation.
3	To <i>apply</i> project planning and scheduling techniques such as WBS, PERT, CPM, and Gantt charts.
4	To <i>analyze</i> project resources, stakeholder communication, and risk management strategies in projects.
5	To <i>evaluate</i> project execution, monitoring, control mechanisms, and project closure processes.

Course Outcomes

The student will be able to	
CO1	<i>describe</i> the concepts, characteristics, and life cycle of project management and the role of a project manager.
CO2	<i>explain</i> project initiation methods, project selection techniques, and stages of team development.
CO3	<i>apply</i> project planning and scheduling tools such as WBS, PERT, CPM, and Gantt charts for project planning.
CO4	<i>analyze</i> resource allocation, stakeholder communication, and risk management techniques in projects.
CO5	<i>evaluate</i> project performance using monitoring and control techniques and explain project closure procedures.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites: Nil		
1.0	Project Management Foundations		07
	1.1	Definition and characteristics of a project, Project vs Operations, Need for and importance of project management, Triple constraints (scope, time, cost).	
	1.2	Project life cycle and phases, Stage gate process, Role and responsibilities of project manager, Organizational structures in project management.	
	1.3	Introduction to project leadership, ethics in projects, Multicultural and virtual projects, PM knowledge areas as per Project Management Institute (PMI). Latest trends in Project Management.	
2.0	Project Initiation and Team Formation		07
	2.1	Project initiation process, strategic project selection, project selection models (numeric/scoring and non-numeric models).	
	2.2	Project portfolio management overview, project sponsor, project charter and project proposal preparation. Project proposal.	
	2.3	Effective project team, Stages of team development & growth (forming, storming, norming & performing), team dynamics.	
3.0	Project Planning and Scheduling		09
	3.1	Work Breakdown Structure (WBS) and Linear Responsibility Chart (LRC).	
	3.2	Interface co-ordination and concurrent engineering, Project cost estimation and budgeting, top-down and bottom-up budgeting.	
	3.3	Network scheduling techniques – PERT, CPM, Gantt charts, Crashing project time. Advanced tools for network scheduling: Oracle Primavera P6, Microsoft Project, Project Manager etc.	
4.0	Resources, Risk and Communication Management		08
	4.1	Resource loading and resource leveling.	
	4.2	Project stakeholders and communication planning.	
	4.3	Risk management: risk identification, risk register, qualitative assessment, probability-impact matrix and response strategies. Advanced tools for risk analysis: Project risk analysis, Predictive Modeling/Analytical Software.	
5.0	Project Execution, Monitoring and Closure		08
	5.1	Project execution and monitoring cycle, team management and project communication.	
	5.2	Monitoring and controlling techniques, Earned Value Management, milestones, scope change and scope creep. Project audit.	
	5.3	Project procurement overview, project closure, customer	

		acceptance, project termination types, final report and lessons learned. Completing a final report; doing a lessons learned analysis; acknowledging successes and failures.	
		Total Hours	39

Suggested Learning Resources

Textbooks

1. Project Management: A Managerial Approach, Jack Meredith and Samuel Mantel, VII Ed., Wiley India, 2009.

Reference Books

1. A Guide to the Project Management Body of Knowledge (PMBOK®Guide), V Ed., Project Management Institute PA, USA, 2013.
2. Project Management, I Ed., Gido Clements, Thomson Press (India) Ltd, 2009.
3. Project Management, II Ed., Gopalan, Wiley India, 2014.
4. Project Management, Dennis Lock, IX Ed., Gower Publishing England, 2013.

Web Resources

1. NPTEL Course on Project Management by Prof. A. Ramesh, Department of Management Studies, IIT Roorkee.
<https://nptel.ac.in/courses/110107430>
2. Oracle - Primavera P6 Enterprise Project Portfolio Management
<https://www.oracle.com/construction-engineering/primavera-p6/>
3. Microsoft Project
<https://www.microsoft.com/en-us/microsoft-365/project/project-management-software>
4. ProjectManagement.com
<https://www.projectmanagement.com/>

2.8.2 Digital Product Development (IL5OE_CX2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
IL5OE_CX2	Digital Product Development	03+01*	04

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

S. No.	Objectives
1	To <i>introduce</i> the basics of digital business and infrastructure requirements for setting up digital business.
2	To <i>teach</i> digital product development and its performance metrics.
3	To <i>explain</i> use of digital marketing methods such as SEO, SEM, social media and email.
4	To <i>teach</i> establishing a brand for products and person using positioning framework.
5	To <i>create</i> awareness about importance and process of regulatory laws involved in setting up a digital business in India.

Course Outcomes

The student will be able to	
CO1	<i>understand</i> basics of digital business and infrastructure required for setting up digital business.
CO2	<i>develop</i> a digital product and <i>use</i> standard metrics to measure its performance.
CO3	<i>use</i> digital marketing methods such as SEO, SEM, social media and email.
CO4	<i>create</i> a brand for products and persons using positioning framework.
CO5	<i>understand</i> importance and process of regulatory laws involved in setting up a digital business in India.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites: Nil		
1.0	Introduction to Digital Business and Infrastructure		08
	1.1	Definition, types of digital businesses, objectives of digital	

		businesses drivers and challenges in digital business adoption case study: Flipkart.	
	1.2	Technologies stack: AI and Big Data: ML use cases, recommendation engines (Netflix, Amazon), predictive analytics, AR-VR and Spatial Computing: Smart factories, immersive retail, Apple Vision Pro - where business meets spatial tech. Blockchain and Cloud Computing: DeFi, smart contracts, SaaS vs IaaS vs PaaS, multi-cloud strategy.	
	1.3	Digital Business Infrastructure: Key components: servers, CDN, APIs, microservices, DevOps, and cybersecurity layer. Building resilient infrastructure: Redundancy, disaster recovery, scalability patterns, and real-world outage analysis (Twitter, AWS us-east-1).	
2.0	Digital Products		08
	2.1	Definition, taxonomy: SaaS, apps, platforms, APIs, marketplaces. Examples: Zerodha, Notion. Product Development Lifecycle: Idea → Discovery → Design → Build → Launch → Iterate. Product Requirement Documents (PRDs). The Hook Model (Part 1): Nir Eyal's 4-phase model — Trigger: External vs Internal. Habit-forming design principles.	
	2.2	Hook Model (Part 2) Fogg Behavior Model (Motivation × Ability × Prompt). UX friction reduction, Variable Reward & Investment, Fixed vs variable rewards, gamification. Investment phase - data, content, followers lock-in, Case Workshop — Hook Model in Practice: Instagram, Duolingo, LinkedIn. What hook cycles do they use?	
	2.3	Launching & Pricing Digital Products: Launch strategies: Product Hunt, App Stores, waiting lists. Pricing models: freemium, subscription, one-time, usage-based Product Metrics & Kano Model: North Star Metric, AARRR funnel (Acquisition-Activation-Retention-Revenue-Referral), NPS, Kano model for feature prioritization.	
3.0	Digital Marketing Fundamentals		08
	3.1	Definition, Digital Marketing vs traditional marketing, the RACE framework, building a digital marketing strategy. Storytelling & Segmentation Targeting & Positioning (STP) Framework, Segmentation, Targeting, Positioning. Storytelling arc in ads: Hero's Journey. Nike, Dove case studies. Lead Generation Frameworks: Lead magnets, landing pages, conversion funnels, TOFU-MOFU-BOFU.	
	3.2	Content Marketing & SEO: Content strategy, blog, video, podcasts. SEO: on-page, off-page, technical. Keyword research live demo. AEO (Answer Engine Optimization): Voice search, AI Overviews (Google SGE), featured snippets, structured data/schema markup. Website & Landing Page Optimization:	

		CRO techniques, A/B testing, heatmaps, and above-the-fold design.	
	3.3	Social media, Email & Mobile Marketing: Platform selection strategy (B2B vs B2C). Email marketing — subject lines, drip campaigns, segmentation. Mobile-first design principles. Pay-Per-Click & Conversion Rate Optimization. Google Ads structure, Quality Score, bidding strategies, ad copywriting. CRO: identify drop-off points. AI in Digital Marketing Generative AI for content (ChatGPT, Jasper), AI-powered ad targeting (Meta Advantage+), predictive personalization.	
4.0	Brand Building		08
	4.1	Brand definition: brand vs. logo vs. product. Brand equity (Keller model)-implications: premium pricing, loyalty, extension. Brand Names & Positioning. Naming strategies (descriptive, invented, and acronym). Positioning maps. Perceptual maps exercise. Brand Architecture: Branded House vs House of Brands vs Endorsed. Case: Tata Group, Google/Alphabet, P&G.	
	4.2	Brand Loyalty & Celebrity Endorsements: Brand loyalty ladder, NPS as loyalty metric, community-led growth. PR in Brand Building: Media relations, crisis PR (Zomato, Ola), earned vs paid vs owned media, Press Release writing workshop. Internal Marketing & Employer Branding: Employee Value Proposition (EVP), Glassdoor impact, culture-first companies - Zoho, Freshworks India.	
	4.3	Personal Branding: LinkedIn optimization, thought leadership, content pillars, and portfolio building for engineers. Why your GitHub/Behance is your resume? Brand in the AI Era: AI-generated brand content, deepfake risks, synthetic media policy. Protecting brand identity online. Class exercise: AI vs human brand voice.	
5.0	Legal and Regulatory Awareness		07
	5.1	Protecting Digital Assets: Patents (process vs product), Trademarks, Copyrights, Trade Secrets. Registering with IP India. Overview: Copyright Act 1957, Trademarks Act 1999.	
	5.2	Data Privacy & IT Act Data Privacy Principles (consent, storage, security). IT Act 2000: cybercrime provisions, intermediary liability. GDPR vs India's DPDP Act 2023.	
	Total Hours		39

Suggested Learning Resources

Textbooks

1. Introduction to E-Business, I Ed., Dr. Mamata Jenamani, Prentice Hall India, 2025.
2. Digital Business and E-Commerce Management, VI Ed., Dave Chaffey, Pearson, 2014.

3. Hooked: How to Build Habit Forming Products, I Ed., Nir Eyal and Ryan Hoover, Portfolio Penguin, 2019.
4. Digital Marketing, III Ed., Seema Gupta, McGraw Hill, 2022.
5. Building Winning Brands: A Commonsense Approach to Brand Building, I Ed., Gurudev Prasad and Suharsh Dikshit, Wyzr Content, 2025.
6. Business and Intellectual Property: Protect Your Idea, I Ed., Anurag K. Agarwal, Penguin Books, 2016.

Reference Books

1. Zero to One: Notes on Startups or How to Build the Future, I Ed., Peter Thiel with Blake Masters, Penguin Random House, 2014.
2. The Lean Startup, I Ed., Eric Ries, Penguin Business, 2011.
3. Harvard Business Review: Entrepreneurs Handbook, I Ed., HBR Press, 2018.

Web Resources

1. Digital Infrastructure: The Complete Guide for Modern Business Success (2026), Gururaj Singh
<https://buzzclan.com/cloud/digital-infrastructure/>
2. The Digital Product Handbook
<https://www.designer.tips/tools/the-digital-product-handbook>
3. Foundations in Digital Marketing: Building Meaningful Customer Relationships and Engaged Audiences, Rochelle Grayson
<https://open.umn.edu/opentextbooks/textbooks/foundations-in-digital-marketing>

2.8.3 Systems Reliability Engineering (IL5OE_CX3)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
IL5OE_CX3	Systems Reliability Engineering	03+01*	04

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

S. No.	Objectives
1	To <i>understand</i> the fundamentals of reliability, availability, safety, and risk in engineering systems.
2	To <i>apply</i> basic reliability and risk assessment techniques for system evaluation.
3	To <i>analyze</i> condition monitoring and predictive maintenance concepts using reliability data.
4	To <i>explain</i> reliability issues in intelligent, digital, and cyber-physical systems.
5	To <i>evaluate</i> safety, resilience, and sustainability aspects of dependable engineering systems.

Course Outcomes

The student will be able to	
CO1	<i>explain</i> the basic concepts of reliability, availability, safety, and risk in engineering systems.
CO2	<i>apply</i> reliability analysis and risk assessment tools for identifying system failures.
CO3	<i>analyze</i> condition monitoring and predictive maintenance techniques in modern systems.
CO4	<i>illustrate</i> reliability challenges and solutions in intelligent and cyber-physical systems.
CO5	<i>evaluate</i> safety, resilience, and sustainability aspects using real-world engineering case studies.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites: Nil		
1.0	Introduction to Systems Reliability		08

	1.1	Fundamentals of Systems Reliability- Introduction to reliable and dependable systems, reliability, availability and safety concepts, Importance of reliability in modern engineering systems, Failure concepts and system behavior, Reliability metrics and downtime concepts.	
	1.2	Reliability in Modern Engineering Systems- Reliability in software systems, Reliability in manufacturing and automation systems, Reliability in transportation and infrastructure systems, Reliability in cyber-physical systems, Case studies of major system failures.	
	1.3	Fundamentals of Uncertainty and Risk- Basic probability concepts, Failure probability and uncertainty, Human errors and system failures, Introduction to resilience engineering.	
2.0	Reliability Analysis and Risk Assessment		08
	2.1	Failure Analysis Techniques- Failure Modes and Effects Analysis (FMEA), Criticality concepts, Root Cause Analysis (RCA), Introduction to FMECA.	
	2.2	System Reliability Modeling- Reliability Block Diagrams (RBD), Series and parallel systems, Fault Tree Analysis (FTA), Event Tree Analysis (ETA).	
	2.3	Risk and Decision Engineering- Risk assessment concepts, Risk prioritization methods, Decision tree analysis, Engineering decision-making under uncertainty.	
3.0	Intelligent Monitoring and Predictive Reliability		08
	3.1	Condition Monitoring Concepts- Introduction to condition monitoring, Sensor-based monitoring systems, Data acquisition concepts, Monitoring parameters in engineering systems.	
	3.2	Predictive Maintenance and Reliability Analytics- Preventive and predictive maintenance concepts, Reliability data analysis basics, Anomaly detection concepts, Fault diagnosis fundamentals, Predictive analytics concepts.	
	3.3	AI Applications in Reliability Engineering- Introduction to Machine Learning in reliability, AI-based fault prediction concepts, Industrial IoT concepts, Smart maintenance systems.	
4.0	Reliability of Modern Intelligent Systems		08
	4.1	Reliability in Digital and Connected Systems- Software reliability concepts, Cloud and network reliability basics, Reliability in embedded systems, Reliability challenges in autonomous systems.	
	4.2	Cyber-Physical and Smart Systems- Cyber-physical systems reliability, Reliability in robotics and automation, Human-machine interaction and reliability, Smart manufacturing systems.	
	4.3	Emerging Reliability Technologies- Digital twins overview, Edge computing and reliability, Data-driven decision systems,	

		Future trends in intelligent reliability engineering.	
5.0	Safety, Resilience and Industrial Applications		07
	5.1	Safety and Reliability Assurance- System safety fundamentals, Hazard identification and mitigation, Reliability-centered thinking Safety and reliability trade-offs.	
	5.2	Resilience and Sustainable Systems- Infrastructure resilience concepts, Reliability in smart cities and critical infrastructure, Sustainable and dependable engineering systems, Cybersecurity and dependable systems basics.	
	5.3	Industrial Applications and Case Studies- Case studies from manufacturing, aviation, railways, cloud computing and healthcare systems; Reliability in autonomous and intelligent systems, Ethical and societal aspects of dependable systems.	
		Total Hours	39

Suggested Learning Resources

Textbooks

1. Engineering Reliability, I Ed., B.S. Dhillon, C. Singh, John Wiley & Sons, 1980.
2. Reliability Engineering, IV Ed., L. S. Srinath, East – West Press, 2005.
3. Reliability in Engineering Design, I Ed., K.C. Kapur, L.R. Lamberson, John Wiley & Sons, 1977.
4. Reliability Engineering, II Ed., E. Balagurusamy, McGraw Hill Education (India), 2002.

Reference Books

1. An Introduction to Reliability and Maintainability Engineering, I Ed., Charles E. Ebeling, Tata McGraw Hill, 1996.
2. Practical Reliability Engineering, II Ed., P.D.T. Connor, John Wiley & Sons, 1985.
3. Probability and Statistics, II Ed., Murray R. Spiegel, Schaum's Outline Series, 2000.

Web Resources

1. NPTEL course on Introduction to Reliability Engineering by Prof. Neeraj Kumar Goyal, IIT Kharagpur.
<https://nptel.ac.in/courses/127105234>
2. NPTEL course on Risk-Based Engineering by Prof. Prabhakar V Varde, Homi Bhabha National Institute.
<https://nptel.ac.in/courses/121101490>

2.8.4 Decision Science & Business Optimization (IL5OE_CX4)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
IL5OE_CX4	Decision Science & Business Optimization	03+01*	04

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

S. No.	Objectives
1	To <i>formulate</i> a real-world problem as a mathematical optimization models.
2	To <i>solve</i> optimization, transportation, and assignment problems using established algorithms.
3	To <i>demonstrate</i> the use of mathematical software (Excel Solver / Python) and simulation tools to <i>solve</i> models.
4	To <i>analyze</i> queuing and inventory systems to <i>manage</i> uncertainty in service and supply chains.
5	To <i>apply</i> dynamic programming and Game Theory to multi-stage and competitive decision problems.

Course Outcomes

The student will be able to	
CO1	<i>formulate</i> and <i>solve</i> Linear Programming Problems using simplex, Big M, and two-phase methods and <i>apply</i> duality and sensitivity analysis to interpret optimal solutions.
CO2	<i>solve</i> transportation and assignment problems to <i>determine</i> cost-minimizing distribution and allocation strategies.
CO3	<i>calculate</i> optimal inventory levels and <i>predict</i> queuing behavior using probabilistic mathematical models and <i>demonstrate</i> solutions using spreadsheet or Python-based tools.
CO4	<i>design</i> and <i>execute</i> Monte Carlo Simulation models to <i>analyze</i> complex engineering and business problems and <i>interpret</i> simulation outputs.
CO5	<i>apply</i> dynamic programming to multi-stage optimization problems and <i>develop</i> competitive strategies using Game Theory concepts.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites		
	Basic linear algebra- Matrices, Systems of equations; Introductory calculus- Functions, maxima, and minima.		
1.0	Introduction to Operation Research		08
	1.1	Introduction to Decision Science and OR: problem formulation, structure of mathematical models, scope, assumptions, and limitations. Orientation to software tools: Excel Solver, Python.	
	1.2	Linear Programming: formulation of LPP, requirements; Graphical method; Simplex method; Big M (Penalty Cost) method; Two-Phase method.	
	1.3	Duality: Primal-Dual construction; Main Duality Theorem (Conceptual); Dual Simplex method. Sensitivity Analysis: ranging of objective coefficients and RHS values; interpretation using solver output.	
2.0	Transportation and Assignment Problems		08
	2.1	Transportation Problem: formulation (balanced and unbalanced); Initial Basic Feasible Solution via Northwest Corner rule, Least Cost method, and Vogel's Approximation Method (VAM); Optimality test using Stepping Stone method and MODI method.	
	2.2	Assignment Problem: mathematical formulation; Hungarian Method algorithm; processing n jobs through 2 and m machines; Graphical method for 2-jobs m-machines problem. Travelling Salesman Problem: formulation and solution approaches.	
3.0	Queuing Models & Inventory Management		07
	3.1	Queuing Systems: structure and characteristics; M/M/1 and M/M/c models; Poisson arrivals, exponential and constant service rates; steady-state performance metrics (L_q , W_q , utilisation ρ); finite and infinite population models.	
	3.2	Inventory Models: Classical EOQ; EOQ with Price Breaks; EOQ with Shortage; Newsvendor (Probabilistic) Model for stochastic demand. Application to supply chain and procurement decisions.	
4.0	Simulation & Monte Carlo Methods		08
	4.1	Introduction to Simulation: concepts, methodology, and procedure. Monte Carlo Simulation: random number generation, simulation of business and engineering problems. Advantages and limitations of simulation.	
	4.2	Hands-on Lab: Monte Carlo simulation using Excel (RAND function / random number tables) or Python (NumPy). Case applications: inventory simulation, project completion time estimation, queuing behaviour modelling.	

5.0	Dynamic Programming & Game Theory		08
	5.1	Introduction to Dynamic Programming: principle of optimality, characteristics, and recursive formulation.	
		DP Applications: Shortest Path / Stagecoach problem; Capital Budgeting; Employment Smoothing; Cargo Loading; Reliability Optimisation. Real-world framing: logistics, project selection, maintenance scheduling.	
	5.2	Introduction to Game Theory: types of games; competitive and cooperative games; rectangular games. Solution Methods: Saddle point; Minimax / Maximin strategy; value of the game; Dominance principle; Mixed strategy for 2×2 games without saddle point. Real world application of Game theory.	
Total Hours			39

Suggested Learning Resources

Textbooks

1. Operations Research - An Introduction, VII Ed., Taha, H.A., Prentice Hall, 2002.
2. Operations Research, I Ed., S. D. Sharma, Kedar Nath-Ram Nath-Meerut, 2008.

Reference Books

1. Introduction to Operations Research, IX Ed., Hiller, F. S. and Lieberman, G. J., Tata McGraw Hill, 2010.

Web Resources

1. NPTEL Course on Operations Research by Prof. Rajendra Singh, IIT Kharagpur
<https://nptel.ac.in/courses/126105663>
2. Google OR-Tools documentation
<https://developers.google.com/optimization>
3. NEOS Server
neos-server.org

2.8.5 Smart Business Information Systems (IL5OE_CX5)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
IL5OE_CX5	Smart Business Information Systems	03+01*	04

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

S. No.	Objectives
1	To <i>understand</i> the role of Management Information Systems (MIS) in digital business transformation and intelligent decision-making.
2	To <i>study</i> emerging technologies such as Artificial Intelligence (AI), Business Analytics, and Enterprise Systems in organizations.
3	To <i>understand</i> cybersecurity, ethical issues, responsible AI practices, and security challenges in modern information systems.
4	To <i>understand</i> data-driven business environments using BI tools, AI-enabled systems, and real-world case studies.
5	To <i>familiarize</i> learners with current trends in cybersecurity, digital platforms, and intelligent enterprise applications.

Course Outcomes

The student will be able to	
CO1	<i>explain</i> the role of information systems in modern digital organizations and AI-driven businesses.
CO2	<i>analyze</i> the impact of intelligent information systems on organizational performance and decision-making.
CO3	<i>understand</i> cybersecurity threats, ethical concerns, privacy issues, and responsible AI practices in modern digital systems.
CO4	<i>apply</i> concepts of business intelligence, analytics, and AI-enabled systems for solving business problems.
CO5	<i>evaluate</i> cybersecurity, ethical issues, and digital transformation practices through real-world case studies.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites: Nil		
	Basic knowledge of Computer Fundamentals and Management Concepts.		
1	Introduction To Information Systems (IS) and Digital Transformation		08
	1.1	Fundamentals of MIS, Components and types of information systems, Role of MIS in organizations, Digital business and Digital transformation.	
	1.2	Strategic Information Systems and competitive advantage, Industry 4.0 concepts.	
	1.3	AI in business operations, Case studies on Amazon, Netflix, and Indian Digital Enterprises.	
2	Data Management, Business Intelligence and AI Analytics		08
	2.1	Database Management Systems, Data warehousing and Data marts, Big Data concepts.	
	2.2	Business Intelligence (BI), Data visualization, AI and Predictive analytics, Decision Support Systems.	
	2.3	Generative AI tools for business reporting and analytics such as Power BI/ Tableau/ Google Looker Studio (case studies).	
3	Cybersecurity, Ethics and Emerging Technologies		07
	3.1	Information security and security threats, Cyber-attacks and Security controls, Privacy and ethical issues in Information Systems.	
	3.2	AI Ethics and Responsible AI, Case Studies on cybersecurity incidents and Digital Governance.	
4	Digital Commerce, Social Media and Intelligent Customer Systems		08
	4.1	E-Business and E-Commerce models (B2B, B2C, C2C), Mobile commerce, Digital payment systems,	
	4.2	Social computing and web technologies, Customer Relationship Management (CRM), AI-enabled chatbots and virtual assistants.	
	4.3	Digital Marketing Analytics, Recommendation systems used in platforms like Amazon and Netflix, Case Studies on modern e-commerce platforms.	
5	Enterprise Information Systems and Modern System Development		08
	5.1	Transaction Processing Systems (TPS), Functional Area Information Systems, Enterprise Resource Planning (ERP), Supply Chain Management (SCM), Human Resource Information Systems (HRIS), Knowledge Management Systems.	
	5.2	AI-enabled Enterprise Systems.	
	5.3	System Development Life Cycle (SDLC), Agile and DevOps approaches, Cloud-based ERP systems, Case Studies on SAP,	

	Oracle ERP, and AI-integrated enterprise applications.	
	Total Hours	39

Suggested Learning Resources

Textbooks

1. Management Information Systems, IV Ed., Kelly Rainer, Brad Prince, Wiley, 2020.
2. Management Information Systems: Managing the Digital Firm, X Ed., K.C. Laudon and J.P. Laudon, Prentice Hall, 2007.
3. Managing Information Systems: Strategy and Organization, III Ed., D. Boddy, A. Boonstra, Prentice Hall, 2008.

Reference Books

1. Principles of Information Systems, XV Ed., Ralph Stair and George Reynolds, Cengage Learning, 2025.

Web Resources

1. NPTEL course on Management Information System by Prof. Kunal Kanti Ghosh, Prof. Saini Das, Prof. Surojit Mookherjee, IIT Kharagpur.
<https://nptel.ac.in/courses/110105148>

2.8.6 Design of Experiments and Data Analytics (IL5OE_CX6)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
IL5OE_CX6	Design of Experiments and Data Analytics	03+01*	04

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

S. No.	Objectives
1	To <i>introduce</i> modern experimentation strategies, RSM, simulation-based experimentation, and the role of DoE in Industry 4.0.
2	To <i>develop</i> understanding of regression modelling, parameter estimation, hypothesis testing, diagnostics, and machine learning-based regression.
3	To <i>enable</i> students to apply factorial designs, blocking, confounding, center points, and split-plot designs in modern engineering systems.
4	To <i>familiarize</i> students with fractional factorial designs and resolution concepts for efficient experimentation in complex systems.
5	To <i>impart</i> knowledge of Taguchi methods, robust design, orthogonal arrays, signal-to-noise ratios, and optimization-based applications.

Course Outcomes

The student will be able to	
CO1	<i>explain</i> the concepts, strategies, and applications of modern experimentation in physical, virtual, digital, and smart engineering systems.
CO2	<i>develop</i> and <i>evaluate</i> regression models using statistical, computational, and machine learning-based approaches for engineering data analysis.
CO3	<i>apply</i> full factorial and split-plot experimental designs for engineering, software, network, embedded, simulation, and digital twin-based applications.
CO4	<i>analyze</i> two-level fractional factorial designs and resolution concepts for efficient experimentation in complex engineering systems.
CO5	<i>design</i> robust experiments using Taguchi methods, orthogonal arrays, signal-to-noise ratios, and optimization techniques for smart industrial applications.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites: Nil		
1.0	Introduction to Engineering Experimentation		08
	1.1	Strategy of Experimentation in Digital and Smart Systems, Applications across various engineering domains, Guidelines for designing experiments in physical and virtual environments, Introduction to Response Surface Methodology (RSM), Experimentation using simulation tools, Role of DoE in Industry 4.0.	
2.0	Data-Driven Regression Modelling		08
	2.1	Linear and nonlinear regression models, Parameter estimation using classical and computational methods, Hypothesis testing and Confidence Intervals in multiple regression, Regression diagnostics and Lack-of-Fit testing, Introduction to Machine Learning-based regression and data analysis.	
3.0	Factorial Designs for Engineering Systems		08
	3.1	Review of 2^2 , 2^3 , and general 2^k designs, Single replicate and center points in experimental design, Blocking and confounding in complex systems, Split-Plot designs in industrial and software experiments, Application in software testing, Network optimization, and embedded systems, Integration with simulation and Digital Twins.	
4.0	Two-Level Fractional Factorial Designs		08
	4.1	The One-Half Fraction of the $2k$ design, The One-Quarter Fraction of the $2k$ design, The General $2^{(k-p)}$ Fractional Factorial Design, Resolution III designs, Resolution IV and V designs, Fractional Factorial Split-Plot designs.	
5.0	Robust Design & Taguchi Methods		07
	5.1	Taguchi Philosophy and Quality Engineering, Orthogonal arrays and Signal-to-Noise Ratios, Crossed Array Designs and Robust parameter design, Analysis techniques and case studies, Applications in AI systems, Electronics and manufacturing, Integration with optimization algorithms (Genetic Algorithms, AI-based Optimization), Case studies in renewable energy, Automation, and Intelligent Systems.	
	Total Hours		39

Suggested Learning Resources

Textbooks

1. Design and Analysis of Experiments, V Ed., D.C. Montgomery, John Wiley & Sons, New York, 2001.

Reference Books

1. Response Surface Methodology: Process and Product Optimization using Designed Experiment, II Ed., Raymond H. Mayers, Douglas C. Montgomery, Christine M. Anderson-Cook, John Wiley & Sons, New York, 2001.
2. Statics for Experimenters: Design, Innovation and Discovery, II Ed., George E P Box, J Stuart Hunter, William G Hunter, Wiley, 2005.
3. Practical Experiment Designs for Engineers and Scientists, III Ed., W J Dimond, John Wiley and Sons, 2001.

Web Resources

1. NPTEL course on Design and Analysis of Experiments by Prof. Jhareswar Maiti, Department of Management, IIT Kharagpur.
<https://nptel.ac.in/courses/110105087>

2.8.7 Energy Audit and Management (IL5OE_CX7)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
IL5OE_CX7	Energy Audit and Management	03+01*	04

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

S. No.	Objectives
1	To <i>provide</i> knowledge of energy resources, energy policies, and the legal framework for energy conservation.
2	To <i>familiarize</i> students with energy cost structures, economic analysis tools, and load management strategies.
3	To <i>equip</i> students with principles of energy management and demand-side management techniques.
4	To <i>train</i> students in energy auditing methodology, instruments, and financial evaluation of projects.
5	To <i>impart</i> understanding of energy-efficient technologies and conservation opportunities in industrial and utility systems.

Course Outcomes

The student will be able to	
CO1	<i>understand</i> the basics of energy, its forms, sources, policies, and legal acts related to energy conservation.
CO2	<i>analyze</i> energy cost structures, <i>perform</i> economic evaluations, and <i>apply</i> load management strategies for efficient energy utilization.
CO3	<i>apply</i> energy management and demand-side management (DSM) techniques to reduce energy demand and optimize consumption.
CO4	<i>conduct</i> energy audits using appropriate methodology, instruments, and financial analysis to <i>evaluate</i> project feasibility.
CO5	<i>identify, apply and implement</i> energy-efficient technologies in motors, drives, lighting, thermal systems, and green buildings for energy conservation and sustainability.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites		
	Forms of energy and final energy consumption.		
1.0	Energy Scenario		05
	1.1	Basics of energy and its various forms - Applications of conventional and non-conventional sources - Energy policy.	
	1.2	Energy conservation act 2001 - Roles and responsibilities of energy managers and energy auditors - Energy labelling and energy standards.	
2.0	Energy Cost and Load Management		10
	2.1	Important concepts in an economic analysis - Economic models, Time value of money, Utility rate structures, Electricity cost, Loss evaluation.	
	2.2	Load management- Demand control techniques, Utility monitoring and control system, HVAC and energy management.	
3.0	Energy Management		05
	3.1	Demand Side Management- Planning, techniques, Load management as a DSM strategy, Energy conservation, Tariff options for DSM.	
4.0	Energy Auditing		10
	4.1	Definition, Energy audit methodology, Financial analysis techniques: SPP, NPV, ROI, IRR, Sensitivity analysis, Project financing options.	
	4.2	Energy Auditing Instruments- Energy audit for generation, distribution and utilization systems- Economic analysis.	
5.0	Energy Efficient Technologies		09
	5.1	Energy saving opportunities in electric motors- Power factor improvement benefit and techniques.	
	5.2	Energy conservation in industrial drives, electric furnaces, ovens and boilers- Lighting techniques: Natural, CFL, LED lighting sources and fittings.	
	5.3	Energy conservation building codes, Green Building, LEED rating.	
	Total Hours		39

Suggested Learning Resources

Textbooks

1. Guide to Energy Management, VIII Ed., Barney L. Capehart, Wayne C. Turner, William J. Kennedy, CRC press, Taylor & Francis Group, 2016.
2. Energy Efficiency for Engineers and Technologists, I Ed., Eastop T.D and Croft D.R, Longman Scientific & Technical, 1990.

3. IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE, 1996.
4. Designing with Light: Lighting Handbook, By Anil Valia, Lighting System

Reference Books

1. Handbook on Energy Audits and Management, I Ed., Amit K. Tyagi, TERI, 2003.
2. Handbook of Electrical Installation Practice, Geofry Stokes, Blackwell Science.
3. Handbook of Energy Audits, Albert Thumann, Terry Niehus and William J. Younger

Web Resources

1. Swayam course on Basic Principles of Energy Management & Energy Audit by Dr. R. N. Patel and Mr. Akhilesh Kumar Tiwari, Chhattisgarh Swami Vivekanand Technical University.
https://onlinecourses.swayam2.ac.in/e-learning/preview/nou23_es05

2.8.8 Climate Change and Disaster Management (IL5OE_CX8)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
IL5OE_CX8	Climate Change and Disaster Management	03+01*	04

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

S. No.	Objectives
1	To <i>develop</i> foundational understanding of disasters, hazards, vulnerabilities, risks, climate-change-driven extreme events.
2	To <i>familiarize</i> learners with global and national disaster management frameworks, policies, and institutional mechanisms.
3	To <i>equip</i> students with knowledge of pre-disaster mitigation strategies—structural and non-structural—and risk reduction measures.
4	To <i>build</i> competency in response, relief, rehabilitation, and recovery mechanisms during and after disasters.
5	To <i>introduce</i> modern technologies such as GIS, remote sensing, and geospatial tools used for disaster risk reduction, assessment, and management.

Course Outcomes

The student will be able to	
CO1	<i>explain</i> the fundamental concepts of disasters, hazards, risks, vulnerabilities, climate change trends, and extreme events.
CO2	<i>describe</i> global and national disaster management frameworks, policies, institutions, and analyze case studies of major natural and anthropogenic disasters.
CO3	<i>apply</i> pre-disaster management strategies, including structural and non-structural mitigation measures, risk reduction tools, and preparedness approaches.
CO4	<i>analyze</i> during- and post-disaster management processes involving response, relief, rehabilitation, recovery, stakeholder roles, and communication systems.
CO5	<i>use</i> technological tools such as GIS, Remote Sensing, and disaster assessment techniques for risk evaluation and disaster management planning.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites: Nil		
1.0	Introduction to Climate Change and Disaster		7
	1.1	Climate Science Basics- Weather Vs Climate, Introduction to climate change, Global warming.	
	1.2	Concepts - Hazard, Risk, Vulnerability, Capacity, Disaster, Types of disasters.	
	1.3	Introduction to climate hazards, Role of climate change in rising trend of disaster at global and local levels.	
2.0	Disaster Management Framework & Policies		8
	2.1	Global policies and practices, The Disaster Management Cycle - Prevention/Mitigation, Preparedness, Response, Recovery (Rehabilitation and Reconstruction).	
	2.2	Disaster Management Frameworks and Policies- DM Act 2005, Institutional Framework for Disaster Management in India, Role of NDMA, SDMA, DDMA and institutes.	
	2.3	Case Studies – Major natural and anthropogenic disasters in India.	
3.0	Technology in Disaster Management		8
	3.1	Disaster Impact Assessment Methods and Tools, Basic concepts of Geographical Information System (GIS) and Remote Sensing (RS), Satellite Position System- An overview.	
	3.2	Early Warning Systems and Information Communication Tools (ICT) for effective disaster management.	
	3.3	Case Studies Risk and vulnerability assessment technologies.	
4.0	Pre-Disaster Management		8
	4.1	Disaster Risk Reduction Methods and Measures, Structural Mitigation: Risk mapping, assessment and analysis, sea walls and embankments, Bio shield, shelters, early warning and communication etc.	
	4.2	Non-Structural Mitigation: Community based disaster preparedness, risk transfer and risk financing, capacity development and training, awareness and education.	
	4.3	Case Studies: Pre-disaster events in general, Climate adaptation strategies.	
5.0	During and Post Disaster Management		8
	5.1	Response - Management of casualties, setting up of emergency facilities.	
	5.2	Relief and Rehabilitation - Setting of relief camps, management of relief supplies and intermediate shelters etc.	
	5.3	Reconstruction and Recovery – Owner driven, Linking recovery	

	with safe development.	
	Total Hours	39

Suggested Learning Resources

Textbooks

1. Introduction to Modern Climate Change, II Ed., Andrew Dessler, Cambridge University Press, 2015.
2. Disaster Management Global Challenges and Local Solutions, I Ed., Rajib Shaw and RR Krishnamurthy, University Press (India) Private Limited, 2012.
3. Management of Natural Disasters in Developing Countries, I Ed., Srivastava, H.N., and Gupta, G.D., Daya Publishing House, 2020.

Reference Books

1. Introduction to International Disaster Management, IV Ed., Damon Coppola, Elsevier, 2020.
2. Concepts and Techniques in Geographic Information Systems, I Ed., Chor Pang Lo, Albert K. W. Yeung, Pearson Prentice Hall, 2007.
3. Ministry of Home Affairs, Disaster Management in India, I Ed., Ministry of Home Affairs, Government of India, 2011.
4. National Disaster Management Authority (NDMA), I Ed., National Policy on Disaster Management, Ministry of Home Affairs, Government of India, 2009.

Web Resources

1. NPTEL Course on Disaster Management by Dr. M. Seenuvasan, National Institute of Technical Teachers Training and Research, Chennai.
https://onlinecourses.swayam2.ac.in/ntr26_ed68/preview
2. National Institute of Disaster Management
<https://nidm.gov.in/>
3. Case studies
<https://nidm.gov.in/CaseStudies.asp>
4. Training Design & Modules
<https://nidm.gov.in/modules.asp>
5. National Disaster Management Authority (NDMA)
<https://ndma.gov.in/>
6. National Policy on Disaster Management
https://ndma.gov.in/index.php/Reference_Material/National_Policy
7. Disaster Management Act 2005
https://ndma.gov.in/index.php/Reference_Material/DMAAct2005
8. NDMA Guidelines
https://ndma.gov.in/Reference_Material/NDMAGuidelines
9. NDMA Reports
https://ndma.gov.in/Reference_Material/NDMAReports
10. NDMA Annual Reports
https://ndma.gov.in/Reference_Material/NDMAAnnualReports
11. Pocketbook on Do's & Dont's
https://ndma.gov.in/Reference_Material/Pocketbook-Dos-Donts

12. Reports-Studies and Awareness Resources of Natural and Manmade Disasters

<https://ndma.gov.in/Resources/Reports-Studies>

3 Semester-VI Course Syllabus

3.1 System Programming and Compiler Construction (CE6PC_CR1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE6PC_CR1	System Programming and Compiler Construction	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

Sr. No.	Objectives
1	To <i>understand</i> the significance of system software in computer systems and its role in program translation, execution, and management.
2	To <i>gain</i> knowledge of formal language concepts, lexical analysis, and parsing techniques used in compiler construction.
3	To <i>familiarize</i> students with semantic analysis methods and intermediate code generation techniques used in compiler design.
4	To <i>learn</i> the principles of code optimization and code generation for producing efficient target programs.
5	To <i>acquire</i> the skills required to design and implement assembler and macro processing systems using appropriate algorithms and data structures.

Course Outcomes

The student will be able to	
CO1	<i>explain</i> the role and functions of various system software components and describe the phases of a compiler and lexical analysis process.
CO2	<i>apply</i> context-free grammars and parsing techniques to design top-down and bottom-up parsers for syntax analysis.
CO3	<i>construct</i> syntax-directed definitions and <i>generate</i> intermediate code representations.
CO4	<i>analyze</i> and <i>apply</i> code optimization techniques and <i>design</i> code generation schemes using basic blocks and flow graphs for efficient program execution.
CO5	<i>design</i> and <i>implement</i> assemblers and macro processors using appropriate pass structures and data structures .

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites: Theory of Computer Science, Computer Organization and Architecture		
1.0	Introduction to System Software and Lexical Analysis		07
	1.1	Introduction to various system programs such as Assembler, Macro processor, Loader, Linker, Compiler, Interpreter, Compiling a C program – Behind the scenes	
	1.2	Introduction to compilers, Phases of compilers	
	1.3	Lexical Analysis: Role of Finite State Automata in Lexical Analysis, Design of Lexical analyzer, data structures used.	
2.0	Syntax Analysis		08
	2.1	Role of Context Free Grammar in Syntax analysis	
	2.2	Types of Parsers: Top down parser, Bottom up parser . Top down parser -Recursive decent parser,LL(1)	
	2.3	Bottom up parser- SR Parser, Operator precedence parser, LR(0), SLR, LALR.	
3.0	Semantic Analysis and Intermediate Code Generation		08
	3.1	Semantic Analysis: Syntax directed definitions.	
	3.2	Intermediate Code Generation: Types of Intermediate codes: Syntax tree, Postfix notation, three address codes: Triples and Quadruples, indirect triples,SSA.	
4.0	Code Optimization and Code Generation		08
	4.1	Code Optimization: Need and sources of optimization, Code optimization techniques: Machine Dependent and Machine Independent.	
	4.2	Code Generation: Issues in the design of code generator, code generation algorithm. Basic block and flow graph	
5.0	Assemblers and Macroprocessor		08
	5.1	Elements of Assembly Language programming, Assembly scheme, pass structure of assembler, Assembler Design: Two pass assembler Design and single pass Assembler.	
	5.2	Introduction, Macro definition and call, Data structures used for macroprocessor,Design of Two pass macro processor.	
Total Hours			39

Suggested Learning Resources

Textbooks

1. Compilers Principles, Techniques and Tools, II Ed., A. V. Aho, R. Shethi, Monica Lam, J.D. Ulman, Pearson Education,2013.
2. Systems Programming, Tata McGraw Hill - Edition 1991, J. J. Donovan, McGraw Hill,1991.
3. System Programming and Operating System, II Ed., D. M. Dhamdhere, Tata McGraw Hill ,1999.

Reference Books

1. Lex & YACC, II Ed., John R. Levine, Tony Mason & Doug Brown, O 'Reilly publication,1992.
2. System software: An introduction to system programming, III Ed., Leland L. Beck, Pearson Publication,1997.

Web Resources

1. Udemmy Course on Introduction to Compiler Construction & Design by Noor Uddin.
<https://www.udemy.com/course/introduction-to-compiler-construction-and-design/>
2. Springer book on Introduction to compiler design
<http://www.diku.dk/~torbenm/Basics>

3.2 System Programming and Compiler Construction Lab (CE6PC_LR1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE6PC_LR1	System Programming and Compiler Construction Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	-	25	-	50

Course Objectives

Sr. No.	Objectives
1	To <i>understand</i> the phases of a compiler and the role of lexical, syntax, and semantic analysis in language processing.
2	To <i>develop</i> skills in designing lexical analyzers and parsers using automata theory and compiler construction tools.
3	To <i>learn</i> intermediate code generation and code optimization techniques used in modern compilers.
4	To <i>study</i> the design and implementation of system software components such as assemblers, macro processors, linkers, and loaders.
5	To <i>apply</i> compiler construction concepts for developing a mini compiler using appropriate programming tools and techniques.

Course Outcomes

The student will be able to	
LO1	<i>implement</i> lexical analyzers and finite automata for token recognition.
LO2	<i>develop</i> parsers for syntax analysis using top-down and bottom-up parsing techniques.
LO3	<i>generate</i> intermediate code and perform semantic analysis using syntax-directed translation.
LO4	<i>apply</i> code optimization techniques to improve program efficiency.
LO5	<i>design and implement</i> assemblers, macro processors, linkers, and mini compilers.

Course Contents

Sr. No.	Suggested List of Experiments
1	To study Compiler Phases by tracing the compilation of a C program from source code to executable file. Analyze preprocessing, compilation, assembly, linking, and loading stages.
2	To implement a lexical analyzer to identify keywords, identifiers, operators, constants, and special symbols from source code.
3	To implement Finite State Automata (DFA/NFA) for token recognition and lexical

	analysis using JFLAP.
4	To develop a lexical analyzer using Flex and compare its performance with a manually coded lexical analyzer.
5	To implement Recursive Descent Parser for a given grammar using python.
6	To implement SLR Parser by generating LR items, ACTION and GOTO tables using python.
7	To develop Syntax Directed Translation Scheme for type checking and expression evaluation using python.
8	To generate Intermediate Code in the form of Syntax Trees, Three Address Code, Quadruples, and Triples in python.
9	To implement Machine Independent Code Optimization techniques such as Common Sub-expression Elimination, Constant Folding, Dead Code Elimination, and Strength Reduction using python.
10	To implement Machine Independent Code Optimization techniques such as Common Sub-expression Elimination, Constant Folding, Dead Code Elimination, and Strength Reduction.
11	To implement a Two-Pass Assembler for a simplified assembly language.
12	To design and implement a Two-Pass Macro Processor with Macro Definition Table (MDT) and Macro Name Table (MNT).
13	To build a Mini Compiler for a simple language supporting lexical analysis, parsing, semantic checking, and intermediate code generation.
14	To create multiple source files and perform separate compilation. Study the role of the linker in combining object modules into an executable program.

Note:1. Lab course shall consist of minimum 10 experiments covering all the topics but not limited to the suggested list.

2. To ensure that the Oral Exam (OrE) evaluates practical competency and is not merely a theoretical assessment, **every student will be required to write one LEX program during the viva**, in addition to answering technical questions asked by the external examiner.

Suggested Lex Programs that can be asked:-

1. Count the number of words, characters, and lines in an input text.
2. Count vowels, consonants, digits, and special characters in an input.
3. Identify and count keywords such as int, float, if, else, while, etc.
4. Identify valid and invalid identifiers according to C/C++ identifier rules.
5. Recognize integer and floating-point constants from an input program.
6. Recognize arithmetic, relational, and logical operators from a C program.
7. Identify arithmetic, relational, logical, and assignment operators from a given C program.
8. Identify and count delimiters such as parentheses, braces, brackets, comma, and semicolon from a given C program.
9. Identify increment (++), decrement (--), and assignment operators from a given C program.
10. Recognize the if, else, for, and while statements in a given C program and count their occurrences.

Suggested Learning Resources

Textbook

1. Compiler Construction: Principles and Practice, I Ed., Kenneth C. Loudon, Cengage Learning, 1997.

2. Modern Compiler Implementation in Java, II Ed., Andrew W. Appel, Cambridge University Press,2002.

Reference Books

1. Compiler Design in C, I Ed., Allen I. Holub, Prentice Hall,1990.
2. Compiler Construction using Flex and Bison, I Ed., Anthony A. Aaby - Free online text,2004.
3. Linkers and Loaders, I Ed., John R. Levine, Morgan Kaufman Publishers, an imprint of Elsevier,1999.

Web Resources

1. LLVM Tutorial
<https://llvm.org/docs/tutorial/>
2. NPTEL Video Course: Compiler Design by Prof.Sanjeev K. Aggarwal.
<http://www.digimat.in/nptel/courses/video/106104123/L10.html>
3. LEX & YACC TUTORIAL
<https://cse.iitkgp.ac.in/~bivasm/notes/LexAndYaccTutorial.pdf>
4. Flex Download
<https://gnuwin32.sourceforge.net/packages/flex.htm>
5. Yacc Download
<https://sourceforge.net/projects/objc/files/byacc/yacc-1.9.1.tar.gz/download>

3.3 Artificial Intelligence (CE6PC_CR2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE6PC_CR2	Artificial Intelligence	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

Sr. No.	Objectives
1	To <i>introduce</i> the fundamental concepts and building blocks of Artificial Intelligence.
2	To <i>learn</i> classical problem-solving approaches using uninformed and informed search strategies.
3	To <i>understand</i> knowledge representation and reasoning for intelligent decision making.
4	To <i>study</i> planning and learning methods for solving complex problems optimally.
5	To <i>design</i> and <i>develop</i> AI applications for real-world domains.

Course Outcomes

The student will be able to	
CO1	<i>develop</i> a basic understanding of building blocks of AI.
CO2	<i>apply</i> appropriate search techniques in problem solving.
CO3	<i>choose</i> an appropriate problem solving method and knowledge representation technique.
CO4	use <i>planning</i> and <i>learning</i> methods to solve intensive problems with optimal solutions.
CO5	<i>design</i> and <i>develop</i> AI applications in real world scenarios.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites Discrete Mathematics, Data Structures and Algorithms.		
1.0	Introduction to Artificial Intelligence		07
	1.1	Definition, history, and scope of AI.	
	1.2	Building blocks of AI systems: Agents and Environments, Perception, Action.	

	1.3	Types of agents: Reflex, Model-based, Goal-based, Utility-based. Characteristics of intelligent agents.	
2.0	Problem Solving and Search Techniques		09
	2.1	Problem formulation and state space representation. Classic examples: 8-puzzle, water jug, route finding	
	2.2	Uninformed Search Methods: Breadth First Search (BFS), Depth First Search (DFS), Depth Limited Search, Depth First Iterative Deepening (DFID). Informed Search Methods: Greedy Best first Search, A* Search. Local search: Hill climbing, Simulated Annealing.	
3.0	Knowledge Representation		09
	3.1	Adversarial search: Minimax algorithm, Alpha-Beta pruning. Example: Tic-Tac-Toe, Chess.	
	3.2	Knowledge-based Agents- need and advantages. The WUMPUS World example. Knowledge representation techniques: Propositional logic, Predicate logic. Logic programming (PROLOG).	
	3.3	Reasoning principles: forward and backward chaining, resolution, unification.	
4.0	Planning & Learning		07
	4.1	Planning problem & components: states, goals, operators. State space planning, classical planning, partial order planning. Conditional & hierarchical planning.	
	4.2	Machine Learning: Supervised, Unsupervised, Reinforcement learning.	
5.0	Expert systems and applications of AI		07
	5.1	Introduction to Natural Language Processing and Computer Vision.	
	5.2	Expert systems: architecture, components, real examples.	
	5.3	Challenges of AI.	
	Total Hours		39

Suggested Learning Resources

Textbooks

1. Artificial Intelligence: A Modern Approach, IV Ed., Stuart J. Russell and Peter Norvig, Pearson Education, 2020.
2. Artificial Intelligence, I Ed., Saroj Kaushik, Cengage Learning, 2011.
3. Artificial Intelligence, Low Price Edition, IV Ed., George F Luger, Pearson Education, 2005.

Reference Books

1. Principles of Artificial Intelligence, I Ed., Nils J. Nilsson, Narosa Publication.
2. A First Course in Artificial Intelligence, I Ed., Deepak Khemani, McGraw Hill Publication.
3. Artificial Intelligence, III Ed., Patrick H. Winston, Pearson Education.
4. Artificial Intelligence, III Ed., Elaine Rich and Kevin Knight, McGraw Hill Education, 2017.

Web Resources

1. NPTEL Online Course: Artificial Intelligence: Foundations and Algorithms by Prof. Mausam, IIT Delhi
https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_cs182

2. NPTEL Online Course: Artificial Intelligence: Concepts and Techniques by Prof. V. SusheelaDevi, IISc Bangalore
https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_cs129

3.4 Artificial Intelligence Lab (CE6PC_LR2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE6PC_LR2	Artificial Intelligence Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	-	25	-	50

Course Objectives

Sr. No.	Objectives
1	To <i>introduce</i> the fundamental concepts of intelligent agents using simulation environments.
2	To <i>learn</i> classical problem-solving approaches using uninformed and informed, strategies.
3	To <i>understand</i> adversarial game-playing mechanics.
4	To <i>study</i> declarative logic representation, rule-based expert systems, and core machine learning paradigms.
5	To <i>design and develop</i> functional AI prototypes to solve practical engineering and text-processing problems.

Course Outcomes

The student will be able to	
LO1	<i>simulate</i> simple reflex agents capable of handling localized environmental conditions.
LO2	<i>apply</i> appropriate uninformed, heuristic, and backtracking techniques to resolve state-space puzzles
LO3	<i>implement</i> adversarial search graphs to construct automated turn-based game models.
LO4	<i>utilize</i> Prolog logic, decision trees, and probabilistic classifiers to build intelligent systems.
LO5	<i>design and implement</i> expert systems for real world problems

Course Contents

Sr. No.	Suggested List of Experiments
1	Implement a simple reflex agent that acts based entirely on immediate environmental perceptions.
2	Write a program to solve the Water Jug Problem using both Breadth-First Search and Depth-First Search.
3	Write a program to solve the Graph Traversal problem using both Breadth-First Search and Depth-First Search.
4	Solve the classic Water Jug Problem (measuring exactly 2 Liters using a 4L and 3L jug) using Depth First Iterative Deepening (DFID) search.

5	Implement A* Search Algorithm to solve 8- Puzzle / Route finding problem.
6	Implement a Hill Climbing Algorithm to solve the N-Queens Problem.
7	Implementation of Adversarial Search for Game playing (Tic Tac Toe Application).
8	Implement a comprehensive Family Relationship Knowledge Base in Prolog. (2nd).
9	Write code to parse a set of Horn clauses and execute a Forward Chaining Inference pattern to deduce new facts from a starting state.
10	Implementation of Partial Order Planning for the Block World Problem.
11	Implement a data-driven Decision Tree Algorithm (such as ID3 or CART) to resolve a binary classification problem.
12	Build a Grid Maze Navigation Simulation where an agent learns to avoid obstacles and reach a specific goal coordinate through value iterations. (Reinforcement Learning).
13	Write a program to demonstrate basic NLP Text Processing.
14	Implementation of an Expert System.

Note: Lab course shall consist of minimum 10 experiments covering all the topics but not limited to the suggested list.

Suggested Learning Resources

Textbook

1. Artificial Intelligence: A Modern Approach, IV Ed., Stuart J. Russell and Peter Norvig, Pearson Education, 2020.
2. Artificial Intelligence, III Ed., Kevin Knight, Elaine Rich, Shivashankar B. Nair, McGraw Hill Education, 2017.
3. Introduction to Machine Learning, II Ed., Alpaydin Ethem, Prentice Hall India Learning Private Limited, 2010.

Reference Books

1. Artificial Intelligence: Foundations of Computational Agents, III Ed., David L. Poole, Alan K. Mackworth, Cambridge University Press, 2023.
2. Machine Learning, II Ed., Tom M. Mitchell, Vineeth N. Balasubramanian, McGraw Hill, 2026.
3. Prolog Programming for Artificial Intelligence, IV Ed., Ivan Bratko, Addison-Wesley Educational Publishers Inc, 2011.
4. Introduction to Artificial Intelligence and Expert Systems, I Ed., Dan W. Patterson, Pearson Education India, 2015.

Web Resources

1. UC Berkeley AI Materials (CS188) by Dan Klein, Stuart Russell.
<https://inst.eecs.berkeley.edu/~cs188/sp26/>
2. 10 Easy AI and Machine Learning Projects for Students and Beginners.
<https://thetempedia.com/blog/simple-ai-and-machine-learning-projects-for-students-and-beginners/>

3.5 Mobile Computing (CE6PC_CR3)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE6PC_CR3	Mobile Computing	2	2

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
15	Continuous	15	1	45	02	75

Course Objectives

Sr. No.	Objectives
1	To <i>understand</i> the fundamental concepts, architectures, and protocols of wireless networks.
2	To <i>analyze</i> the key features and architectural aspects of 5G networks.
3	To <i>understand</i> the fundamentals of mobile computing.
4	To <i>explore</i> Android and iOS platforms with emphasis on application frameworks and development environments.
5	To <i>understand</i> MIMO, AI in smartphones, and wearable computing.

Course Outcomes

The student will be able to	
CO1	<i>explain</i> the characteristics and working principles of wireless networks.
CO2	<i>analyze</i> the key features, architecture, and technological advancements of 5G networks.
CO3	<i>illustrate</i> the architecture for mobile computing, including three-tier models and cellular systems.
CO4	<i>compare</i> Android and iOS application frameworks in terms of architecture, APIs, and development environments.
CO5	<i>analyze</i> the benefits of MIMO, AI-powered smartphones, and wearable computing applications.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites: Computer Network and System Security		
1.0	Wireless Networks		05
	1.1	Wireless Networks: IEEE 802.11: system and protocol architecture; Bluetooth: system and protocol architecture.	

	1.2	Medium Access Control (MAC): Motivation for a specialized MAC and Solution, Hidden and Exposed terminal, MACA.	
2.0	Mobile Telecommunication System		05
	2.1	GSM Mobile services, System Architecture, GPRS system and protocol architecture, UTRAN, UMTS.	
	2.2	5G Wireless Technology , Key Features of 5G, Advancement in the Technology, Impact on Mobile App Development Challenges and Considerations for Developers, 5G Network Architecture, Challenges and Limitations of 5G.	
3.0	Fundamentals of Mobile Computing		05
	3.1	Introduction to Mobile Computing , Telecommunication Generations: 1G, 2G, 3G and 4G, 5G Architecture of mobile computing, three-tier architecture, Introduction to 6G: Key Characteristics, Network Architecture.	
	3.2	Cellular systems, Electromagnetic Spectrum, Antenna, Signal Propagation spreads spectrum.	
4.0	Mobile Devices & Operating System		05
	4.1	Mobile device architecture: smartphones, tablets, IoT devices,	
	4.2	Android & iOS platforms – application frameworks, Mobile device security features (biometrics, sandboxing, secure boot).	
5.0	Introduction to MIMO		06
	5.1	Concept of multiple antennas: transmitter & receiver, Evolution from SISO, SIMO, MISO, MIMO, Benefits: higher capacity, reliability, spectral efficiency, Types of MIMO Techniques: Spatial Diversity, Spatial Multiplexing (V-BLAST, D-BLAST).	
	5.2	Artificial Intelligence (AI) in Smartphones: Wearable Computing: Smartwatches, Fitness bands, Smart glasses, Health monitoring, Medical wearables.	
Total Hours			26

Suggested Learning Resources

Textbooks

1. Mobile Communication, II Ed., Jochen Schiller Addison wisely, Pearson Education, 2004.
2. Wireless Communications & Networks, II Ed., William Stallings, Pearson Education, 2009.
3. Mobile Computing, II Ed., Raj Kamal Oxford University Press-New Reference Books, 2011.
4. Fundamentals of wireless communication, I Ed., David Tse and Pramod Viswanath, Cambridge University Press, 2005.

Reference Books

1. Networks (SON): Network Management Automation for Operational Efficiency, I Ed., Seppo Hämmäläinen, Henning Sanneck, Cinzia Sartori, Wiley publications, 2012.
2. Mobility Protocols and Handover, I Ed., Ashutosh Dutta, Henning Schulzrinne, Wiley-IEEE Press, 2014.
3. Optimization: Design, Evaluation and Application, IEEE Press, Wiley Publication, 2014.
4. Build your own security lab, Michael Gregg, Wiley India edition, 2012.
5. Emerging Wireless Technologies and the Future Mobile Internet, Dipankar Raychaudhuri, Mario Gerla, Cambridge, 2011.
6. Wireless Communications, II Ed., Andreas F. Molisch, Wiley Publication, 2011.

Web Resources

1. Smart Device & Mobile Emerging Technologies By John-Moon Chung.
<https://www.coursera.org/learn/smart-device-mobile-emerging-technologies>
2. Introduction to Wireless and Cellular Communication By Prof. David Koilpillai, IIT Madras.
<https://nptel.ac.in/courses/106106167>
3. Enabling Technologies for 6G Communications Networks (Hindi), IIIT Delhi By Prof. Vivek Ashok Bohara.
<https://nptel.ac.in/courses/108106588>

3.6 Mobile Computing Application Lab (CE6PC_LR3)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE6PC_LR2	Artificial Intelligence Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	-	25	-	50

Course Objectives

Sr. No.	Objectives
1	To <i>enable</i> students to develop Android applications in Kotlin that access device hardware and display real-time data.
2	To <i>familiarize</i> students with profiling tools like Layout Inspector, GPU overdraw, and Systrace/Profiler in Android Studio.
3	To <i>help</i> students compare PWA and native app architectures, performance, and usability.
4	To <i>integrate</i> knowledge of mobile hardware, app design, and real-time messaging.
5	To <i>develop</i> skills in enhancing user interaction and engagement through notifications.

Course Outcomes

The student will be able to	
LO1	<i>develop</i> Android applications using Kotlin to implement mobile computing features such as sensors, GPS, camera, notifications, and network connectivity.
LO2	<i>analyze</i> mobile network communication and traffic using tools such as Wireshark to evaluate connectivity, protocols, and Quality of Service (QoS) parameters.
LO3	<i>evaluate</i> Android application permissions, security risks, and privacy issues using appropriate mobile security and analysis tools.
LO4	<i>implement</i> emerging mobile technologies such as Progressive Web Applications (PWA), offline caching, REST API communication using Retrofit, and cellular network detection.
LO5	<i>analyze</i> Android device performance by monitoring processes, memory usage, network changes, and other system resources using suitable development and debugging tools.

Course Contents

Sr. No.	Suggested List of Experiments
1	To implement an Android application that reads data from the device accelerometer and displays the sensor values on the screen.
2	To implement and analyze network traffic generated by a mobile application using Wi-Fi or USB tethering and Wireshark.
3	To implement an application permission analysis system to identify the permissions

	requested by installed Android applications and analyze potential privacy issues.
4	To implement a cellular network detection application that identifies the current mobile communication technology such as 2G, 3G, 4G, or 5G.
5	To implement a Progressive Web Application (PWA) that caches web assets and provides offline functionality, and compares its features with a native mobile application.
6	To implement a GPS-based Android application that obtains and displays the user's geographical location using latitude and longitude.
7	To implement an Android application that captures images using the device camera and displays the captured images from the camera or gallery.
8	To implement an Android application that generates and displays foreground and local push notifications.
9	To implement an Android application using Retrofit to fetch data from an online REST API and display the retrieved data.
10	To implement an Android application that detects network connectivity changes and identifies switching between Wi-Fi and mobile data networks.
11	To implement a Quality of Service (QoS) analysis system for multimedia streaming by measuring parameters such as bandwidth, latency, jitter, and packet loss.
12	To implement an Android application for monitoring operating system processes and analyzing process states and memory usage.
13	Design and implement a smart mobile application integrating multiple mobile computing technologies such as GPS, sensors, camera, network connectivity, notifications, and REST API communication. (Smart Emergency Assistance Mobile Application).

Note: Lab course shall consist of minimum 10 experiments covering all the topics but not limited to the suggested list.

Suggested Learning Resources

Textbook

1. Android Studio Development, II Ed., Neil Smyth eBookFrenzy 2015.
2. Elements of Kotlin, Final Version, by Mark L. Murphy CommonsWare, LLC 2021.
3. MobSF – Mobile Security Framework by Ajin Abraham, Magaofoi, Matan Dobrushin, Vincent Nadal Open-source mobile application security framework, 2015.

Reference Books

1. Kotlin Language Documentation. Kotlin Language Documentation, Version 2.4.10. JetBrains, 2026.
2. The Busy Coder's Guide to Android Development, Final Version By Mark L. Murphy, CommonsWare, LLC, 2019.

Web Resources

1. Android Developers – Android Basics & Developer Documentation by Google.
<https://developer.android.com/>
2. Wireshark – Official Documentation & Learning Resources by Wireshark Foundation.
[Wireshark Documentation](#)

3.7 Software Product development Tools and Techniques (CE6VS_LR4)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE6VS_LR4	Software Product development Tools and Techniques	04	02

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	-	25	-	50

Course Objectives

Sr. No.	Objectives
1	<i>To understand</i> and prepare Software Requirement Specifications (SRS) and UML models.
2	<i>To apply</i> UI/UX design principles and how to set up professional coding environments.
3	<i>To understand</i> Agile methodologies and collaborative workflows using Git/GitHub.
4	<i>To design</i> and implement RESTful APIs and perform Database management operations.
5	<i>To apply</i> software Testing techniques and application deployment using Docker.

Course Outcomes

The student will be able to	
LO1	<i>design</i> SRS documents and UML diagrams for a given problem.
LO2	<i>apply</i> Agile practices and Git commands to manage team tasks and code versions.
LO3	<i>create</i> user-friendly interfaces and functional RESTful APIs for software systems.
LO4	<i>execute</i> test cases to check code quality and perform database backup/restore tasks.
LO5	<i>develop and deploy</i> applications using advanced tools and techniques.

Course Contents

Sr. No.	Suggested List of Experiments
1	To identify the requirements for a software project and create an SRS document with analysis models.
2	To design user-friendly interfaces and logical navigation flow.
3	To plan sprints and track progress using Agile methodology. (Create Kanban boards, assign tasks, and manage iterations.).
4	To implement Collaborative Workflows: Branching, Merging, and Conflict Resolution using Git and GitHub.
5	To set up IDEs (Integrated Development Environment) with essential extensions and plugins.
6	To design and implement RESTful APIs.

7	To create and execute test cases for implemented modules and generate coverage reports.
8	To perform database backup and restore operations.
9	To containerize and deploy an application using Docker or similar advanced tools.
10	To execute Post-Deployment Monitoring and Log Analysis activity.

Note: Lab course shall consist of minimum 08 experiments covering all the topics but not limited to the suggested list.

Suggested Learning Resources

Textbooks

1. Fundamentals of DevOps and Software Delivery, I Ed., Yevgeniy Brikman, O'Reilly Media, 2025.
2. The DevOps Handbook, II Ed., Gene Kim, Jez Humble, Patrick Debois, John Willis, and Nicole Forsgren, IT Revolution Press, 2021.
3. DevOps Tools from Practitioner's Viewpoint, I Ed., Deepak Gaikwad, Viral Thakkar, Wiley, 2019.

Reference Books

1. Learning DevOps: A Comprehensive Guide to Accelerate DevOps Culture and Processes, II Ed., Mikael Krief, Packt Publishing, 2022.
2. DockerDeep Dive, III Ed., Nigel Poulton, Leanpub, 2023.
3. Software Engineering , X Ed. Ian Sommerville, Pearson Education, 2022.

Web Resources

1. Docker Documentation
<https://docs.docker.com/manuals/>
2. Atlassian Agile & Jira Guides
<https://www.atlassian.com/agile>
3. W3Schools, MDN Web Docs For web development and API integration practices.
https://developer.mozilla.org/en-US/docs/Learn_web_development/Extensions/Client-side_APIs/Introduction
4. Introduction to Agile Development and Scrum : Coursera course by John Rofrano
<https://www.coursera.org/learn/agile-development-and-scrum?action=enroll> :

3.8 Program Elective Course-II

3.8.1 Deep Learning (CE6PE_CX2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE6PE_CX2	Deep Learning	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

Sr. No.	Objectives
1	To <i>learn</i> the fundamentals of Neural Network.
2	To <i>gain</i> an in-depth understanding of training Deep Neural Networks.
3	To <i>acquire</i> knowledge of advanced concepts of Convolution Neural Networks, Autoencoders and Recurrent Neural Networks.
4	To <i>gain</i> knowledge of RNN(Recurrent Neural Networks).
5	To <i>gain</i> familiarity with the recent trends in Deep Learning.

Course Outcomes

The student will be able to	
CO1	<i>gain</i> basic knowledge of Neural Networks.
CO2	<i>acquire</i> in-depth understanding of training Deep Neural Networks.
CO3	<i>design</i> appropriate DNN model for supervised, unsupervised and sequence learning applications.
CO4	<i>gain</i> knowledge of RNN(Recurrent Neural Networks).
CO5	<i>gain</i> familiarity with recent trends and applications of Deep Learning.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites: Deep Learning Fundamentals		
1.0	Wireless Networks		07
	1.1	Biological neuron, Mc-Culloch Pitts Neuron, Perceptron, Perceptron Learning, Delta learning, Multilayer Perceptron: Linearly separable, linearly non-separable classes	
	1.2	Deep Networks: Fundamentals, Brief History, Three Classes of	

		Deep Learning Basic Terminologies of Deep Learning	
2.0	Training, Optimization and Regularization of Deep Neural Network		08
	2.1	Training Feedforward DNN Multi Layered Feed Forward Neural Network, Learning Factors, Activation functions: Tanh, Logistic, Linear, Softmax, ReLU, Leaky ReLU, Loss functions: Squared Error loss, Cross Entropy, Choosing output function and loss function.	
	2.2	Optimization Learning with backpropagation, Learning Parameters: Gradient Descent (GD), Stochastic and Mini Batch GD, Momentum Based GD, Nesterov Accelerated GD, AdaGrad, Adam, RMSProp.	
	2.3	Regularization Overview of Overfitting, Types of biases, Bias Variance Tradeoff Regularization Methods: L1, L2 regularization, Parameter sharing, Dropout, Weight Decay, Batch normalization, Early stopping, Data Augmentation, Adding noise to input and output.	
3.0	Autoencoders: Unsupervised Learning		08
	3.1	Introduction, Linear Autoencoder, Undercomplete Autoencoder, Overcomplete Autoencoders, Regularization in Autoencoders.	
	3.2	Denoising Autoencoders, Sparse Autoencoders, Contractive Autoencoders.	
	3.3	Application of Autoencoders: Image Compression.	
4.0	Convolutional Neural Networks (CNN): Supervised Learning		08
	4.1	Convolution operation, Padding, Stride, Relation between input, output and filter size, CNN architecture: Convolution layer, Pooling Layer, Weight Sharing in CNN, Fully Connected NN vs CNN, Variants of basic Convolution function.	
	4.2	Modern Deep Learning Architectures: LeNET: Architecture, AlexNET: Architecture.	
5.0	Recurrent Neural Networks (RNN), Recent Trends and Applications		08
	5.1	Sequence Learning Problem, Unfolding Computational graphs, Recurrent Neural Network, Bidirectional RNN, Backpropagation Through Time (BTT), Vanishing and Exploding Gradients, Truncated BTT.	
	5.2	Long Short Term Memory: Selective Read, Selective write, Selective Forget, Gated Recurrent Unit.	
	5.3	Generative Adversarial Network (GAN): Architecture and Applications.	
	Total Hours		39

Suggested Learning Resources

Textbooks

1. Deep Learning, I Ed., Ian Goodfellow, Yoshua Bengio, Aaron Courville, MIT Press Ltd, 2016.

2. Deep Learning Methods and Applications, I Ed., Li Deng and Dong Yu, Publishers Inc., 2014.
3. Neural Networks: A Classroom Approach, II Ed., Satish Kumar, Tata McGraw-Hill, 2017.
4. Introduction to Artificial Neural Systems, I Ed., JM Zurada, Jaico Publishing House, 1994.
5. Algorithms for Optimization, I Ed., M. J. Kochenderfer, Tim A. Wheeler, MIT Press, 2019.

Reference Books

1. Fundamentals of deep learning: Designing next generation machine intelligence algorithms, I Ed., Buduma, N. and Locascio, N., O'Reilly Media, Inc., 2017.
2. Deep learning with Python, I Ed., François Chollet., New York: Manning, 2017.
3. Deep Learning Cookbook, I Ed., Douwe Osinga, O'REILLY, 2018.
4. Neural Network- A Comprehensive Foundation, II Ed., Simon Haykin, Prentice Hall International, Inc., 1998.
5. Principles of soft computing, III Ed., S.N.Sivanandam and S.N. Deepa, Wiley India, 2018.

Web Resources

NPTEL Lecture Series:

1. Introduction to Deep Learning By Prof. Bhiksha Raj, Prof. Rita Singh, IIT Kharagpur
<https://deeplearning.cs.cmu.edu/S21/index.html>

3.8.2 Deep Learning Lab (CE6PE_LX2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE6PE_LX2	Deep Learning Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	25	-	-	50

Course Objectives

Sr. No.	Objectives
1	To <i>develop</i> a strong foundation in artificial neural networks and their underlying principles.
2	To <i>understand</i> the architecture, training methodologies, and optimization techniques of deep neural networks.
3	To <i>design and implement</i> deep learning models using Convolutional Neural Networks (CNNs), Autoencoders, and Recurrent Neural Networks (RNNs) for real-world applications.
4	To <i>apply</i> advanced deep learning techniques for image, text, and sequential data analysis using modern frameworks.
5	To <i>familiarize</i> students with emerging trends, tools, and research directions in deep learning and artificial intelligence.

Course Outcomes

The student will be able to	
LO1	<i>explain</i> the fundamental concepts, architectures, and working principles of artificial neural networks and deep learning.
LO2	<i>design, train, and optimize</i> deep neural network models using appropriate learning algorithms and optimization techniques.
LO3	<i>develop and evaluate</i> CNN, Autoencoder, and RNN-based models for image processing, classification, and sequence learning applications.
LO4	<i>utilize</i> contemporary deep learning frameworks and libraries to implement intelligent solutions for diverse real-world problems.
LO5	<i>analyze, compare, and apply</i> recent advancements and best practices in deep learning to address emerging AI challenges.

Course Contents

Sr. No.	Suggested List of Experiments
1	To implement Mc-Culloch Pitts model for binary logic functions.
2	To implement Perceptron algorithm to simulate any logic gate.
3	To implement Multilayer Perceptron algorithm to simulate XOR gate.
4	To explore python libraries for deep learning e.g. Theano, TensorFlow etc.

5	To implement any of the following learning algorithms to learn the parameters of the supervised single layer feed forward neural network. a. Stochastic Gradient Descent b. Mini Batch Gradient Descent c. Momentum GD d. Nestorev GD e. Adagrad GD f. Adam Learning GD
6	To implement a backpropagation algorithm to train a DNN with at least 2 hidden layers.
7	To design and implement a fully connected deep neural network with at least 2 hidden layers for a classification application. Use appropriate Learning Algorithm, output function and loss function.
8	To design the architecture and implement the autoencoder model for Image Compression
9	To design the architecture and implement the autoencoder model for Image denoising.
10	To design and implement a CNN model for digit recognition application.
11	To design and implement a CNN model for image classification.
12	To design and implement LSTM for Sentiment Analysis.
13	To design and implement GRU for classification on text data.
14	To design and implement RNN for classification of temporal data.

Note: Lab course shall consist of minimum 10 experiments covering all the topics but not limited to the suggested list.

Suggested Learning Resources

Textbook

1. Pattern Recognition and Machine Learning, I Ed., Christopher M. Bishop, Springer, 2006.
2. Deep Learning for Computer Vision, I Ed., Rajalingappaa Shanmugamani, Packt Publishing, 2018.
3. Neural Networks: Principles and Applications, I Ed., James A. Anderson, PHI Learning, 1995.

Reference Books

1. Deep Learning for Coders with fastai and PyTorch, I Ed., Jeremy Howard and Sylvain Gugger, O'Reilly Media, 2020.
2. Grokking Deep Learning, I Ed., Andrew W. Trask, Manning Publications, 2019.
3. Dive into Deep Learning, I Ed., Aston Zhang, Zachary C. Lipton, Mu Li and Alexander J. Smola, Cambridge University Press, 2023.

Web Resources

1. TensorFlow Tutorials
<https://www.tensorflow.org/tutorials>
2. Keras Examples
<https://keras.io/examples/>
3. PyTorch Tutorials
<https://docs.pytorch.org/tutorials/>

4. Google Colab
<https://colab.research.google.com/>
5. Kaggle Learn
<https://www.kaggle.com/learn>

3.8.3 Advance Computer Network & System Security (CE6PE_CX2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE6PE_CX2	Advance Computer Network & System Security	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

Sr. No.	Objectives
1	To <i>introduce</i> concepts and fundamentals of advanced computer networks.
2	To <i>explore</i> high performance routing algorithms and switching
3	To <i>understand</i> various modern network architecture.
4	To <i>understand</i> network attacks and the need for intrusion monitoring using IDS, and to learn firewall concepts, architectures, deployment topologies, and policies for effective perimeter security.
5	To <i>understand</i> VPN concepts, working, tunneling and authentication mechanisms, and to study wireless technologies, their security challenges, and countermeasures.

Course Outcomes

The student will be able to	
CO1	<i>understand</i> the concepts of data communication.
CO2	<i>understand</i> high performance routing and packet classification.
CO3	<i>analyze</i> and compare SDN with traditional networks.
CO4	<i>analyze</i> intrusion stages, <i>understand</i> IDS and firewall architectures, and <i>implement</i> effective perimeter defense solutions.
CO5	<i>analyze</i> VPN architectures, types, and security mechanisms while <i>identifying</i> wireless vulnerabilities and <i>applying</i> appropriate protections to secure networks.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites Computer Network, System security		
1.0	Wireless Networks		07
	1.1	Internet Multicasting, NAT, VPN – Routing Algorithms – BGP, RIP, OSPF	

	1.2	Differentiated and Integrated Services – SONET, ATM – MPLS -Next generation Internet architectures.	
2.0	Advance Routing and Switching		08
	2.1	High Performance Switching and Routing: Introduction, performance considerations, IP address lookup.	
	2.2	Algorithms for IP address lookup and optimization.	
	2.3	Packet Classification: Need for packet classification and methods for packet classification. Quality of Service.	
3.0	Modern Network architecture		08
	3.1	Introduction Software Defined Networking (SDN)	
	3.2	Comparison between SDN and traditional networks -SDN controller, Switch design, SDN Controller-Switch Protocols, Open Flow Protocol.	
	3.3	Network Function Virtualization (NFV) - Architecture and Concepts.	
4.0	Convolutional Neural Networks (CNN): Supervised Learning		08
	4.1	Network Attacks-The stages, Need for Intrusion Monitoring & Detection.	
	4.2	Intrusion Detection for Information Systems Security.	
	4.3	What are Firewalls, Demilitarized Zone(DMZ), Need for firewalls, Proxy Servers, Topologies for Different Types of Firewalls Examining firewalls in IDS, Design and implementation Issues in Firewalls, Policies for Firewalls, Using Firewalls effectively.	
5.0	Comprehensive Network Security: Virtual Private Networks and Wireless Security		08
	5.1	Virtual Private Network(VPN), The need for VPN, Role of VPN for an Enterprise, Use of Tunneling with VPN, Working of VPN	
	5.2	Authentication Mechanisms in VPN, Types of VPN and their Usage, Tunneling Security, VPN Architecture	
	5.3	An overview of wireless technology, Attacks on Wireless Networks, Countermeasure and Mitigations for Wireless Network.	
Total Hours			39

Suggested Learning Resources

Textbooks

1. Computer Networks, IV Ed., A.S. Tanenbaum, Pearson Education, 2003.
2. Information Systems Security, Nina Godbole, I Ed, Wiley, 2009.

Reference Books

1. Computer Networks: An Engineering Approach To Computer Networking, II Ed, S. Keshav, Pearson.
2. Computer Networks: A Systems Approach, V Ed., Larry L. Peterson, Bruce S. Davie, The Morgan Kaufmann Series in Networking.
3. Cryptography and Network Security, IV Ed., Atul Kahate, Tata McGraw-Hill Education, 2003.

Web Resources

NPTEL Lecture Series:

1. Online NPTEL course By Prof. Neminath Hubballi, Prof. Sameer G Kulkarni
https://onlinecourses.nptel.ac.in/noc23_cs35/preview
2. Cisco Networking Academy
<https://www.netacad.com/courses/networking/networking-essentials>
3. Hash Generator
<https://caddy.tech/tools/hash-generator>

3.8.4 Advance Computer Network & System Security Lab (CE6PE_LX2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE6PE_LX2	Advance Computer Network & System Security Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	25	-	-	50

Course Objectives

Sr. No.	Objectives
1	To <i>provide</i> students with practical exposure of CISCO Packet Tracer/NS2 for implementation of Dynamic Routing Algorithm.
2	To <i>enable</i> students to understand Networking commands for IP Address lookup.
3	To <i>enable</i> students to understand the Open flow protocol of SDN.
4	To <i>provide</i> hands-on exposure to network attacks, intrusion stages, and perimeter defense mechanisms using IDS, firewalls, and DMZ architecture.
5	To <i>introduce</i> VPN technologies and wireless security concepts by exploring tunnelling, authentication, VPN architectures, and common wireless vulnerabilities.

Course Outcomes

The student will be able to	
LO1	<i>understand</i> concept of dynamic routing algorithms.
LO2	<i>identify</i> the different uses of IP addresses.
LO3	<i>understand</i> working of SDN Open Flow Protocol.
LO4	<i>detect</i> and analyze intrusion activities using IDS tools and implement effective firewall policies with DMZ architecture to secure internal networks.
LO5	<i>configure</i> VPN solutions, <i>evaluate</i> authentication mechanisms and VPN architectures, and <i>analyze</i> wireless attacks to deploy appropriate security countermeasures.

Course Contents

Sr. No.	Suggested List of Experiments
1	Implementation of RIP Routing Algorithms.
2	Implementation of OSPF Routing Algorithms.
3	Implementation of linear search Algorithms for IP address lookup.
4	Implementation of Binary search Algorithms for IP address lookup.
5	Simulation of SDN controller.
6	Simulation of Open Flow Protocol.
7	Implementation of dictionary attack.

8	Implementation of Network Attacks.
9	Study of Firewall Configuration.
10	Study of VPN Configuration and Working.

Note: Lab course shall consist of minimum 08 experiments covering all the topics but not limited to the suggested list.

Suggested Learning Resources

Textbook

1. Computer Networking: A Top-Down Approach Featuring the Internet, VII Ed, James F. Kurose, Keith W. Ross, Addison Wesley.
2. Cryptography & Network Security, 3Ed, Behrouz A. Ferouzan , Tata Mc Graw Hill, 2015.

Reference Books

1. Computer Networks: Principles, Technologies & Protocols for Network Design, Natalia Olifer & Victor Olifer, Wiley India, 2011.
2. Computer Networks: A Systems Approach, VEd , Larry L. Peterson, Bruce S. Davie, The Morgan Kaufmann Series in Networking.
3. Cryptography and Network Security, Atul Kahate, IEd, Tata McGraw-Hill Education, 2008.

3.8.5 Design Principles of UI/UX (CE6PE_CX2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE6PE_CX2	Design Principles of UI/UX	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

Sr. No.	Objectives
1	To <i>introduce</i> the fundamental principles and processes of User Interface (UI) and User Experience (UX) design.
2	To <i>understand</i> user-centered design methodologies and usability engineering.
3	To <i>develop</i> the ability to design effective, efficient, and aesthetically pleasing interfaces.
4	To <i>explore</i> design tools, prototyping methods, and user testing techniques.
5	To <i>cultivate</i> empathy-driven thinking and iterative design through real-world projects.

Course Outcomes

The student will be able to	
CO1	<i>understand</i> the fundamental concepts, principles, and processes of UI/UX design.
CO2	<i>apply</i> user-centered design techniques for requirement analysis and persona creation.
CO3	<i>design</i> and prototype interactive user interfaces using modern design tools.
CO4	<i>evaluate</i> user interfaces using usability principles, heuristic evaluation, and user testing.
CO5	<i>create</i> and document an end-to-end UX project demonstrating design thinking.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites: Computer Graphics		
1.0	Wireless Networks		07
	1.1	UX vs UI: Definitions, Differences, and Relationships, Evolution of UX - From Usability to Experience Economy.	

	1.2	UX Process: Research, Design, Prototyping, Testing, Iteration, Design Thinking: Empathize, Define, Ideate, Prototype, Test.	
2.0	Principles of Visual & Interaction Design		08
	2.1	Visual Design: Alignment, Balance, Contrast, Consistency, Hierarchy.	
	2.2	Interaction Design: Affordance, Feedback, Constraints, Mapping, Layouts, Typography, Color Psychology, Accessibility and Inclusive Design.	
3.0	User Research & Requirement Analysis		08
	3.1	Introduction to user research, User Research Methods: Interviews, Surveys, Observation, Persona Creation, Empathy Mapping, and User Scenarios, Information Architecture and Task Flows, Journey Mapping and Storyboarding.	
	3.2	Context of use analysis, requirement gathering techniques, Requirement documentation, Tools and deliverables.	
4.0	Prototyping, Mobile & Responsive UX		08
	4.1	Low-fidelity vs High-fidelity Prototypes, Wireframing Tools: Figma, Adobe XD, Sketch, InVision.	
	4.2	Design Systems: Material Design, Human Interface Guidelines, Mobile & Responsive UX, Adaptive Layouts, and Fluid Grids.	
	4.3	Introduction to Voice and Gesture Interfaces.	
5.0	Usability Testing and Evaluation		08
	5.1	Heuristic Evaluation (Nielsen's 10 Heuristics), Cognitive Walkthrough and Think-Aloud Protocol.	
	5.2	Usability Metrics: Efficiency, Effectiveness, Satisfaction, Agile UX, Lean UX, and Case Study Documentation.	
	5.3	AR/VR UX, AI-driven Personalization.	
Total Hours			39

Suggested Learning Resources

Textbooks

1. The Design of Everyday Things, Revised and Expanded Edition, Don Norman, Basic Books, 2013.
2. About Face: The Essentials of Interaction Design, IV Ed, Alan Cooper, Robert Reimann, David Cronin and Christopher Noessel, Wiley, 2014.
3. The Elements of User Experience: User-Centered Design for the Web and Beyond, II Ed, Jesse James Garrett, New Riders, 2011.

Reference Books

1. Lean UX: Applying Lean Principles to Improve User Experience, II Ed, Jeff Gothelf and Josh Seiden, O'Reilly Media, 2016.

Web Resources

1. Coursera / Google UX Certificate Learning Materials.
<https://www.coursera.org/professional-certificates/google-ux-design>

3.8.6 Design Principles of UI/UX Lab (CE6PE_LR2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE6PE_LR2	Design Principles of UI/UX Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	25	-	-	50

Course Objectives

Sr. No.	Objectives
1	To <i>understand</i> and apply user-centered design (UCD) methodologies.
2	To <i>create</i> low- and high-fidelity prototypes using modern design tools.
3	To <i>evaluate</i> interfaces through usability testing and heuristic methods
4	To <i>evaluate</i> usability testing and heuristic evaluation techniques.
5	To <i>design</i> an end-to-end UX with data-driven design improvements.

Course Outcomes

The student will be able to	
LO1	<i>identify</i> and define user needs using research and requirement analysis techniques.
LO2	<i>design</i> user personas, empathy maps, and journey maps based on collected data.
LO3	<i>create</i> low-fidelity wireframes and high-fidelity prototypes using tools like Figma/Adobe XD.
LO4	<i>conduct</i> usability testing, heuristic evaluation, and suggest design improvement.
LO5	<i>develop</i> and present a complete, end-to-end UX case study project.

Course Contents

Sr. No.	Suggested List of Experiments
1	To conduct a user interview or survey to identify usability issues in an existing website or mobile app.
2	To create user personas and empathy maps from collected data.
3	To develop information architecture and user journey maps for a chosen app/website, highlighting touchpoints.
4	To conduct open/closed card sorting to design or evaluate information architecture.
5	To create low-fidelity wireframes for a mobile or web interface using digital tools.
6	To develop a high-fidelity prototype using Figma or Adobe XD.
7	To conduct usability testing using think-aloud and record findings.
8	To perform heuristic evaluation based on Nielsen's 10 heuristics and recommend improvements.
9	To compare two design variations and collect peer feedback to analyze preferences.

10	To evaluate a website against WCAG guidelines (color contrast, alt text, keyboard navigation).
11	To use heatmap tools or observation to study visual attention on a webpage.
12	To prepare a UX case study report documenting research, design, testing, and iteration.

Note: Lab course shall consist of minimum 10 experiments covering all the topics but not limited to the suggested list.

Suggested Learning Resources

Textbook

1. Don't Make Me Think: A Common Sense Approach to Web Usability, III Ed., Steve Krug, New Riders, 2014.
2. Designing Interfaces: Patterns for Effective Interaction Design, III Ed., Jenifer Tidwell, Charles Brewer, Aynne Valencia, O'Reilly Media, 2020.
3. 100 Things Every Designer Needs to Know About People, I Ed., Susan M. Weinschenk, New Riders, 2011.

Reference Books

1. The UX Book: Agile UX Design for a Quality User Experience, II Ed., Rex Hartson and Pardha Pyla, Morgan Kaufmann, 2019.
2. Laws of UX: Using Psychology to Design Better Products & Services, II Ed., Jon Yablonski, O'Reilly Media, 2024.

Web Resources

1. Figma UI/UX design & prototyping
<https://www.figma.com/>.
2. Miro Visual collaboration & whiteboarding
<https://miro.com/>
3. Maze User testing & insights
<https://maze.com/>

3.8.7 Advanced Web Technologies (CE6EX_CR2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE6EX_CR2	Advanced Web Technologies	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

Sr. No.	Objectives
1	To <i>develop</i> skills for building responsive and interactive web applications using advanced HTML5, CSS3, and modern JavaScript.
2	To <i>develop</i> skills for building scalable single-page applications using React.js and PWA techniques.
3	To <i>develop</i> skills for building RESTful APIs and performing database operations using Node.js, Express.js, and MongoDB.
4	To <i>equip</i> students with web security practices and DevOps skills for secure and automated application deployment.
5	To <i>develop</i> skills in browser-based ML, headless CMS, and IoT for web-integrated applications.

Course Outcomes

The student will be able to	
CO1	<i>build</i> responsive and interactive web applications with HTML5, CSS3, and JavaScript.
CO2	<i>build</i> responsive SPAs with React.js and PWA features.
CO3	<i>build</i> RESTful APIs and <i>integrate</i> MongoDB with Node.js applications.
CO4	<i>apply</i> web security and DevOps practices to <i>build</i> and <i>deploy</i> secure, automated applications.
CO5	<i>create</i> web-integrated applications using ML, headless CMS, and IoT technologies.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites		
	Internet Programming, Database Management System		
1.0	Advanced Programming with HTML5, CSS3, and JavaScript		
	1.1	Advanced HTML5 (Canvas, Semantic Tags, Web Storage), CSS3: Flexbox, Grid, Animations & Responsive Design	07
	1.2	ES6+ JavaScript: Modules, Promises, Async/Await, AJAX/ Fetch API & Asynchronous Data Handling	
2.0	Introduction to React.js		08
	2.1	Overview of React.js and its benefits. Setting up the React.js development environment.	
	2.2	React.js: JSX, Components, SPA(Single Page Applications) with Forms & State Management.	
	2.3	Progressive Web App (PWA) Techniques: Offline, Caching, Push Notifications	
3.0	Backend Development with Node.js and Express.js		08
	3.1	Node.js & Express.js: Server Setup, REST APIs, Routing, and CRUD Operations.	
	3.2	MongoDB with Node.js: MongoDB Basics, Database Connectivity, CRUD Operations.	
4.0	Security, Performance & DevOps		08
	4.1	Web Security & Performance: OWASP Risks, HTTPS, CORS, XSS/CSRF, Caching, CDN.	
	4.2	DevOps: Principles, GitHub, CI/CD, Build & Automation, Docker Deployment.	
5.0	Emerging Technologies		08
	5.1	Machine Learning in the Browser and its Benefits, Key Tools & Frameworks: TensorFlow.js.	
	5.2	Introduction to Headless CMS, Working of Headless CMS, Headless CMS vs Traditional CMS.	
	5.3	Introduction to IoT & Architecture: Devices, Sensors, Connectivity, Cloud, Web Interfaces. Web Technologies for IoT—Using HTML5, JavaScript, and Node.js (APIs, dashboards) to monitor and control IoT devices.	
Total Hours			39

Suggested Learning Resources

Textbooks

1. Building the Web of Things: With HTML5, JavaScript, and Node.js, I Ed., Dominique Guinard & Vlad Trifa, 2016.
2. Black Book HTML 5, II Ed., Dreamtech Publication, 2009.
3. Beginning Node.js, Express & MongoDB Development, Greg Lim, September 1, 2020.
4. Learning DevOps, II Ed., Mikael Krief, 2022.
5. The Web Application Hacker's Handbook, II Ed., Dafydd Stuttard & Marcus Pinto 2011.

Reference Books

1. HTML & CSS: Design and Build Websites, I Ed., Jon Duckett, 2011.
2. Node.js Design Patterns, III Ed., Mario Casciaro, 2020.

3. OWASP Testing Guide, OWASP Foundation, 2025.
4. The DevOps Handbook: How to Create World-Class Agility, Reliability, & Security in Technology Organizations, II Ed., Gene Kim, Jez Humble, Patrick Debois, John Willis, 2021.
5. TensorFlow.js: Machine Learning for JavaScript, Stanley Bileschi, Eric Nielsen, Shanqing Cai, 2020.
6. Internet of Things: A Hands-On Approach, I Ed., Arshdeep Bahga & Vijay Madisetti, 2014.

Web Resources

1. HTML Tutorial W3 Schools.
<https://www.w3schools.com/>
2. HTML Basics Geek for Geeks.
<https://www.geeksforgeeks.org/web-development/>
3. Full Stack Development Course Tutorials Point.
https://www.tutorialspoint.com/full_stack_web_development/index.htm
4. TensorFlow.js Library for machine learning in Java Script.
<https://www.tensorflow.org/js>
5. Article on IoT for All.
<https://www.iotforall.com/>
6. A Resource Library to inspire developers and businesses.
<https://www.docker.com/resources/>

3.8.8 Advance Web Technologies Lab (CE6EX_LR2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE6EX_LR2	Advanced Web Technologies	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	25	-	-	50

Course Objectives

Sr. No.	Objectives
1	To <i>design</i> and <i>develop</i> responsive web applications using modern frontend technologies.
2	To <i>implement</i> modern JavaScript for dynamic RESTful API data handling.
3	To <i>build</i> a React SPA with components, state management, forms, and routing.
4	To <i>develop</i> a secure Node.js REST API with Express and MongoDB for CRUD operations.
5	To <i>deploy</i> containerized PWAs using Docker, CI/CD, and cloud platforms with offline capabilities.

Course Outcomes

The student will be able to	
LO1	<i>develop</i> dynamic, responsive, and interactive web applications using HTML5, CSS3, and modern JavaScript.
LO2	<i>apply</i> modern JavaScript for RESTful API interaction and dynamic content handling.
LO3	<i>construct</i> a React SPA with routing, state management, and offline PWA functionality.
LO4	<i>design</i> and <i>implement</i> secure RESTful APIs using Node.js, Express, and MongoDB for CRUD operations.
LO5	<i>deploy</i> a containerized full-stack application using Docker, CI/CD, and cloud platforms.

Course Contents

Sr. No.	Suggested List of Experiments
1	To implement an HTML5-based resume/portfolio for a job interview.
2	To implement a responsive multi-section webpage using CSS Grid, Flexbox, and CSS3 animations/transitions.
3	To implement an interactive web application using HTML5 Canvas, Web Storage, and Geolocation APIs.
4	To implement ES6 modules and Fetch API with Async/Await to retrieve and display

	data from a REST API.
5	To implement a small React SPA (To-Do application) using components, state, forms, and React Router for navigation.
6	To implement a Progressive Web Application (PWA) from a React SPA using service workers, caching strategies, and offline fallback.
7	To implement REST API endpoints (GET, POST, PUT, DELETE) with MongoDB for data storage.
8	To implement web security mechanisms by demonstrating Reflected XSS, Stored XSS, and CSRF vulnerabilities and applying appropriate mitigations.
9	To implement containerization of a Node.js application using Docker, a basic GitHub Actions CI pipeline, and container image deployment.
10	To implement deployment of a web application using Heroku or AWS EC2.
11	To implement an end-to-end web application by integrating a React frontend with an Express REST API to perform CRUD operations and display data.
12	To implement a TensorFlow.js-based machine learning application in the browser for prediction or classification.

Note: Lab course shall consist of minimum 10 experiments covering all the topics but not limited to the suggested list.

Suggested Learning Resources

Textbook

1. Learning Web Design, VI Ed., Jennifer Niederst Robbins, O'Reilly Media, 2025.
2. JavaScript: The Definitive Guide, VII Ed., David Flanagan, O'Reilly Media, 2020.
3. Learning React, II Ed., Alex Banks & Eve Porcello, O'Reilly Media, 2020.
4. Building the Web of Things: With Examples in Node.js and Raspberry Pi, I Ed., Dominique Guinard & Vlad Trifa, Manning Publications, 2016.

Reference Books

1. JavaScript: The Definitive Guide, VII Ed., David Flanagan, 2020.
2. Learning React, II Ed., Alex Banks & Eve Porcello, 2020.
3. Node.js Design Patterns, III Ed., Mario Casciaro & Luciano Mammino, 2020.
4. Docker Deep Dive, Nigel Poulton, 2023.

Web Resources

1. Resources for Developers by Developers
<https://developer.mozilla.org>
2. The library for web and native user interfaces
<https://react.dev>
3. Express Fast, Unopinionated, minimalist web framework for Node.js
<https://expressjs.com>
4. Welcome to the MongoDB Docs
<https://www.mongodb.com/docs/>
5. Explore the world of Cyber Security
<https://owasp.org>

3.9 Multi-Disciplinary Minor Course

3.9.1 Digital Image Processing (ET6MM_CX1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
ET6MM_CX1	Digital Image Processing	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

Sr. No.	Objectives
1	To <i>introduce</i> the fundamental concepts and mathematical models of digital image processing.
2	To <i>familiarize</i> students with various image transformation techniques and their applications.
3	To <i>develop</i> an understanding of image enhancement techniques using spatial and frequency domain filtering operations.
4	To <i>impart</i> knowledge of image morphology and image restoration techniques.
5	To <i>introduce</i> various image segmentation techniques for effective image analysis and interpretation.

Course Outcomes

The student will be able to	
CO1	<i>explain</i> the fundamental concepts and principles of digital image processing.
CO2	<i>analyze</i> and <i>apply</i> mathematical operations and image transformation techniques to represent images in different domains.
CO3	<i>apply</i> spatial and frequency domain techniques to enhance digital image quality.
CO4	<i>apply</i> image morphology and restoration techniques for image analysis and recovery.
CO5	<i>analyze</i> and <i>implement</i> image segmentation techniques based on discontinuity and similarity principles using appropriate algorithms.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites		
1.0	Digital Image Fundamentals and Point Processing		

	1.1	Introduction –Steps in Digital Image Processing, concept of spatial and intensity resolution, Image sampling and Quantization, Relationships between pixels, Distance Measure. Digital Image Formats, Color models: RGB, YUV, YCbCr.	06
	1.2	Point Processing : Image Negative, Log Transform, Power Law transform, Bit plane slicing, Contrast stretching , Histogram equalization and Histogram Specification (Only introduction).	
2.0	Image Transforms		06
	2.1	2D DFT, DCT, Wavelet Transform, Haar Transform.	
3.0	Image Enhancement		08
	3.1	Spatial Domain filtering: Smoothing Spatial Filters-Linear Filters-Averaging filter, Order-Statistic Filters- Median filter, Applications. Sharpening Spatial Filters- Derivative Operators: The Laplacian, Unsharp Masking.	
	3.2	Frequency Domain Filtering: Steps for Filtering in the Frequency Domain, Correspondence Between Filtering in the Spatial and Frequency Domains, Frequency domain Image Smoothing and sharpening filter - Ideal, Butterworth , Gaussian.	
4.0	Image Morphology and Restoration		07
	4.1	Morphology: Erosion and Dilation, Opening and Closing, The Hit-or-Miss Transformation, Boundary extraction, Hole filling, Thinning.	
	4.2	Restoration : A Model of the Image Degradation/Restoration Process, Removal periodic noise, Principle of Inverse filtering.	
5.0	Image Segmentation		08
	5.1	Point, Line, and Edge Detection: Detection of Isolated Points, Line detection, edge models (Sobel, Prewitt, Laplacian), Canny's edge detection algorithm , Edge linking : Local processing and boundary detection using regional processing (polygonal fitting).	
	5.2	Region Based segmentation: Thresholding, Role of illumination and reflectance, Basic Global thresholding, Region Growing, Region Splitting and merging.	
Total Hours			39

Suggested Learning Resources

Textbooks

1. Digital Image Processing, III Ed., Gonzales and Woods, Pearson Education, India.
2. Pattern Classification and Scene Analysis, R. O. Duda & P. E. Hart, Wiley-Interscience Publication.
3. Pattern Recognition and Machine Learning, I Ed., Christopher M. Bishop, Springer, 2006.

Reference Books

1. Fundamentals of Image Processing, I Ed., Anil K. Jain, Prentice Hall of India, 1989.
2. Digital Image Processing, III Ed., W. Pratt, Wiley Publication, 2002.
3. Image Processing and Pattern Recognition: Fundamentals and Techniques, Frank Y. Shih, Wiley-IEEE Press, 2010

Web Resources

1. <https://nptel.ac.in/courses/117105135>
2. <https://nptel.ac.in/courses/106105032>

3.9.2 Digital Image Processing Lab(ET6MM_LX1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
ET6MM_LX1	Digital Image Processing Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	-	-	-	25

Course Objectives

Sr. No.	Objectives
1	To <i>teach</i> implementing basic theoretical concepts in Image Processing relevant software.
2	To <i>give</i> an exposure to students to various image enhancement techniques.
3	To <i>facilitate</i> students for understanding frequency spectrum of digital images
4	To <i>give</i> an exposure to students to various morphological operations
5	To <i>give</i> an exposure to students to image segmentation techniques

Course Outcomes

The student will be able to	
LO1	<i>understand</i> the basic fundamentals pre-processing operation on an digital image.
LO2	<i>transform</i> an image one domain to another domain.
LO3	<i>perform</i> enhancement of digital images in spatial and frequency domain.
LO4	<i>perform</i> morphological operations on digital images
LO5	<i>perform</i> edge detection and segmentation operations on digital images.

Course Contents

Sr. No.	Suggested List of Experiments
1	Point Processing Methods – Negative, Log, Power law, Contrast stretching, Bit plane slicing.
2	Histogram calculation and equalization.
3	Image Transform 2D DFT.
4	Spatial Domain Filtering 1. Smoothing filters 2. Sharpening with Laplacian 3. Unsharp masking
5	Frequency Domain Filtering : Ideal, Butterworth and Gaussian.
6	Image segmentation using region growing technoque.
7	Image segmentation using derivative operator.

8	Morphological operation – Erosion, dilation, opening, closing, Boundary extraction.
9	Image segmentation using global Thresholding Algorithm.
10	Canny edge detection.

Suggested Learning Resources

Textbook

1. Digital Image Processing, III Ed., Gonzales & Woods, Pearson Education, India.
2. Pattern Classification and Scene Analysis, R. O. Duda & P. E. Hart, Wiley-Interscience Publication.
3. Pattern Recognition and Machine Learning, Christopher M. Bishop, Springer, 2006.

Reference Books

1. Fundamentals of Image Processing, I Ed., Anil K. Jain, Prentice Hall of India, 1989.
2. Digital Image Processing, III Ed., W. Pratt, Wiley Publication, 2002.
3. Image Processing and Pattern Recognition: Fundamentals and Techniques, Frank Y. Shih, Wiley-IEEE Press, 2010.

3.9.3 Advanced Microcontroller & Interfacing (ET6MM_CX2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
ET6MM_CX2	Advanced Microcontroller & Interfacing	3	3

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

Sr. No.	Objectives
1	To <i>study</i> basics of 32 bit Microcontroller.
2	To <i>programming</i> for ARM 32 bit advanced processor.
3	To <i>understand</i> architecture and features PIC18F Microcontroller .
4	To <i>learn</i> interfacing of real-world peripheral devices with microcontroller.
5	To <i>design</i> and develop microcontroller based embedded application.

Course Outcomes

The student will be able to	
CO1	<i>understand</i> the fundamentals of ARM 32 bit advanced microcontroller.
CO2	<i>learn</i> basics of ARM 32 programming.
CO3	<i>analyze</i> the features of PIC 18F.
CO4	<i>design</i> the peripheral support interfacing with PIC 18F microcontroller.
CO5	<i>develop</i> interfacing models for various applications .

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites		
	Digital System Design MPMC.		
1.0	PIC18F Microcontroller architecture and Instruction Set.		08
	1.1	Overview of PIC microcontroller family, features of PIC microcontroller,, PIC18F architecture with generalized block diagram, CPU architecture and Data memory organization, Register file structure, Bank selection using Bank Select Register, Pin out diagram, Reset operations, Watch Dog Timers,Power down modes.	

	1.2	Overview of instruction set. Instructions and Assembly Programs: Instruction Set, Instruction formats, Addressing modes, Assembler Directives, PIC18F assembly & C programming and development tools.(MPLAB X IDE).	
2.0	PIC 18F Peripherals.		08
	2.1	Brief Summary of peripheral support, I/O port configuration, Timers and its Programming (mode 0 & 1), Interrupt Structure, PORTB change Interrupts, use of timers with interrupts.	
	2.2	CCP modes: Capture, Compare and PWM generation, DC Motor speed control with CCP, Analog to digital Converter, ADC programming.	
3.0	Real World Interfacing with PIC 18F& applications		08
	3.1	Port structure programming. Interfacing LED display, LCD (16x2) Interfacing, Keyboard.	
	3.2	Sensor interfacing-temperature, IR, Ultrasonic sensors, Examples-Digital temperature meter.	
4.0	ARM7: A 32 bit Microcontroller		08
	4.1	The RISC and the CISC design philosophy. Concept of Cortex-A, the Cortex-R and the Cortex-M. Features of ARM Microcontroller.	
	4.2	ARM7 Dataflow diagram, Pipeline Architecture, Register structures Exceptions, Interrupt and Vector Table.	
5.0	ARM7 Programming with Embedded C		07
	5.1	Data Processing Instructions, Conditional and Branching Instructions, ARM-THUMB Interworking, Single-Register Load-Store Instructions	
	5.2	Stack Instructions, Software Interrupt Instructions, General Purpose Input Output Timer Mode.	
Total Hours			39

Suggested Learning Resources

Textbooks

1. Fundamentals of Microcontrollers and Applications in Embedded Systems (with the PIC 18 Microcontroller Family), Ramesh Gaonkar, Penram International Publications (Ind.) Pvt. Ltd.
2. PIC Microcontroller and Embedded Systems, Ali Mazidi, Rolind D. McKinlay & Danny Causey, Pearson Education Ltd., 2015.
3. Embedded Systems: An Integrated Approach, I Ed., Lyla Das, Pearson Publication.

Reference Books

1. Design with PIC Microcontroller, I Ed., John B. Peatman, Pearson Education PTE.

Web Resources

1. NPTEL Course:
<https://nptel.ac.in/courses/117/104/117104072/>
<https://nptel.ac.in/courses/108/105/108105102/>

3.9.4 Advanced Microcontroller & Interfacing Lab (ET6MM_LX2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
ET6MM_LX2	Advanced Microcontroller & Interfacing Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	-	-	-	25

Course Objectives

Sr. No.	Objectives
1	To <i>learn</i> fundamentals of Microprocessor and Microcontrollers programming.
2	To <i>write</i> Assembly Language Programming for PIC18F Microcontroller I/O Interfacing.
3	To <i>learn</i> ALP for Interrupts, Timers and counter applications.
4	To <i>interface</i> peripheral devices with PIC18F I/O microcontrollers.
5	To <i>design</i> an real time applications using PIC18F I/O programming conepts.

Course Outcomes

The student will be able to	
LO1	<i>explain</i> the architecture, memory organization, registers, I/O ports, and development environment of PIC18F and ARM7 microcontrollers.
LO2	<i>develop</i> and debug assembly language and embedded C programs for microcontroller-based applications using the PIC18F and ARM7 instruction sets and programming environments.
LO3	<i>interface</i> and program GPIO, timers, interrupts, and CCP/PWM modules for applications such as LED control, time-delay generation, square-wave generation, and DC motor speed control.
LO4	<i>interface</i> and acquire data from sensors and display devices, including temperature sensors, ultrasonic sensors, and 16×2 LCDs, for measurement and monitoring applications.
LO5	<i>design</i> , implement, test, and troubleshoot microcontroller-based embedded systems by integrating hardware peripherals and software to develop real-time control and measurement applications.

Course Contents

Sr. No.	Suggested List of Experiments
1	Study of PIC18F Microcontroller Architecture and MPLAB X IDE Environment.
2	LED Blinking using PIC18F I/O Ports.
3	Assembly Language Programming using PIC18F Instruction Set.
4	Timer0 Programming for Time Delay Generation.

5	Square Wave Generation using Timer and Interrupts.
6	Rel PWM Signal Generation using CCP Module.
7	DC Motor Speed Control using PWM.
8	Temperature Sensor Interfacing and Digital Temperature Meter.
9	16×2 LCD Interfacing with PIC18F.
10	Ultrasonic Sensor Interfacing for Distance Measurement.
11	Study of ARM7 Architecture and Register Organization.
12	GPIO Programming for LED and Switch Interfacing.
13	Timer Programming using ARM7.

Note: course shall consist of minimum 10 experiments covering all the topics but not limited to the suggested list.

Suggested Learning Resources

Textbook

1. Fundamentals of Microcontrollers and Applications in Embedded Systems (with the PIC 18 Microcontroller Family), Ramesh Gaonkar, Penram International Publications (Ind.) Pvt. Ltd.
2. PIC Microcontroller and Embedded Systems, Ali Mazidi, Rolind D. McKinlay & Danny Causey, Pearson Education Ltd., 2015.
3. Embedded Systems: An Integrated Approach, I Ed., Lyla Das, Pearson Publication.

Reference Books

1. Design with PIC Microcontroller, I Ed., John B. Peatman, Pearson Education PTE.

Web Resources

1. NPTEL Course:
<https://nptel.ac.in/courses/117/104/117104072/>
<https://nptel.ac.in/courses/108/105/108105102>

3.9.5 Energy Systems and Charging Infrastructure (EE6MM_CX1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
EE6MM_CX1	Energy Systems and charging infrastructure	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

Sr. No.	Objectives
1	To <i>understand</i> the fundamental characteristics, performance parameters, and energy-storage technologies used in electric vehicles.
2	To <i>understand</i> the construction, operation, and management of EV batteries, including Battery Management Systems (BMS), battery pack design, cell balancing, thermal management, and battery safety.
3	To <i>understand</i> different EV charging systems, charging levels, charging technologies, and the operation of AC, DC, wireless, and battery-swapping systems.
4	To <i>familiarize</i> students with EV charging standards, communication protocols, smart charging, V2G, V2H, and IoT-based charging infrastructure.
5	To <i>develop</i> awareness of electrical safety, thermal safety, fire protection, regulatory requirements, certification standards, and government policies related to EV charging infrastructure.

Course Outcomes

The student will be able to	
CO1	<i>explain</i> the characteristics of energy-storage systems and evaluate their suitability for electric vehicle applications.
CO2	<i>explain</i> EV battery technologies, battery pack configurations, BMS functions, cell balancing, thermal management, and battery safety mechanisms.
CO3	<i>describe</i> and <i>compare</i> different EV charging levels, charging systems, charging technologies, and charging infrastructure.
CO4	<i>explain</i> major EV charging standards and communication protocols, including CCS, CHAdeMO, GB/T, OCPP, V2G, V2H, and smart charging.
CO5	<i>identify</i> and <i>apply</i> appropriate safety practices, regulatory requirements, certification standards, and relevant policies for EV charging infrastructure.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites		
1.0	Introduction to Energy Storage for EVs		
	1.1	Performance characteristics: Energy density, power density, efficiency, cycle life, and thermal stability.	08
	1.2	Hybridization of Energy sources. Battery pack design considerations: Series and parallel configurations, interconnections, and thermal management of Battery.	
2.0	Batteries for Electric Vehicles		08
	2.1	Importance and functions of BMS in EVs BMS hardware: Microcontrollers, sensors, power electronics, and communication modules. Types of BMS.	
	2.2	Battery-cell/pack design, battery modelling, BMS, SOC/SOH/SOP, cell balancing, thermal management, safety/thermal runaway, degradation, advanced BMS, second life/recycling. Fire hazards and emergency shutdown mechanisms in battery packs.	
3.0	Introduction to EV Charging Systems and Charging Technologies		08
	3.1	Importance of EV Charging Infrastructure -Overview of Charging Levels (Level 1, Level 2, DC Fast Charging), AC vs. DC Charging On-board vs. Off-board Chargers.	
	3.2	Charging Power Levels and Efficiency Wireless (Inductive) and Battery Swapping Technologies.	
4.0	Charging Standards and Communication Protocols		08
	4.1	Global Charging Standards (CCS, CHAdeMO, GB/T, Tesla Superchargers) Open Charge Point Protocol (OCPP).	
	4.2	Vehicle-to-Grid (V2G) and Vehicle-to-Home (V2H) Communication Smart Charging and IoT Integration	
5.0	Emerging Technologies		07
	5.1	Electrical Safety in Charging Stations Thermal Management and Fire Safety Government Policies and Incentives for EV Charging.	
	5.2	International and National Regulatory Frameworks	
Total Hours			39

Suggested Learning Resources

Textbooks

1. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, II Ed., Mehrdad Ehsani, Yimin Gao, Stefano Longo & Kambiz Ebrahimi, CRC Press, 2018.
2. Electric Vehicle Technology Explained, John Lowry & James Larminie, John Wiley & Sons, 2012.
3. Electric and Hybrid Vehicles: Design Fundamentals, I Ed., Iqbal Hussein, CRC Press, 2003.

Reference Books

1. Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, II Ed., Chris Mi & M. Abul Masrur, John Wiley & Sons, Inc., 2018.
2. Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Sheldon S. Williamson, Springer, 2013.

Web Resources

1. Introduction to Hybrid and Electric vehicles by Dr. Praveen Kumar and Prof. S. Majhi (IIT Guwahati), NPTEL Course.
<https://nptel.ac.in/courses/108/103/108103009/>.
2. Charging Infrastructure by Dr. Apurv Kumar Yadav (IIT Roorkee),
https://onlinecourses.nptel.ac.in/noc25_ee134/preview.

3.9.6 Energy Systems and Charging Infrastructure Lab (EE6MM_LX1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
EE6MM_LX1	Energy Systems and Charging Infrastructure Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	-	-	-	25

Course Objectives

Sr. No.	Objectives
1	To <i>develop</i> practical understanding of EV battery technologies, battery characteristics, battery-pack configurations, and energy-storage systems using simulation tools.
2	To <i>develop</i> skills in modelling and analysis of EV batteries and BMS, including SOC, SOH, SOP estimation, cell balancing, battery protection, and thermal management.
3	To <i>analyze</i> different EV charging systems and technologies, including AC charging, DC fast charging, wireless charging, and bidirectional charging.
4	To <i>familiarize</i> students with smart charging, V2G/V2H, charging communication, and IoT-based EV charging concepts using MATLAB/Simulink and open-source software.
5	To <i>develop</i> simulation, programming, data-analysis, and problem-solving skills for evaluating the performance, safety, efficiency, and reliability of EV battery and charging systems.

Course Outcomes

The student will be able to	
LO1	<i>model and analyze</i> EV batteries, battery packs, and their charging/discharging characteristics using suitable simulation tools.
LO2	<i>implement and evaluate</i> BMS functions including SOC/SOH/SOP estimation, cell balancing, battery protection, and thermal management.
LO3	<i>simulate and analyze</i> different EV charging systems and evaluate their charging performance and efficiency.
LO4	<i>implement and analyze</i> smart charging, V2G/V2H, and communication-based EV charging concepts using MATLAB/Python and other open-source tools.
LO5	<i>analyze and interpret</i> battery and EV charging system performance, safety, degradation, and power-quality characteristics using simulation and data-analysis techniques.

Course Contents

Sr. No.	Suggested List of Experiments
Part A: Lab Experiments	
1	Study and simulation of EV battery charging and discharging characteristics.
2	Comparison of Li-ion battery chemistries based on energy density, power density and performance
3	Design and simulation of an EV battery pack using series and parallel cell configurations
4	Development of an equivalent-circuit model of an EV battery
5	Experimental Study of Li-ion Battery Charging and Discharging Characteristics
6	Simulation of Battery Management System for monitoring and protection of an EV battery pack
7	Study and Simulation of AC Level-1/Level 2 EV charging system
8	Study and simulation of EV charging communication and smart charging using Python
9	Study of Effect of C-Rate on EV Battery Charging and Discharging Performance
10	Analysis of EV Charging Load Profile for Multiple EVs
Part B: Course Project	
1	Thermal Management and Safety Analysis of an EV Battery Pack.

Note: Journal submission shall include minimum 06 Lab Experiments and 01 course project.

Suggested Learning Resources

Textbook

1. Advanced Battery Management Technologies for Electric Vehicles, I Ed., Rui Xiong & Weixiang Shen, Wiley, 2019.
2. Electric Vehicle Machines and Drives: Design, Analysis and Application, I Ed., K. T. Chau, Wiley-IEEE Press, 2015.
3. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design, III Ed., Mehrdad Ehsani, Yimin Gao, Stefano Longo & Kambiz Ebrahimi, CRC Press, 2018.
4. Electric and Hybrid Vehicles: Design Fundamentals, II Ed., Iqbal Husain, CRC Press, 2011.

Reference Books

1. Advanced Battery Management System for Electric Vehicles, I Ed., Shichun Yang, Xinhua Liu, Shen Li & Cheng Zhang, Springer, 2023.
2. Electric Vehicle Charging Infrastructures and Its Challenges, I Ed., Ashutosh K. Giri & Madhusudan Singh, Springer, 2025.
3. Electric Vehicle Powertrains: Design Fundamentals, Components, and Applications, I Ed., B. Ashok & V. Indra Gandhi, Elsevier, 2026.
4. Handbook of Electric Vehicle Charging Infrastructure Implementation, NITI Aayog, Government of India.
5. Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, I Ed., Sheldon S. Williamson, Springer, 2013.

Web Resources

1. NPTEL course, Charging Infrastructure, Prof. Apurv Kumar Yadav, IIT Roorkee, nptel.ac.in/courses/108107715.
2. NPTEL course, Electric Vehicle: Its Components, Charging Infrastructure and Grid Integration Solution, Prof. Siba Kumar Patro, Prof. Narayana Prasad Padhy & Prof. Ramkrishna Pasumathy, IIT Roorkee, nptel.ac.in/courses/108107002.

3.9.7 IoT System Design, Development, and Security (EC6MM_CX1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
EC6MM_CX1	IoT System Design, Development, and Security	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

Sr. No.	Objectives
1	To <i>understand</i> the principles of IoT system design, requirement analysis, and engineering methodologies for developing scalable IoT solutions.
2	To <i>develop</i> IoT applications by integrating embedded devices, communication protocols, cloud platforms, and data management techniques.
3	To <i>analyze</i> IoT communication technologies and networking protocols to select appropriate solutions for diverse IoT applications.
4	To <i>apply</i> security, privacy, and risk management techniques to design secure and reliable IoT systems.
5	To <i>evaluate</i> IoT systems through testing, deployment, maintenance, and emerging technologies for real-world industrial and societal applications.

Course Outcomes

The student will be able to	
CO1	<i>analyze</i> user requirements and apply IoT system design methodologies to develop scalable and efficient IoT solutions.
CO2	<i>design</i> and implement IoT applications by integrating communication protocols, cloud platforms, and data management techniques.
CO3	<i>select</i> and evaluate appropriate networking technologies, communication protocols, and edge/cloud computing solutions for various IoT applications.
CO4	<i>apply</i> cybersecurity principles, authentication mechanisms, encryption techniques, and privacy-preserving practices to secure IoT devices and networks.
CO5	<i>test</i> , deploy, and evaluate IoT systems for real-world applications while incorporating emerging technologies such as AIoT, Edge AI, Digital Twins, and Industry 4.0.

Course Contents

Module	Unit	Detailed Contents	Hours
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	Prerequisites		
	Basic Networking Concepts, Data Communication Fundamentals, Elementary C Programming.		
1.0	IoT System Design and Engineering		08
	1.1	IoT Design Methodology- Requirement analysis and problem identification, Purpose and requirement specification, Process specification, Domain model specification, Information model specification, Service specification, Functional view and operational view, Device and component integration, IoT design workflow with case studies.	
	1.2	IoT System Modeling and Architecture Design- Functional decomposition of IoT systems, Use case modeling and UML diagrams for IoT, Sequence, activity, and deployment diagrams, IoT data flow modeling, Selection of hardware, communication, and cloud services, Scalability, reliability, and maintainability considerations, Design constraints: power, latency, bandwidth, cost, and security, Design documentation and architecture evaluation.	
	1.3	IoT Project Planning and System Integration- Project planning and feasibility analysis, Selection of sensors, actuators, communication technologies, and cloud platforms, Bill of Materials (BOM) preparation, System integration strategies, Prototype validation, Performance evaluation and optimization, Documentation and technical reporting.	
2.0	IoT Communication and Networking		08
	2.1	IoT Communication Protocols- MQTT architecture and Quality of Service (QoS), CoAP protocol, HTTP/HTTPS for IoT, WebSocket communication, AMQP basics, Protocol selection based on application requirements.	
	2.2	Wireless Communication Technologies- Wi-Fi, Bluetooth Low Energy (BLE), ZigBee, Thread LoRaWAN, NB-IoT, LTE-M, 5G-enabled IoT, Performance comparison of wireless technologies.	
	2.3	IoT Gateway and Edge Computing- IoT gateways and their functions, Data aggregation and protocol translation, Edge computing concepts, Edge analytics, Fog computing overview.	
3.0	IoT Application Development and Cloud Integration		08
	3.1	Embedded Software Development- Firmware development lifecycle, Embedded C/C++, programming for ESP32, Event-driven programming , Interrupts and timers, Introduction to FreeRTOS, Task scheduling and multitasking.	
	3.2	Cloud Integration- ThingSpeak platform, Blynk IoT platform, AWS IoT Core overview, Azure IoT Hub overview, Device registration and cloud connectivity, Data publishing and subscription.	
	3.3	Data Management and Dashboard Development- REST APIs, JSON data format, Sensor data storage, SQL and NoSQL databases, Dashboard creation, Data visualization and reporting.	

4.0	IoT Security and Privacy		08
	4.1	Security Fundamentals- IoT security requirements, Threat modeling, Attack surface analysis, Common attacks: DoS and DDoS, Replay attack, Man-in-the-Middle attack, Spoofing, Malware and Botnets	
	4.2	Secure IoT Communication- Authentication and authorization, SSL/TLS, Secure MQTT, Cryptography fundamentals, Symmetric and asymmetric encryption, Digital certificates, Secure firmware updates, Secure boot.	
	4.3	Privacy and Security Standards- Data privacy in IoT, Identity and access management, Risk assessment, Vulnerability assessment, OWASP IoT Top 10, NIST IoT Cybersecurity Framework, Best practices for secure IoT deployment.	
5.0	IoT Deployment, Testing, and Emerging Technologies		07
	5.1	IoT Testing and Deployment- Functional testing, Integration testing, Performance testing, Device provisioning, Deployment strategies, Remote monitoring and diagnostics, Scalability and maintenance.	
	5.2	Industrial IoT Case Studies- Smart Manufacturing, Smart Agriculture, Smart Healthcare, Smart Cities, Energy Management, Predictive Maintenance.	
	5.2	Emerging Trends in IoT- Artificial Intelligence of Things (AIoT), TinyML, Edge AI, Digital Twins, Blockchain for IoT, Green IoT, Future directions in IoT.	
Total Hours			39

Suggested Learning Resources

Textbooks

1. Internet of Things: A Hands-On Approach, II Ed., Arshdeep Bahga, Vijay Madiseti, Universities Press, 2015.
2. Designing the Internet of Things, I Ed., Adrian McEwen, Hakim Cassimally, Wiley, 2013.
3. Building the Internet of Things with Arduino and Raspberry Pi, Charalampos Doukas, I Ed., CreateSpace Independent Publishing Platform, 2012.
4. Internet of Things: Principles and Paradigms, I Ed., Rajkumar Buyya, Amir Vahid Dastjerdi, Morgan Kauffman, 2016.
5. Fundamentals of Internet of Things: Design, Ideas, and Applications, Sudip Misra, Anandarup Mukherjee, and Arijit Roy, Springer, 2019

Reference Books

1. Internet of Things – Architecture and Design Principles, I Ed., Kamal, R., Mcgraw Hill, 2017.
2. The Internet of Things: Enabling Technologies, Platforms, and Use Cases, Pethuru Raj and Anupama C. Raman, CRC Press, 2017.
3. Architecting the Internet of Things, Dieter Uckelmann, Mark Harrison, and Florian Michahelles, Springer, 2011.
4. Practical Internet of Things Security, Brian Russell and Drew Van Duren, 2nd Edition, Packt Publishing, 2018.
5. Designing Connected Products: UX for the Consumer Internet of Things, Claire Rowland, Elizabeth Goodman, Martin Charlier, Ann Light, and Alfred Lui, O'Reilly Media, 2015.

6. Building Smart Home Automation Solutions with Home Assistant, Marco Carvalho, Packt Publishing, 2023.

Web Resources

1. NPTEL course on Introduction to IoT by Prof. Sudip Misra, IIT Kharagpur
<https://archive.nptel.ac.in/courses/106/105/106105166/>
2. Cisco Networking Academy – Introduction to IoT
<https://www.netacad.com/courses/iot>
3. AWS IoT Core Documentation
<https://docs.aws.amazon.com/iot/>
4. ESP32 Programming Guide (Espressif Systems)
<https://docs.espressif.com/projects/esp-idf/>

3.9.8 IoT Prototyping and Cloud Integration Lab (EC6MM_LX1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
EC6MM_LX1	IoT Prototyping and Cloud Integration Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	-	-	-	25

Course Objectives

Sr. No.	Objectives
1	To <i>familiarize</i> students with IoT cloud platforms, development tools, and cloud-based IoT application environments.
2	To <i>develop</i> skills for collecting, storing, processing, and visualizing IoT data using cloud platforms and databases.
3	To <i>enable</i> students to apply data analytics techniques for extracting meaningful information from IoT sensor data.
4	To <i>provide</i> hands-on experience in designing secure IoT applications using authentication, access control, encryption, and secure communication mechanisms.
5	To <i>develop</i> integrated IoT solutions involving cloud connectivity, real-time dashboards, data analytics, and security mechanisms.

Course Outcomes

The student will be able to	
LO1	<i>use</i> IoT cloud platforms, development tools, and communication interfaces for cloud-enabled IoT applications.
LO2	<i>acquire</i> , store, process, and visualize IoT sensor data using cloud services and databases.
LO3	<i>apply</i> suitable data analytics techniques to IoT datasets and interpret analytical results.
LO4	<i>implement</i> security mechanisms such as authentication, authorization, encryption, and secure communication in IoT applications.
LO5	<i>design</i> and implement secure cloud-connected IoT solutions with remote monitoring, dashboards, and data analytics.

Course Contents

Sr. No.	Suggested List of Experiments
1	Introduction to IoT cloud platforms, cloud service models, IoT data flow, and cloud-based IoT architecture.
2	Interfacing an ESP32 with a sensor and transmitting sensor data to a cloud platform

	using Wi-Fi.
3	Implementation of real-time temperature and humidity monitoring with cloud data logging and visualization.
4	Implementation of an IoT cloud dashboard for monitoring sensor parameters and generating real-time charts.
5	Acquisition and storage of IoT sensor data in a cloud database and execution of basic data queries.
6	Data preprocessing and exploratory analysis of IoT sensor data using suitable analytical tools.
7	Implementation of statistical analysis and visualization of IoT time-series data.
8	Implementation of threshold-based anomaly detection for IoT sensor data.
9	Implementation of a cloud-based IoT alert system using sensor data and event/threshold rules.
10	Implementation of secure device authentication and access control for an IoT cloud application.
11	Implementation of secure data communication between an IoT device and cloud platform using appropriate security mechanisms.
12	Study and implementation of MQTT-based secure IoT communication with authentication and access control.
13	Analysis of IoT security threats and implementation of basic security measures for a cloud-connected IoT system.
14	Design and implementation of a secure IoT monitoring system integrating cloud connectivity, data analytics, and remote alerts.
15	Implementation of an integrated IoT cloud dashboard for real-time monitoring, historical data analysis, and security status visualization.

Note:

1. Lab course shall consist of minimum 10 experiments covering all the topics but not limited to the suggested list.
2. Various types of sensors, actuators, microcontrollers, cloud platforms, databases, data analytics tools, and wired and wireless communication technologies must be used.

Suggested Learning Resources

Textbook

1. Internet of Things: A Hands-On Approach, II Ed., Arshdeep Bahga, Vijay Madisetti, Universities Press, 2015.
2. Internet of Things: Principles and Paradigms, I Ed., Rajkumar Buyya, Amir Vahid Dastjerdi, Morgan Kaufman, 2016.
3. Designing the Internet of Things, I Ed., Adrian McEwen, Hakim Cassimally, Wiley, 2013.
4. Practical Internet of Things Security, II Ed., Brian Russell, Drew Van Duren, Packt Publishing, 2018.
5. Internet of Things – Architecture and Design Principles, I Ed., Kamal, R., Mcgraw Hill, 2017.

Reference Books

1. The Internet of Things: A Guide to the Connected World, II Ed., Samuel Greengard, The MIT Press, 2021.

2. IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, I Ed., David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton, Jerome Henry, Cisco Press, 2017.

Web Resources

1. NPTEL course on Introduction to IoT by Prof. Sudip Misra, IIT Kharagpur.
<https://archive.nptel.ac.in/courses/106/105/106105166/>
2. Arduino Documentation
<https://docs.arduino.cc/?utm>
3. ESP-IDF Programming Guide
[https://docs.espressif.com/projects/esp-idf/en/latest/esp32/?utm _](https://docs.espressif.com/projects/esp-idf/en/latest/esp32/?utm_)
4. Raspberry Pi Documentation
<https://www.raspberrypi.com/documentation/?utm>
5. Get Started with ThingSpeak
<https://www.mathworks.com/help/thingspeak/getting-started-with-thingspeak.html>
6. MQTT Official Website– MQTT protocol specifications and tutorials
<https://mqtt.org>
7. AWS IoT Documentation– Cloud IoT integration and security
<https://docs.aws.amazon.com/iot>
8. Google Cloud IoT Documentation– IoT device management and data visualization
<https://cloud.google.com/iot>
9. ThingsBoard / ThingSpeak Platforms– IoT data visualization and dashboards
<https://thingsboard.io>
<https://thingspeak.com>

3.9.9 Additive Manufacturing for Industrial Applications (ME6MM_CX1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
ME6MM_CX1	Additive Manufacturing for Industrial Applications	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

Sr. No.	Objectives
1	To <i>introduce</i> modern approaches to product innovation, rapid prototyping, and on-demand manufacturing.
2	To <i>understand</i> material requirements and classifications used in various additive manufacturing processes.
3	To <i>study</i> rapid tooling methods, including direct and indirect tooling for product development.
4	To <i>explore</i> applications of additive manufacturing in aerospace, including materials, evaluation, and space technologies.
5	To <i>develop</i> skills in Design for Additive Manufacturing (DFAM) using topology optimization and generative design techniques.

Course Outcomes

The student will be able to	
CO1	<i>explain</i> modern product innovation methods and the role of rapid prototyping in design cycles.
CO2	<i>identify and compare</i> different AM feedstock materials and their suitability for specific processes.
CO3	<i>differentiate and apply</i> rapid tooling strategies for manufacturing applications.
CO4	<i>evaluate</i> the use of AM in aerospace, including materials, NDE, and space-related components.
CO5	<i>apply</i> DFAM concepts, including topology optimization and generative design, for engineering product development.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites		
	Additive Manufacturing, CAD for Additive Manufacturing.		

1.0	Modern Approaches to Product Innovation and Manufacturing		08
	1.1	Innovation and Product Development, Rapid Prototyping and Iterative Design, Mass Customization and On-Demand Manufacturing.	
2.0	Materials for Additive Manufacturing		08
	2.1	Overview of AM Material Requirements, Solid-State Feedstock Materials, Liquid-State Feedstock Materials, Powder-Based Feedstock Materials.	
3.0	Rapid Tooling		08
	3.1	Direct Rapid Tooling, Indirect Rapid Tooling, Hard Tooling vs Soft Tooling.	
4.0	Applications in Aerospace Industries		08
	4.1	Use of AM in Aerospace, Metal AM in Aerospace, Super alloys, Non-Destructive Evaluation, Space technology.	
5.0	Design for Additive Manufacturing (DFAM)		07
	5.1	Topology optimization for AM, Generative Design Applications in Engineering, Analysis and Planning.	
Total Hours			39

Suggested Learning Resources

Textbooks

1. Additive Manufacturing, I Ed., Dr. R. B. Chaudary, Khanna Publishers, 2022.
2. Rapid Prototyping: Principles and Applications, II Ed., Chua Chee Kai & Kah Fai Leong, Tata McGraw-Hill, 2018.
3. 3D Printing and Additive Manufacturing Technologies, I Ed., K. Thrimurthulu, K. Srinivasa Rao & S. Sudhakara Rao, Springer, 2018.

Reference Books

1. Additive Manufacturing: Principles, Technologies and Applications, I Ed., C. P. Paul & A. N. Jinoop, McGraw-Hill India, 2021.
2. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Ian Gibson, David W. Rosen & Brent Stucker, Springer, 2020.

Web Resources

1. NPTEL Course, Navigating the Latest Trends in Additive Manufacturing Landscape, Prof. Alankar Prof. Akshatha Hulmani Dayananda, IIT Bombay, <https://nptel.ac.in/courses/112101623>
2. NPTEL Course, Advances in Additive Manufacturing of Materials: Current status and emerging opportunities, Prof. Bikramjit Basu, IISc Bangalore, <https://nptel.ac.in/courses/113108632>

3.9.10 Additive Manufacturing Lab (ME6MM_LX1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
ME6MM_LX1	Additive Manufacturing Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	-	-	-	25

Course Objectives

Sr. No.	Objectives
1	To <i>introduce</i> students to CAD modeling techniques suitable for rapid prototyping applications.
2	To <i>familiarize</i> students with preprocessing and slicing software used in FDM and SLA 3D printing technologies.
3	To <i>enable</i> students to design and manufacture components using different RP processes and materials.
4	To <i>study</i> the process constraints and limitations of various RP systems, including accuracy, supports, and post-processing.
5	To <i>expose</i> students to industrial practices and real-world applications of rapid prototyping through industry visits.

Course Outcomes

The student will be able to	
LO1	<i>prepare</i> accurate CAD models suitable for 3D printing using solid and free-form surface modeling techniques.
LO2	<i>perform</i> preprocessing operations such as slicing, orientation, support generation, and parameter selection using software like FlashForge, Chitubox, and Ultimaker Cura.
LO3	<i>fabricate</i> functional prototypes using FDM and SLA rapid prototyping processes.
LO4	<i>analyze</i> and <i>compare</i> constraints of different RP systems in terms of layer thickness, build orientation, supports, surface finish, and post-processing requirements.
LO5	<i>correlate</i> industrial rapid prototyping practices with academic knowledge gained through hands-on experiments and industrial visits.

Course Contents

Sr. No.	Suggested List of Experiments
1	Preparation of CAD model of an object and preprocessing on Flash Forge software for FDM 3D printing.
2	Preparation of CAD model of an object and preprocessing on Chitubox software for SLA 3D printing.

3	Preparation of CAD model of an object and preprocessing on Ultimaker - Cura software for FDM 3D printing.
4	Design an object with free-form surface & print it using any RP process.
5	Check the constraints of any two RP systems for features like layer thickness, orientation of geometry, support generation, post-processing etc.
6	Industrial Visit to Rapid Prototype Industry.

Suggested Learning Resources

Textbook

1. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, II Ed., Ian Gibson, David W. Rosen & Brent Stucker, Springer, 2014.
2. Rapid Prototyping: Principles and Applications, III Ed., C. K. Chua, K. F. Leong & C. S. Lim, World Scientific, 2010.

Reference Books

1. Additive Manufacturing, II Ed., Jing Zhang & Yeon-Gil Jung, Elsevier Inc., 2018.
2. 3D Printing: A Revolutionary Process for Industry Applications, I Ed., Richard Sheng, Academic Press (Elsevier), 2022.

Web Resources

1. Coursera Course, Rapid Prototyping Using 3D Printing Specialization, Keng Hsu, [Rapid Prototyping Using 3D Printing Specialization \[3 courses\] \(ASU\) | Coursera](#)
2. CHITUBOX SLA/DLP/LCD 3D Slicer Software, <https://www.chitubox.com>

3.9.11 Robot Perception and Control (ME6MM_CX2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
ME6MM_CX2	Robot Perception and Control	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2.5	100

Course Objectives

Sr. No.	Objectives
1	To <i>introduce</i> robot sensing principles, sensor characteristics, and camera geometry for robotic perception.
2	To <i>acquaint</i> with image processing, feature extraction, and learning-assisted vision methods for robotic perception.
3	To <i>develop</i> understanding of feedback control principles and motion control strategies for robotic systems.
4	To <i>introduce</i> probabilistic state estimation and perception-driven robot control methods.
5	To <i>illustrate</i> advanced autonomous robotics concepts involving SLAM, learning-based robotics, and decision-making under uncertainty.

Course Outcomes

The student will be able to	
CO1	<i>explain</i> sensing principles, sensor uncertainties, and robot vision geometry for robotic systems.
CO2	<i>apply</i> image processing and feature recognition techniques for robotic vision tasks.
CO3	<i>analyse</i> control concepts for regulating robotic motion and actuation.
CO4	<i>interpret</i> robot state uncertainty and <i>implement</i> basic sensor fusion and vision-guided control concepts.
CO5	<i>evaluate</i> advanced methods for autonomous robotic perception, learning, and decision-making.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites		
	Pose representation; Laplace transforms; Normal distribution.		
1.0	Robot Sensing		08

	1.1	Foundations of sensing: Need for perception; Measurement model; Types of sensors; Uncertainty in sensor measurements; Sensor bias, drift and noise; Sampling frequency and aliasing; Sensor misalignment and time synchronization issues; Sensor calibration process.	
	1.2	Sensors: Proprioceptive and exteroceptive sensing: Encoders; Inertial sensing; Force, torque and strain sensing; Proximity and range sensors; Tactile and haptic sensors; Vision sensors.	
	1.3	Vision sensor: Pinhole camera model; Intrinsic and extrinsic parameters; Image distortion; Camera matrix; Camera-to-robot transforms; Homography for planar transforms; Omnidirectional and depth camera concepts.	
2.0	Robot Vision		08
	2.1	Image processing: Digital image representation; Colour space; Normalizing; Thresholding; Image noise; Morphological operations.	
	2.2	Image understanding: Filter concept and operations; Corner point detection; Edge detection; Frequency domain concepts and filtering.	
	2.3	Feature extraction and recognition: Image segmentation; Image features; Neural network essentials; Use of pretrained CNN models for object identification and classification.	
3.0	Robot Control		08
	3.1	Control system fundamentals: Need for control; Parts of a control system; Block diagram; Basics of Laplace transform; Open-loop and closed-loop transfer functions; Block diagram algebra; Overview of state-space representation.	
	3.2	Control system analysis: First-order and second-order system response; Transient and steady-state behaviour; Concept of stability; Basics of PID, digital and non-linear control.	
	3.3	Mechatronic system control: DC motor dynamics and torque-speed curves; Heading and trajectory tracking control.	
4.0	Integration of Perception and Control		08
	4.1	State estimation: Concept of state and state estimation; State estimation by dead reckoning; Robot belief and uncertainty; State uncertainty ellipses and covariance.	
	4.2	Multisensor fusion: Improving robot belief through sensor fusion; Kalman filter (KF); 1-D KF for position tracking; Basics of Extended and Unscented Kalman filters (EKF, UKF); State estimation through wheel encoder and IMU fusion.	
	4.3	Vision-based estimation and control: Visual servoing basics; Image-based and pose-based visual servoing; Simple point tracking; Introduction to visual odometry; Feature tracking for motion estimation.	
5.0	Advanced Robot Autonomy		07
	5.1	Simultaneous localisation and mapping (SLAM): SLAM motivation; Loop closure in autonomous navigation; Overview of graph SLAM, LiDAR SLAM and visual SLAM methods; Mapping and localization trade-offs.	
	5.2	Learning-assisted perception and control: Limitations of	

		model-based robotics; Data-driven perception and control; Learning-based navigation and object recognition; Sim-to-real transfer; Overview of embodied AI and physical AI; Safety and explainability issues in AI robotics.	
	5.3	Decision Making Under Uncertainty: Uncertainty in sensing and perception; Basics of Markov Decision Process (MDP); Risk-aware planning; Active perception; Decentralized decision making in swarm robotics.	
	Total Hours		39

Suggested Learning Resources

Textbooks

1. Robotics, Vision and Control: Fundamental Algorithms in Python, III Ed., Peter Corke, Springer, 2023.
2. Modern Robotics: Mechanics, Planning, and Control, I Ed., Kevin M. Lynch & Frank C. Park, Cambridge University Press, 2017.
3. Robotics Modelling, Planning and Control, I Ed., Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani & Giuseppe Oriolo, Springer, 2009.
4. Introduction to Autonomous Robots: Mechanisms, Sensors, Actuators, and Algorithms, Nikolaus Correll, Bradley Hayes, Christoffer Heckman & Alessandro Roncone, The MIT Press, 2022.

Reference Books

1. Embedded Robotics: From Mobile Robots to Autonomous Vehicles with Raspberry Pi and Arduino, IV Ed., Thomas Bräunl, Springer, 2022.
2. Introduction to Autonomous Mobile Robots, II Ed., Ronald Siegwart, Illah Reza Nourbakhsh & Davide Scaramuzza, The MIT Press, 2011.
3. Theory of Applied Robotics: Kinematics, Dynamics, and Control, II Ed., Reza N. Jazar, Springer, 2010.
4. Introduction to Robotics: Analysis, Control, Applications, II Ed., Saeed B. Niku, Wiley, 2010.
5. Probabilistic Robotics, Sebastian Thrun, Wolfram Burgard & Dieter Fox, The MIT Press, 2006.

Web Resources

1. NPTEL course, Wheeled Mobile Robots, Prof. Asokan Thondiyath & Prof. Santhakumar, Mohan IITM & IIT Palakkad.
nptel.ac.in/courses/112106298.
2. NPTEL course, Drone Systems and Control, Prof. Suresh Sundaram, IISc Bangalore.
nptel.ac.in/courses/101108661.
3. NPTEL course, Robotics: Basics and Selected Advanced Concepts, Prof. Ashitava Ghosal, IISc Bangalore.
nptel.ac.in/courses/112108298.
4. NPTEL course, Introduction To Robotics, Prof. Asokan T, Prof. Balaraman Ravindran & Prof. Krishna Vasudevan, IIT Madras.
nptel.ac.in/courses/107106090.

3.9.12 Robot Perception and Control Lab (ME6MM_LX2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
ME6MM_LX2	Robot Perception and Control Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	-	-	-	25

Course Objectives

Sr. No.	Objectives
1	To <i>enable</i> acquisition and interpretation robot sensing and perception data.
2	To <i>develop</i> practical understanding of robot vision and feature-based perception methods.
3	To <i>train</i> students in implementation of feedback-based robot motion control and localization.
4	To <i>introduce</i> probabilistic state estimation and multisensor fusion techniques.
5	To <i>acquaint</i> with integrated autonomous navigation workflows using perception and control.

Course Outcomes

The student will be able to	
LO1	<i>acquire</i> and <i>analyse</i> robot sensing data using perception tools and algorithms.
LO2	<i>apply</i> image processing and feature extraction methods for robot perception tasks.
LO3	<i>implement</i> feedback control and odometry methods for robotic motion regulation.
LO4	<i>evaluate</i> robot state using sensor fusion and filtering techniques.
LO5	<i>develop</i> autonomous robot navigation workflows using perception-driven control strategies.

Course Contents

Sr. No.	Suggested List of Experiments
	Part A: Lab Experiments
1	Study of IMU data acquisition and sensor characteristics.
2	Camera image acquisition and image processing for robot perception.
3	Object detection using pre-trained learning models.
4	Camera calibration and pose estimation using fiducial markers.
5	Closed-loop motor speed control.

6	Trajectory tracking of mobile robot.
7	Wheel encoder based odometry.
8	Multisensor fusion for state estimation.
9	Kalman filter for noisy position tracking.
10	Visual odometry and feature tracking.
	Part B: Course Project
1	Autonomous navigation using perception feedback.

Note:

1. Journal submission shall include minimum 06 Lab Experiments and one course project.
2. Recommended hardware: ESP32 microcontroller board, DC motors, L298N motor driver, MPU 6050 inertial sensor, generic webcam or ESP32-CAM camera, ArUco markers, wheel encoders.
3. Recommended software tools: Webots, Python, OpenCV, Pytorch, TensorFlow, Keras.

Suggested Learning Resources

Textbook

1. Peter Corke, Robotics, Vision and Control: Fundamental algorithms in Python, III Ed., Springer, 2023.
2. Lentin Joseph, ROS Robotics Projects, I Ed., Packt, 2017.
3. Lentin Joseph and Jonathan Cacace, Mastering ROS 2 for Robotics Programming, IV Ed., Packt, 2025.
4. Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo, Robotics Modelling, Planning and Control, I Ed., Springer, 2009.

Reference Books

1. Thomas Bräunl, Embedded Robotics: From Mobile Robots to Autonomous Vehicles with Raspberry Pi and Arduino, IV Ed., Springer, 2022.
2. Jonathan Cacace, Ultimate Robotics Programming with ROS 2 and Python, I Ed., Orange Education, 2024.
3. Anil Mahtani, Louis Sanchez, Enrique Fernandez, Aaron Martinez and Lentin Joseph, ROS Programming: Building Powerful Robots, I Ed., Packt, 2018.
4. Kevin M. Lynch and Frank C. Park, Modern Robotics: Mechanics, Planning, and Control, I Ed., Cambridge University Press, 2017.
5. Saeed B. Niku, Introduction to Robotics: Analysis, Control, Applications, II Ed., Wiley, 2010.

Web Resources

1. NPTEL course, Wheeled Mobile Robots, Prof. Asokan Thondiyath & Prof. Santhakumar, Mohan IITM & IIT Palakkad,
<https://nptel.ac.in/courses/112106298>
2. NPTEL course, Drone Systems and Control, Prof. Suresh Sundaram, IISc Bangalore,
<https://nptel.ac.in/courses/101108661>
3. NPTEL course, Robotics: Basics and Selected Advanced Concepts, Prof. Ashitava Ghosal, IISc Bangalore,
<https://nptel.ac.in/courses/112108298>

4. NPTEL course, Introduction To Robotics, Prof. Asokan T, Prof. Balaraman Ravindran & Prof. Krishna Vasudevan, IIT Madras,
nptel.ac.in/courses/107106090.

3.10 Exit Courses

3.10.1 CCNA (CE6EX_CR1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE6EX_CR1	CCNA	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2	100

Course Objectives

Sr. No.	Objectives
1	To <i>understand</i> networking models and protocols.
2	To <i>configure</i> routers and switches for LAN/WAN environments.
3	To <i>apply</i> subnetting and routing techniques.
4	To <i>implement</i> security measures in enterprise networks.
5	To <i>explore</i> automation in modern networking.

Course Outcomes

The student will be able to	
CO1	<i>explain</i> fundamental networking concepts.
CO2	<i>configure</i> and troubleshoot routing & switching.
CO3	<i>design</i> secure LAN/WAN architectures.
CO4	<i>apply</i> ACLs, NAT, and QoS.
CO5	<i>demonstrate</i> awareness of SDN & automation.

Course Contents

Module	Unit	Detailed Contents	Hours
	Prerequisites		
	Networking		
1.0	Networking Fundamentals		08
	1.1	OSI & TCP/IP models ,IP addressing & subnetting	
	1.2	Switching vs routing,Network devices: routers, switches, firewalls	
	1.3	Basics of VLANs and trunking	
2.0	Routing Concepts & Protocols		08

	2.1	Static vs dynamic routing ,RIP, OSPF, EIGRP	
	2.2	Default routes and route summarization ,Troubleshooting routing tables	
3.0	Switching & LAN Technologies		08
	3.1	VLAN configuration ,Inter-VLAN routing	
	3.2	Spanning Tree Protocol (STP) ,Switch security (port security, DHCP snooping)	
4.0	WAN & IP Services		07
	4.1	WAN technologies (PPP, Frame Relay, MPLS basics) ,NAT, PAT, ACLs	
	4.2	DHCP, DNS, SNMP ,QoS fundamentals.	
5.0	Network Security & Automation		08
	5.1	Firewalls & VPN basics ,Secure device management	
	5.2	Introduction to SDN ,Basics of network automation (Python scripts, Cisco Packet Tracer automation)	
Total Hours			39

Suggested Learning Resources

Textbooks

1. CCNA 200-301 Official Cert Guide Library, II Ed., Wendell Odom, Cisco Press, 2024.
2. CCNA Certification Study Guide, Vol. 1 & 2, II Ed., Todd Lammle, Sybex, 2024.
3. 31 Days Before Your CCNA Exam, II Ed., Allan Johnson, Cisco Press, 2024

Reference Books

1. CCNA Certification Practice Tests, II Ed., Jon Buhagiar, Sybex.
2. CCNA Portable Command Guide, VI Ed., Scott Empson, Cisco Press.

Web Resources

1. Cisco Networking Academy (NetAcad): Cisco Packet Tracer and networking courses.
<https://www.netacad.com/>
2. GNS3: Network simulation and lab practice platform.
<https://www.gns3.com/>
3. EVE-NG: Network emulation platform for virtual networking labs.
<https://www.eve-ng.net/>
4. Boson: CCNA practice exams and network simulation tools.
<https://www.boson.com/>
5. Cisco Learning Network: CCNA certification resources and exam preparation.
<https://learningnetwork.cisco.com/>
6. Cisco CCNA 200-301 Exam Information: Official certification topics and exam details.
<https://www.cisco.com/site/us/en/learn/training-certifications/exams/ccna.html>

3.10.2 CCNA (CE6EX_LR1)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE6EX_LR1	CCNA Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	-	25	-	50

Course Objectives

Sr. No.	Objectives
1	To <i>develop</i> hands-on skills in configuring routers & switches.
2	To <i>apply</i> routing protocols in simulated environments.
3	To <i>implement</i> VLANs & ACLs for segmentation & security.
4	To <i>configure</i> IP services like DHCP, NAT, DNS .
5	To <i>explore</i> automation tools for network management.

Course Outcomes

The student will be able to	
LO1	<i>configure</i> and <i>verify</i> router & switch operations.
LO2	<i>demonstrate</i> VLANs, ACLs, and NAT.
LO3	<i>apply</i> routing protocols in lab setups.
LO4	<i>implement</i> DHCP and IP services.
LO5	<i>showcase</i> basic automation in Packet Tracer/GNS3.

Course Contents

Sr. No.	Suggested List of Experiments
1	To implement Basic Router Configuration.
2	To implement Switch Configuration & VLANs.
3	To implement Inter-VLAN Routing.
4	To implement Static & Dynamic Routing.
5	To implement OSPF Configuration.
6	To implement EIGRP Configuration.
7	To implement Access Control Lists.
8	To implement NAT & PAT.
9	To implement DHCP Server Setup.

10	To implement Network Security & Automation.
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Note: Lab course shall consist of minimum 08 experiments covering all the topics but not limited to the suggested list.

Suggested Learning Resources

Textbook

1. Cisco CCNA 200-301 Official Cert Guide Library, II Ed., Wendell Odom, Cisco Press, 2024.
2. CCNA Certification Study Guide, Vol. I & II, II Ed., Todd Lammle, Sybex, 2024.
3. 31 Days Before Your CCNA Exam, II Ed., Allan Johnson, Cisco Press, 2024.

Reference Books

1. CCNA Certification Practice Tests, II Ed., Jon Buhagiar, Sybex.
2. CCNA Portable Command Guide, VI Ed., Scott Empson, Cisco Press.

Web Resources

1. Free CCNA Labs providing step-by-step networking exercises for VLANs, OSPF, NAT, ACLs, STP, and EtherChannel using Packet Tracer, GNS3, or real networking devices.
<https://computingforgeeks.com/>
2. Learn CCNA Labs offering browser-based networking labs with interactive configuration, troubleshooting, and automated checking.
<https://learnccnallabs.com/>
3. Cisco Networking Academy providing free Cisco Packet Tracer simulation software, guided activities, and networking lab exercises.
<https://www.netacad.com/>
4. Boson NetSim providing paid network simulation software with hands-on CCNA configuration exercises and exam-oriented practice.
<https://www.boson.com/>
5. CiscoForAll providing free CCNA study guides, networking reference notes, troubleshooting exercises, and subnetting practice resources.
<https://www.ciscoforall.com/>

3.10.3 Web Product Development (CE6EX_CR2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE6EX_CR2	Web Product Development	03	03

Examination and Evaluation Scheme

ISE				ESE		Total Marks
CA		MSE				
Marks	Duration	Marks	Duration (Hrs.)	Marks	Duration (Hrs.)	
20	Continuous	20	1	60	2	100

Course Objectives

Sr. No.	Objectives
1	To <i>understand</i> full stack application architecture and select appropriate data storage.
2	To <i>develop</i> server side functionality.
3	To <i>integrate</i> applications with databases.
4	To <i>design</i> RESTful APIs and implement authentication.
5	To <i>apply</i> web security and basic cloud deployment practices.

Course Outcomes

The student will be able to	
CO1	<i>design</i> the architecture of a full-stack web application by identifying frontend, backend, and database components for a given problem.
CO2	<i>develop</i> server-side modules using Python/Flask/Django or Node.js/Express to process requests, forms, sessions, and files.
CO3	<i>implement</i> database connectivity, CRUD operations, prepared statements, transactions, and server-side validation.
CO4	<i>build</i> RESTful APIs and apply authentication, authorization, password hashing, and role-based access control.
CO5	<i>identify</i> common web vulnerabilities and <i>apply</i> secure coding practices and <i>deploy</i> and <i>test</i> a full -stack application with basic performance and scalability considerations.

Course Contents

Module	Unit	Detailed Contents	Hours
1.0	Prerequisites		
	Networking ,DBMS, Web Development		
	Full-Stack Architecture and Database Fundamentals		07

	1.1	Full-stack application architecture: frontend, backend, APIs, and database layers , · Request-response cycle and the role of databases in web applications.	
	1.2	Relational and NoSQL databases; selection of storage based on application requirements	
	1.3	Problem definition, requirements, and high-level application design.	
2.0	Server-Side Programming		08
	2.1	Introduction to Python/Node.js for server-side development, Variables, data types, operators, control structures, loops, functions, and modules.	
	2.2	Handling HTTP requests and responses; GET and POST methods, Form processing, file handling, sessions, cookies, and basic error handling.	
3.0	Database Connectivity and Data Management		08
	3.1	Relational database concepts and PostgreSQL; tables, keys, and constraints, SQL CRUD operations and database connectivity using psycopg2 or Node.js pg driver.	
	3.2	Prepared statements and parameterized queries, Transactions, error handling, data validation, and data integrity, Server-side validation and introductory data-security practices.	
4.0	APIs, Frameworks, and Application Access Control		08
	4.1	MVC architecture and application development using Flask/Django or Express.js, RESTful web services; JSON and XML data exchange; HTTP methods and status codes .	
	4.2	Authentication and authorization; JWT/OAuth overview, Password hashing, role-based access control, secure file upload/download, and server-side caching concepts.	
5.0	Application Security, Deployment, and Scalability		08
	5.1	Common web vulnerabilities: SQL injection, cross-site scripting (XSS), and cross-site request forgery (CSRF), Secure coding practices, HTTPS/TLS concepts, input validation, and output encoding, Testing, debugging, logging, and performance optimization.	
	5.2	Application deployment basics and introduction to cloud hosting (e.g., AWS EC2), Scalability, load balancing, caching, and overview of modern frameworks such as Django, Express.js, and Laravel, Project documentation, demonstration, and deployment checklist.	
Total Hours			39

Suggested Learning Resources

Textbooks

1. Web Development with Node and Express: Leveraging the JavaScript Stack, II Ed., Ethan Brown, O'Reilly Media, 2019.
2. Learning Python, V Ed., Mark Lutz, O'Reilly Media, 2013.
3. Learning Web Development with Django, II Ed., Ayman Hourieh, O'Reilly Media.
4. Database System Concepts, VII Ed., Abraham Silberschatz, Henry F. Korth and S. Sudarshan, McGraw Hill, 2019.

5. *PostgreSQL: Up and Running*, III Ed., Regina Obe and Leo Hsu, O'Reilly Media, 2017.

Reference Books

1. *Flask Web Development: Developing Web Applications with Python*, II Ed., Miguel Grinberg, O'Reilly Media, 2018.
2. *Django for APIs: Build Web APIs with Python and Django*, IV Ed., William S. Vincent, WelcomeToCode, 2022.
3. *RESTful Web APIs*, Leonard Richardson, Mike Amundsen and Sam Ruby, O'Reilly Media, 2013.

Web Resources

1. **Node.js Documentation:** Official documentation for server-side JavaScript development.
[Node.js Documentation](#)
2. **Django Documentation:** Tutorials and references for developing secure web applications using Django.
[Django Documentation](#)
3. **Flask Documentation:** Official guide for developing lightweight Python web applications and REST APIs.
[Flask Documentation](#)
4. **PostgreSQL Documentation:** Database administration, SQL queries, transactions, and database connectivity.
[PostgreSQL Documentation](#)
5. **Express.js:** Documentation for building server-side applications and RESTful APIs using Node.js.
[Express.js Documentation](#)
6. **OWASP:** Web application security guidelines, common vulnerabilities, and secure coding practices.
[OWASP Foundation](#)

3.10.4 Web Product Development Lab (CE6EX_LR2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE6EX_LR1	Web Product Development Lab	02	01

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	25	25	-	-	50

Course Objectives

Sr. No.	Objectives
1	To <i>enable</i> students to design and build responsive, multi-tier web applications using modern frontend technologies, server-side frameworks, and relational database management systems.
2	To <i>cultivate</i> an understanding of application security fundamentals, including secure data handling, input validation, authentication mechanisms, and protection against common web vulnerabilities.
3	To <i>enable</i> students to design, implement, and consume RESTful APIs for seamless communication between application components.
4	To <i>instill</i> industry-standard testing methodologies and cloud deployment workflows to deliver reliable, production-ready web applications.
5	To <i>train</i> students to produce comprehensive technical documentation, architecture diagrams, API specifications, and defend their design decisions through technical demonstrations and viva voce examinations.

Course Outcomes

The student will be able to	
LO1	<i>formulate</i> functional requirements for a practical application domain and design a modular full-stack architecture with an optimized PostgreSQL relational database schema.
LO2	<i>implement</i> a responsive user interface using HTML, CSS, and JavaScript, paired with a robust server-side backend built with Flask, Django, or Express.js.
LO3	<i>construct</i> secure RESTful API endpoints to facilitate structured data communication between frontend components and backend services.
LO4	<i>integrate</i> application-level security controls, including cryptographic password hashing, input sanitization, authentication/authorization pipelines, and parameterized database queries.
LO5	<i>perform</i> functional testing, error handling validation, and basic security vulnerability checks to verify application reliability and host the full-stack application on a cloud server environment and generate complete technical documentation.

Course Contents

Suggested List of Experiments

Project Title: Design and Deployment of a Secure Full-Stack Application

Students shall develop an application addressing a practical problem, such as a student activity management system, appointment booking system, inventory management system, or service request portal etc..

The application should incorporate the following components:

1. **Frontend:** Responsive user interface using HTML, CSS, and JavaScript.
2. **Backend:** Server-side implementation using Flask, Django, or Express.js.
3. **Database:** PostgreSQL integration with appropriate tables, relationships, and CRUD operations.
4. **API Integration:** RESTful endpoints for communication between application components.
5. **Security:** Input validation, secure database queries, password hashing, and authentication.
6. **Testing:** Functional testing, error handling, and basic security testing.
7. **Deployment:** Hosting on an approved cloud platform or server environment.
8. **Documentation:** Application architecture, database schema, API details, test cases, deployment instructions, and user documentation.

Expected Deliverables

- Working application.
- Source code and database schema.
- API documentation.
- Test cases and results.
- Security implementation evidence.
- Deployment details and user guide.
- Project demonstration and individual viva voce.

Suggested Learning Resources

Textbook

1. Web Development with Node and Express: Leveraging the JavaScript Stack, II Ed., Ethan Brown, O'Reilly Media, 2020.
2. Flask Web Development: Developing Web Applications with Python, II Ed., Miguel Grinberg, O'Reilly Media, 2018.
3. Web Application Security: Exploitation and Countermeasures for Modern Web Applications, I Ed., Andrew Hoffman, O'Reilly Media, 2020.

Reference Books

1. PostgreSQL: Up and Running, III Ed., Regina O. Obe and Leo S. Hsu, O'Reilly Media, 2017.
2. API Design Patterns, I Ed., JJ Geewax, Manning Publications, 2021.

Web Resources

1. MDN Web Docs providing comprehensive documentation, reference guides, and tutorials for responsive user interface design using HTML, CSS, JavaScript, and modern web APIs.
<https://developer.mozilla.org/>
2. PostgreSQL Official Documentation offering technical references for schema design, table relationships, indexing, SQL queries, and CRUD operations.
<https://www.postgresql.org/docs/>
3. OWASP Cheat Sheet Series providing actionable architecture and security guidelines for input validation, password hashing, authentication mechanisms, and vulnerability mitigation
<https://cheatsheetseries.owasp.org/>
4. Postman Learning Center offering step-by-step guides for designing, testing, documenting, and consuming RESTful APIs across application tiers.
<https://learning.postman.com/>
5. Render Documentation providing end-to-end deployment guides, database hosting tutorials, environment variable configuration, and web service management for cloud hosting.
<https://docs.render.com/>

3.10.5 Internship in Networking/Full Stack Development (CE6EX_LR2)

Teaching Scheme

Course Code	Course Name	Contact Hours	Credits
CE6EX_LR2	Internship in Networking/Full stack development	08	04

Examination and Evaluation Scheme

Evaluation	ISE	ESE			Total Marks
	CA	PE	OrE	PrE	
Marks	50	-	-	100	150

Course Objectives

Sr. No.	Objectives
1	To <i>gain</i> practical experience in networking or full stack development by working on industry-oriented tasks and understanding real-world technical requirements.
2	To <i>apply</i> theoretical knowledge of computer networks, web technologies, programming, databases, and software development to solve real-world industry problems.
3	To <i>develop</i> technical competencies in network configuration, network troubleshooting, or full stack application development, following industry standards, best practices, and professional ethics.
4	To <i>enhance</i> communication, teamwork, problem-solving, and interpersonal skills while collaborating with professionals and contributing to industry-based projects.

Course Outcomes

The student will be able to	
CO1	<i>apply</i> theoretical knowledge and academic concepts of computer engineering to solve practical problems in networking or full stack development.
CO2	<i>demonstrate</i> technical proficiency in network configuration, network troubleshooting, or full stack application development using relevant tools, technologies, and industry practices.
CO3	<i>identify</i> and evaluate career opportunities and professional roles in networking or full stack development based on industry exposure and practical experience.
CO4	<i>demonstrate</i> professionalism, accountability, ethical work practices, teamwork, and adaptability in a real-world work environment.

Guidelines

A. Process of internship identification for exit program

- The student shall approach industry for internship opportunities. The industry and the role/profile need to be approved by HoD/Dean Academics. The student may also take guidance from TPO/ IIC/IIIC for identification of a suitable opportunity.
- The internship taken up by the student should result in either being converted to job or job ready for a similar role.

B. Continuous Monitoring and Assessment

- A mentor is to be appointed at the department level to guide the student.
- The mentor should assess the progress of the students on a weekly basis and record their observations in the logbook. Preferably, the mentors should interact with the industry mentor and may also visit the company to assess his/her progress.
- Mentors need to visit the industry minimum once in a semester if required.
- ISE mark to be given based on continuous evaluation and recommendation from industry mentor.

C. End Semester Examination

- A report to be prepared and submitted by the student.
- A presentation summarizing the work done in the industry needs to be done. The external examiner should preferably be from the industry.

Mark distribution for internship for exit program after second year of Engineering

Assessment Tool	Components	Marks
CA	Logbook	25
	Approval presentation and mid sem presentation	25
	Total	50
ESE	Report	50
	Final Presentation	50
	Total	100