CURRICULUM STRUCTURE
PG: M.TECH.

COMPUTER ENGINEERING

REVISION: FRCRCE-1-24

Effective from Academic Year 2024-25

Board of Studies Approval: 08/03/2023

Academic Council Approval: 16/03/2023

DR. DEEPAK BHOIR	Dr. Sujata P. Deshmukh	DR. SURENDRA RATHOD
Dean Academics	HOD (Computer)	Principal

Preamble:

Greetings and congratulations to all the education partners Fr Conceicao Rodrigues College of Engineering for getting autonomous status to the college from the year 2024-25. University Grant Commission vide letter No. F. 2-10/2023(AC-Policy) dated 23rd Nov 2023 conferred the autonomous status to Fr. Conceicao Rodrigues College of Engineering, Fr. Agnel Ashram, Bandstand, Bandra (West), Mumbai 400050 affiliated to University of Mumbai for a period of 10 years from the academic year 2024-2025 to 2033-2034 as per clause 7.5 of the UGC (Conferment of Autonomous Status Upon Colleges and Measures for Maintenance of Standards in Autonomous Colleges) Regulations,2023. We look towards autonomy as a great opportunity to design and implement curriculum sensitive to needs of Learner, Indian Society and Industries.
Government of Maharashtra has also directed Autonomous Colleges to revise their curriculum in line with National Education Policy (NEP) 2020 through Government Resolution dated 4th July 2023. We commit to ourselves to the effective implementation of UGC Regulations and NEP 2020 in its spirit.

Based on recent recommendations of the GR, we are pleased to offer our holistic curriculum for 2024-26, a "**H-Tree Model"** of Engineering Education. A unique **"H-Tree Model"** of Engineering Education Curriculum is carefully designed to systematically develop IQ (Intelligence Quotient), PQ (Physical Quotient), EQ (Emotional Quotient) and SQ (Spiritual Quotient) of a learner.
In alignment with the National Higher Education Qualifications Framework (NHEQF) guidelines set forth by the University Grants Commission, this Master of Technology (M. Tech.) program in Computer Engineering is meticulously crafted. This syllabus is designed to cultivate graduates who demonstrate a deep commitment to ethical practices, critical thinking, and holistic problem-solving.

The postgraduate programmes help students to extend their knowledge of their chosen subject and prepare them for higher research studies. The advanced knowledge and specialized skills they gain in the PG programme are crucial to sustaining the journey of a student from the acquirer of knowledge to the creator of knowledge.

Drawing inspiration from the NHEQF level descriptors, this two-year postgraduate program aims to equip students with the knowledge and skills necessary to address complex challenges in the field of Computer Engineering. PG framework is in sync with National Credit Framework (NCrF) for the creditization of all learning and assignment, accumulation, storage, transfer & redemption of credits, subject to assessment. By emphasizing the application of theoretical principles to practical scenarios, the curriculum fosters a deep understanding of physical principles, methodologies, and interdisciplinary approaches essential for solving real-world problems. The PG programme also includes vocational courses relevant to the chosen discipline.

Furthermore, the program places a strong emphasis on self-directed learning, encouraging students to continuously upgrade their knowledge and skills to adapt to the evolving demands of the industry. Through a blend of theoretical coursework, hands-on projects, and research opportunities, students will develop the ability to gather and interpret data, critically evaluate theories, and make informed decisions based on evidence.

Central to the ethos of this program is the cultivation of a strong sense of personal responsibility and accountability. Graduates of this M.Tech. program will be equipped to navigate the dynamic landscape of technological advancements, exhibit full ownership of their work outputs, and demonstrate leadership qualities essential for driving innovation and sustainable development.

Various steps are taken to transform teaching learning process to make learning a joyful experience for students. We believe that this curriculum will raise the bar of academic standards with the active involvement and cooperation from students, academic and administrative units.

Graduate Attributes of Master's Programme:
NHEQF has outlined the statement of learning achievements at a particular level on the basis of the following elements of descriptors:

- Knowledge and understanding
- General, technical, and professional skills required to perform and accomplish tasks
- Application of knowledge and skills
- Generic learning outcomes
- Constitutional, humanistic, ethical, and moral values
- Employability and job-ready skills, and entrepreneurship skills and capabilities/qualities and mindset

Credit requirement and Eligibility for the Master's Programme:
A 4-year Bachelor's degree (e.g. B.E., B.Tech. etc.) with a minimum of 160 credits for a 2-year/4-semester Master's programme (e.g. M.E., M. Tech. etc.) at level 7 of NHEQF.

Curriculum and Credit Distribution for M.Tech in Computer Engineering**:**

	Two-Year PG Programme (Generic and Professional) Minimum Credits		
	Course Work	Research (Dissertation)	Total
1st Semester	20	-	40
2nd Semester	20	-	
3rd Semester	-	20	40
4th Semester	-	20	

Main features of the master's curriculum framework:

- ✔ Opportunity for learners to choose the courses of their interest.
- ✔ Flexibility to switch to alternative modes of learning (offline, ODL, Online learning, and hybrid modes of learning).
- ✔ Mobility and flexibility as per the UGC (Establishment and Operation of Academic Bank of Credits in Higher Education) Regulations, 2021, and UGC Guidelines for Multiple Entry and Exit in Academic Programmes offered in Higher Education Institutions. These documents are to facilitate the implementation of the proposed "Curriculum and Credit Framework for Postgraduate Programmes."
- ✔ As emphasized by NEP 2020, the curriculum includes formative and continuous assessment rather than summative assessment.
- ✔ Another opportunity for students is the facility to pursue two academic programmes simultaneously. Fr. CRCE has no objection if a student wish to pursue two academic programmes simultaneously, one in full-time physical mode at Fr. CRCE and another in Open and Distance Learning (ODL)/Online mode with any HEI which is recognised by UGC/Statutory council/ Government of India for running such programs.
- ✔ The candidates having relevant experience / proficiency of atleast 4 years in experience in a trade or profession, will be exempted from the related ONE course in the curriculum. To complete the credit

requirements in lieu of this, the candidate need to complete the project given by the department for the equivalent credit.

- ✔ The candidates having relevant experience / proficiency of more than 4 years in a trade or profession will be exempted from the related TWO courses in the curriculum. To complete the credit requirements in lieu of this, the candidate need to complete the project given by the department for the equivalent credit.
- ✔ The candidate has to prove the relevant experience / proficiency through documents endorsed by the concerned authorities.
- ✔ Exit Point: For the PG programme, there shall only be one exit point for those who join two-year PG programme. Students who exit at the end of 1st year shall be awarded a Postgraduate Diploma.

Curriculum Structure for PG Programs at Fr CRCE w.e.f. A.Y. 2024-25

Nomenclature of the courses in the curriculum	
Abbreviation	**Title**
PSBC	Program Specific Bridge Course
PCC	Program Core Courses
PEC	Program Elective Courses
OE	Open Elective
CCL	Core Course Lab
SBL	Skill Based Lab
MP	Major Project

Credit Specification:

- ❖ Theory: 1 credit = 13 to 15 hrs of teaching
- ❖ Lab: 1 Credit = 26 to 30 hrs of lab work

Seminar/Group Discussion: 1 Credit=13 to 15 hrs of participation

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SEMESTERWISE CURRICULUM STRUCTURE
FIRST YEAR M.TECH. COMPUTER ENGINEERING Program:

SEM-I												
Course Code	Course Vertical	Sub-Vertical	Course Name		Contact Hours	Examination Marks					Credits	
						ISE 1	MS E	ISE 1	ESE	Total	Points	Total
PSBC21CE01	PCPSBC	PSBC	*Bridge Course	TH	2	20	30	20	30	100	2	3
				TU/PR	2	20	--	30	-	50	1	
PCC21CE01	PCPEC	PCC	Database Management Systems in Modern Era	TH	2	20	30	20	30	100	2	3
				PR	2	20	--	30	-	50	1	
PCC21CE02	PCPEC	PCC	Advance Algorithms and Complexity	TH	2	20	30	20	30	100	2	3
				PR	2	20	--	30	-	50	1	
PEC21CE01X	PCPEC	PEC	Program Elective 1	TH	2	20	30	20	30	100	2	3
				PR	2	20	--	30	-	50	1	
PEC21CE02X	PCPEC	PEC	Program Elective 2	TH	2	20	30	20	30	100	2	3
				PR	2	20	--	30	-	50	1	
OE211X	OE	OE	Open Elective 1	TH	2	20	30	20	30	100	2	3
				TU	1	20	--	30	-	50	1	
CCL21CE01	CCLSBL	CCL	Program Lab-I Data Science	PR	2	25	--	25	--	50	1	1
SBL21CE01	CCLSBL	SBL	Full Stack Development	PR	2	25	--	25		50	1	1
Total					**TH:TU:PR 12:1:14=27**	**290**	**180**	**350**	**180**	**1000**	**20**	**20**

***Bridge Course**- Students who have completed graduation in Computer Engineering will have bridge course in Mathematics for research and for other branch students will have bridge course covering Fundamentals of computer Engineering.

Course Code	Program Elective 1 (PEC21CE01X)	Course Code	Program Elective 2 (PEC21CE02X)
PEC21CE011	High Performance Computing	PEC21CE021	Geographical Information Systems
PEC21CE012	Quantum Computing	PEC21CE022	Agile Methodologies in Software Engineering
PEC21CE013	Embedded Systems and RTOS	PEC21CE023	Block chain Technology & DeFi

Course Code	Open Elective 1 (OE211X)
OE2111	Constitution of India and Professional Ethics
OE2112	Digital Business Management
OE2113	Design of Experiments

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SEM-II												
Course Code	Course Vertical	Sub-Vertical	Course Name		Contact Hours	Examination Marks					Credits	
						ISE 1	MSE	ISE2	ESE	Total	Points	Total
PSBC21CE02	PCPSBC	PSBC	Research Methodology and Intellectual property	T H	2	20	30	20	30	100	2	3
PSBC21CE03			Effective Technical Communication	T U	2	10	15	10	15	50	1	
PCC21CE03	PCPEC	PCC	Operating Systems in Modern Era	T H	2	20	30	20	30	100	2	3
				P R	2	20	--	30	-	50	1	
PCC21CE04	PCPEC	PCC	Emerging Paradigms in Communication	T H	2	20	30	20	30	100	2	3
				P R	2	20	--	30	-	50	1	
PEC21CE03X	PCPEC	PEC	Program Elective3	T H	2	20	30	20	30	100	2	3
				P R	2	20	--	30	-	50	1	
PEC21CE04X	PCPEC	PEC	Program Elective4	T H	2	20	30	20	30	100	2	3
				P R	2	20	--	30	-	50	1	
OE212X	OE	OE	Open Elective 2	T H	2	20	30	20	30	100	2	3
				T U	1	20	--	30	-	50	1	
CCL21CE02	CCLSBL	CCL	Program Lab-II-Advanced Cloud Computing	P R	2	25	--	25	--	50	2	1
SBL21CE02	CCLSBL	SBL	Skill Based Lab-II-Cyber Forensic	P R	2	25	--	25	--	50	2	1
Total					**TH:TU:PR 12:1:14=27**	**290**	**180**	**350**	**180**	**1000**	**20**	**20**

Course Code	Program Elective 3 (PEC21CE03X)	Course Code	Program Elective 4 (PEC21CE04X)
PEC21CE031	Optimization in Machine Learning	PEC21CE041	Data Architecture and Management
PEC21CE032	Generative AI	PEC21CE042	Bioinformatics
PEC21CE033	Deep Learning with NLP	PEC21CE043	Industrial IOT

Course Code	Open Elective 2 (OE212X)
OE2121	Project Management
OE2122	Finance Management
OE2123	Environmental Management

Note 1: Skill Based Lab- I and II are focused on the learning through experience. SBL shall facilitate the learner to acquire the fundamentals of practical engineering in his or her specialization in a project-oriented environment. The learning through skill based labs can be useful in facilitating their research work and hence useful in early completion of their dissertation work.

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SEMESTERWISE CURRICULUM STRUCTURE
SECOND YEAR M.TECH. COMPUTER ENGINEERING Program:

Course Code	Course Name		Contact Hours	Examination Marks					Credits	
				ISE1	MSE	ISE2	ESE	Total	Points	Total
MP22CE01	Major Project: Dissertation -I	PR	28	20	--	30	50	100	14	14
SLC22CE01	Online Credit Course-1	TH	--	-	-	-	-	-	3	3
SLC22CE02	Online Credit Course-2	TH	--	-	-	-	--	-	3	3
TH:TU:PR 12:0:28=40			28	20	--	30	50	100	**20**	**20**

Note 1: It is mandatory to complete the Online Credit Courses (OCC) available on NPTEL / Swayam /MOOC or similar platform approved by UoM. These two courses shall be completed in any semester I or II or III, but not later end of the Semester III. Institute shall make a provision that credits earned with OCC- I and OCC-II shall be accounted in the third semester grade-sheet with actual names of courses. The learner shall be allowed to take up these courses from his or her institute or organisation/ industry where his / her major project is carried out. The students shall complete the courses and shall qualify the exam conducted by the respective authorities/ instructor from the platform. The fees for any such courses and the corresponding examination shall be borne by the learner.

Semester long industrial internship with Major Project will be permitted

Online Credit Course – I

The learner shall opt for the course in the domain of area of M. Tech dissertation. The opted course shall be of 3 credits of equivalent number of weeks.

Online Credit Course –II

The learner shall opt for the course recommended by Faculty Advisor/ Project Supervisor from the institute. The opted course shall be of 3 credits of equivalent number of weeks.

Course Code	Course Name		Contact Hours	Examination Marks					Credits	
				ISE1	MSE	ISE2	ESE	Total	Points	Total
MP22ME02	Major Project: Dissertation -II	PR	40	50	--	50	100	200	20	20
TH:TU:PR 0:0:40=40			40	50	--	50	100	**200**	20	**20**

Note 2: The Dissertation -II submission shall not be permitted till the learner completes all the requirements M.Tech. course.

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PSBC21CE01	Bridge Course-Mathematics for Research	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	50	

Pre-requisite	Probability distributions: Bernoulli, Binomial, Poisson, and Normal	
Course Outcomes	CO1	Classify stochastic processes in a given time domain as per their properties.
	CO2	Execute a sequence of events in a system with the help of Markov chains.
	CO3	Operate modern statistical techniques of estimation of parameters associated with different real life data sets.
	CO4	Interpret the results of regression and ANOVA models.

Theory:

Module No.	Unit No.	Topics	Ref.	Hrs.
1	Title	**Stochastic Processes**	1,2,3,4	**06**
	1.1	Introduction and classification of stochastic processes		02
	1.2	Bernoulli process, Poison process, Renewal processes		04
2	Title	**Markov Chains**	1,2,3,4	**07**
	2.1	Discrete-time Markov chains: computation of n-step transition probabilities, state classification and limiting probabilities, distribution of time between time changes, M/G/1 queuing system		03
	2.2	Continuous-Time Markov chains: Birth-Death process (M/M/1 and M/M/m queues), non-birth-death processes, Petri nets		04
3	Title	**Statistical Inference**	1,2,3,4	**07**
	3.1	Parameter Estimation – sampling from normal distribution, exponential distribution		02
	3.2	Estimation related to Markov chains		02
	3.3	Hypothesis testing		03
4	Title	**Regression and Analysis of Variance**	1,2,3,4	**06**
	4.1	Least square curve fitting		02
	4.2	Linear and non-linear regression		02
	4.3	Analysis of variance		02
			Total	**26**

Tutorial/Practical:

Exp. No.	Tutorial/ Practical Details
1	Introduction and classification of stochastic processes
2	Bernoulli process, Poison process, Renewal processes
3	Discrete-time Markov chains
4	Continuous-time Markov chains
5	Estimation (parameter and Markov chain related)
6	Hypothesis testing
7	Curve fitting and regression
8	Analysis of variance

Course Assessment:

Theory:

ISE-1: MCQ: 20 Marks

ISE-2: MCQ: 20 Marks

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. ISE-1 will be conducted for three tutorials. Continuous pre-defined rubrics-based evaluation for 20 marks.

2. ISE-2 will be conducted for five tutorials. Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:

[1] Ronald Walpole, Raymond Myers, Sharon Myers, and Keying Ye, "*Probability and Statistics for Engineers and Scientists*", Pearson Publications, 9th Edition.

[2] Kishor Trivedi, "*Probability and Statistics with Reliability, Queuing and Computer Science Applications",* John Wiley and Sons (New York), 2nd Edition

[3] V. Sundarapandian, "*Probability, Statistics and Queuing Theory*", PHI Learning Private Limited, 1st Edition

[4] Randolph Nelson, "*Probability, Stochastic Processes and Queuing Theory*", Springer, 1st Edition

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PSBC21CE01	Bridge Course- Fundamentals of computer Engineering	L	T	P	L	T	P	Total
		2		2	2		1	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100(30% weightage)	100	
		Lab	20	--	30	--	50	

Pre-requisite	Fundamentals of computer engineering	
Course Outcomes	CO1	Describe data structure for real world application
	CO2	Elaborate basic concepts of RDMS
	CO3	Explain operating system concepts and principles.
	CO4	Characterize the distinction between various cloud models and services
	CO5	State working of different networking devices based on network layer.
	CO6	Apply data mining and machine learning concepts to solve real world problems.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Review of Basic Data structure concepts:** Abstract data type, Data structures, Algorithms, Big Oh, Small Oh, Omega and Theta notation. Solving recurrence equations, Master theorems, Generating function Techniques	1,2	4
2	2.1	**Transaction Management:** Overview of transaction management: Transaction concept, Transaction state, Implementation of Atomicity and Durability, Concurrent Executions, Serializability, Recoverability, Concurrency control: Lock-Based Protocols, Timestamp-Based Protocols, Validation-Based Protocols, Recovery System: Recovery and Atomicity, Log Based Recovery, Recovery with concurrent transactions, ARIES(Algorithm for Recovery and Isolation Exploiting Semantics),which support partial rollbacks of transactions, fine granularity(e.g. Record)locking and recovery using write-ahead logging(WAL)	3,4	5
3	3.1	**Introduction to Operating System:** Definition and objectives of an operating system, Historical perspective and evolution of operating systems, Types of operating systems (e.g., batch processing, time-sharing, distributed)	5	4

	3.2	**Process Management:** Process concept and characteristics, Process states and state transitions, Process scheduling algorithms (e.g., FCFS, SJF, Round Robin), Inter process communication and synchronization mechanisms		
4	**4.1**	**Introduction to cloud computing:** Benefits and challenges to cloud architecture, cloud delivery models- SaaS, PaaS, LaaS. Cloud deployment models- Public Cloud, Private Cloud, Community Cloud and Hybrid Cloud, Service level agreements in clouds, Case studies on cloud services, Cloud Adoption Challenges. The Handshaking Problem, Connectivity and Paths, Matrix representation of graphs, Konigsberg Bridge problem, Eulerian and Hamiltonian graphs, Spanning trees and Minimal spanning trees,	6,7	4
5	**5.1**	**Overview of Internet Protocol (IP):** Routing protocols (distance vector, link state packet routing); protocols - TCP, UDP, RPC; Application protocols for email, ftp, web, DNS. Connection establishment, flow control, congestion control concepts and mechanisms (choke packets, leaky bucket, token bucket); IPv4, CIDR (Classless Interdomain routing)	8	4
6	**6.1**	**Data Mining and Machine Learning:** Applications, Motivation, Data mining knowledge discovery process, kinds of data, data mining techniques, issues in data mining, Introduction to Machine learning: Applications of ML, Design perspective and issues in ML, Supervised, Unsupervised learning with applications and issues.	9	5
			Total	**26**

Module No.	**Sr.no**	**Suggested List of experiments**
1	**1**	**Experiments on Data structure:** Experiment based on sorting and searching using different data structure
	2	Perform Create, Insert, Delete and traverse operations on linked list
2	**3**	**Experiments on DBMS**: CRUD operations on Database
	4	Simulate ARIES recovery system
3	**5**	**Experiments on OS:** Explore process scheduling algorithms (e.g., FCFS, Round Robin) and compare their performance
	6	Implement a simple process creation and termination mechanism.
4	**7**	**Experiments on Cloud Computing:** Analyze the Cloud computing setup with its vulnerabilities and applications using different architectures
	8	Apply and design suitable Virtualization concept, Cloud Resource Management and design scheduling algorithms.

5	**9**	**Experiment on Computer Network:** Study different types of networking devices
	10	**Experiment on ML:**Build a system for natural language understanding using techniques such as semantic parsing or semantic role labeling

Course Assessment:

Theory:

ISE-1:
Activity: Quiz and assignments 20 Marks
ISE-2: Two hours 20 Marks
Activity: Article Discussion, Quiz and Assignments
Outcome: Reflective Journal

MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Lab:

ISE:
1. ISE-1 will be conducted for five experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2
a. Five experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Simulation using modern tools to solve the given problem statement for 10 marks

Recommended Books:

[1] **Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein *"Introduction to Algorithms"***, The MIT Press
[2] **Robert Lafore "Data Structures and Algorithms in Java" ,** Sams Publishing.
[3] **Abraham Silberschatz, Henry F. Korth, and S. Sudarshan" Database System Concepts",** McGraw-Hill Education
[4] **Ramez Elmasri and Shamkant B. Navathe" *Fundamentals of Database Systems*",** Pearson Education
[5] **Abraham Silberschatz, Peter B. Galvin, and Greg Gagne" Operating System Concepts", Wiley**
[6] Rajkumar Buyya, Christian Vecchiola, S.Thamarai Selvi "Mastering Cloud Computing Foundations and Applications"
[7] Thomas Erl, Zaigham Mahmood, and Ricardo Puttini "Cloud Computing Concepts, Technology & Architecture"
[8] **James F. Kurose and Keith W. Ross" *Computer Networking: A Top-Down Approach*",** Pearson
[9] **Christopher M. Bishop"Pattern *Reccognition and Machine Learning*",** Springer

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PCC21CE01	Database Management Systems in Modern Era	L	T	P	L	T	P	Total
		2	--	2	2	--	1	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Lab	20	--	30	--	50	

Pre-requisite	DBMS, Object oriented programming	
Course Outcomes	CO1	Explain steps involved in development of an enterprise data warehousing solution.
	CO2	Demonstrate the fundamentals of data storage and query processing
	CO3	Develop applications involving distributed databases
	CO4	Apply various ODBMS database techniques to design database for real life scenarios
	CO5	Use advanced XML queries on database
	CO6	Manipulate data using MongoDB / No SQL commands

Module No.	Unit No.	Topics	Ref.	Hrs.
1		Data warehousing Design	5,6, 7	4
	1.1	Introduction, need of Data warehouse, Data mart, Data warehousing Components, Building a Data warehouse, Data Warehouse Architecture, Dimensional Design, Star schema, Snowflake schema, Data Extraction, Cleanup, and Transformation Tools, Online Analytical Processing (OLAP) and Multidimensional Data Analysis.		
2		Distributed database	1,2	4
	2.1	Distributed database concepts - overview of client - server architecture and its relationship to distributed databases, Homogeneous and Heterogeneous Databases, Distributed Data Storage, Distributed Transactions, Distributed Database Management System (DDBMS). DDBMS Architecture, Design, strategies (top-down, bottom-up), Fragmentation, Allocation and replication of fragments. Query Processing Overview, Query Optimization and Concurrency control		
3		Data interoperability – XML and JSON	10	4
	3.1	XML Databases: Document Type Definition, XML Schema, Querying and Transformation: XPath and XQuery, XML Technologies: DOM		

		&SAX Interfaces X pointer, Xlink, XHTML, SOAP, WSDL, UDDI, XML database Application Basic JSON syntax, (Java Script Object Notation),JSON data types, Stringifying and parsing the JSON for sending & receiving, JSON Object retrieval using key-value pair and JQuery, XML Vs JSON		
4		Object oriented database	8	5
	4.1	Notion of Abstract Data Type, Object Oriented Systems, Object Oriented Database: Object Identity, Object structure, Type Constructors, Encapsulation of Operations, Methods, Persistence, Type and Class Hierarchies, Inheritance, Complex Objects, Object-oriented DBMS, Languages and Design: ODMG Model, Object Definition Languages (ODL), Object Query Languages (OQL). Object Oriented DB Design. Expert Databases: Use of Rules of Deduction in Databases, Recursive Rules.		
5		**NoSQL Distribution Model**	1,2	4
	5.1	NoSQL database concepts: NoSQL data modeling, Benefits of NoSQL, comparison between SQL and NoSQL database system, Replication and sharding, Distribution Models Consistency in distributed data, CAP theorem, Notion of ACID Vs BASE, handling Transactions, consistency and eventual consistency, Types of NoSQL databases: Key-value data store, Document database and Column Family Data store, Comparison of NoSQL databases w.r.t CAP theorem and ACID properties		
6		NoSQL using MongoDB	3,9	4
	6.1	NoSQL using MongoDB: Introduction to MongoDB Shell, Running the MongoDB shell, MongoDB client, Basic operations with MongoDB shell, Basic Data Types, Arrays, Embedded Documents , Querying MongoDB using find() functions, advanced queries using logical operators and sorting, simple aggregate functions, saving and updating document. MongoDB Distributed environment: Concepts of replication and horizontal scaling through sharding in MongoDB		
7		Trends in Advance databases	2	2
	7.1	Temporal database: Concepts, time representation, time dimension, incorporating time in relational databases. Graph Database: Introduction, Features, Transactions, consistency, Availability, Querying, Case Study Neo4J Spatial database: Introduction, data types, models, operators and queries		
			Total	**26**

Sr.no	Suggested List of experiments
1	Design data warehouse for any application
2	Perform OLAP Operations using Tool

3	Design Distributed database for any real-life example
4	Write XML query
5	Develop some XML application
6	Perform CRUD operations on NoSQL database queries
7	Write MongoDB queries
8	Perform ETL operations on Tableau database
	Mini project/presentation/Article discussion/ Research paper implementation

Course Assessment:

Theory:

ISE-1:

Activity: Quiz and assignments 20 Marks

ISE-2:

Activity: Article Discussion, Quiz and Assignments

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Lab:

ISE:

1. ISE-1 will be conducted for four experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

2. ISE-2

a. Four experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

b. Mini project//presentation/Article discussion/ Research paper implementation for 10 marks

Recommended Books:

1. Elmasri and Navathe, Fundamentals of Database Systems, 6th Edition, *Addison-Wesley*, 2003
2. Korth, Siberchatz,Sudarshan, "Database System Concepts", 6 thEdition, McGraw Hill , 2010
3. Niall O'Higgins, "Mongo D B and Python", O'reilly, 2011.
4. Distributed Database; Principles & Systems By Publications, Stefano Ceri and Giuseppo Pelagatti,, McGraw-Hill International Editions (1984)
5. George M. Marakas, "Modern Data Warehousing, Mining and Visualization: Core Concepts", Pearson Education
6. Alex Berson & Stephen J. Smith, "Data Warehousing, Data Mining & OLAP", Tata McGraw-Hill
7. Sam Anahory, Dennis Murray ,"Data Warehousing in the real World", Pearson Education Chapter and Section-W
8. Won Kim, "Introduction to Object-Oriented Databases", MIT press
9. PramodSadalge, Martin Fowler, NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence, Addison Wesely/ Pearson
10. Jeff Friesen , Java XML and JSON, Second Edition, 2019, après Inc.

Online Recourses:

1. https://cassandra.apache.org
2. https://www.mongodb.com
3. https://riak.com
4. https://neo4j.com
5. https://martinfowler.com/articles/nosql-intro-original.pdf
6. https://www.w3schools.com/js/js_jquery_elements.asp

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
PCC21CE02	Advance Algorithms and Complexity	2	- -	2	2	--	1	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE		Total
		Theory	20	30	20	100 (30% weightage)		100
		Lab	20	--	30	--		50

Pre-requisite		Data Structure and Analysis of Algorithm
Course Outcomes	CO1	Apply different analysis techniques to compute complexity. (Apply) (Asymptotic, Amortized, Probability and Randomization)
	CO2	Describe appropriate data structure and design techniques for different problems. (Apply)
	CO3	Apply appropriate algorithms to be applied for the various application like geometric modelling, robotics, network flow etc. (Apply)
	CO4	Design approximation algorithms to solve NP-Complete Problems (Design)

Module No.	Unit No.	Topics	Ref.	Hrs
1	1.1	**Fundamental of Algorithms:** Asymptotic Notations, Properties of Asymptotic Comparisons, Theorem related to Asymptotic Notations, Proving technique (contradiction, mathematical induction), Complexity of Recursive Algorithms	1,2	2
2	2.1	**Analysis Techniques:** Amortized Analysis - Aggregate analysis, accounting method, Potential method, Dynamic tables Probabilistic Analysis and Randomized Algorithms - The hiring problem, Indicator random variables.	1,2	2
3	3.1	**Advanced Data Structures:** **Heap:** Priority queues and binary heap trees, Binomial heaps, Fibonacci heaps, Comparison of heap time complexities, Heap sort	1,2	8
	3.2	**Advanced Trees:** 2-3 tress, 2-3-4 trees, Red-Black Trees, Splay trees, Tries.		
4	4.1	**Flow Networks** Flow networks, Ford Fulkerson method, Max bipartite matching	3	4
5	5.1	**Computational Geometry** Line Segment properties, determining whether any pair of segment intersects, finding the convex hull, finding the closest	1,2	3

		pair of points.		
6	**6.1**	**Approximation algorithms** Vertex-cover problem, Traveling-salesman problem, Set-covering problem, Subset-sum problem	3	4
7	**7.1**	**Computational Complexity** Polynomial Time verification, Reducibility, NP-completeness - Complexity Classes, NP-Hard and NP-Complete problems.	3	3
		Total		**26**

- **Course Assessment:**

Theory:

ISE-1: Activity: Regular Quizzes of 20 Marks
ISE-2: Activity: Regular Quizzes of 20 Marks
MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Lab:

ISE-1: Practical Assessment after completing first 4 experiments (20 Marks)
ISE-2: Practical Assessment after completing next 4 experiments (20 Marks)
Article Presentation. (10 Marks)

Module No.	Suggested List of experiments
	Randomized Algorithms
1.	a. Randomized Quick sort b. Searching a Skip List
	Advanced Data Structures
2.	a. Heap Sort b. Binary Heap c. Binomial Heap d. Fibonacci Heap
	Trees
3.	a. 2-3-4 Tree operations b. RB Tree operations c. Splay Tree d. Tries
	Flow Networks
4.	a. Ford Fulkerson's algorithm b. Relabel to front algorithm
	Computation Geometry
5.	a. Segment Intersection b. Convex Hull c. Closest Pair of points

Approximation Algorithms	
6.	a. Vertex Cover b. Boolean Satisfiability Problem c. Travelling Salesman Problem d. Knapsack problem

Recommended Books:

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, "Introduction to Algorithms", PHI, India Second Edition.
2. Ellis Harwitz, Sartaz Sahani, "Fundamentals of Computer Algorithms", Galgotia.
3. Harsh Bhasin, "Algorithms – Design and Analysis", Oxford.

Further Reading:

1. Rajeev Motwani, Prabhakar Raghavan , "Randomized algorithms", Delhi Cambridge University Press 1995
2. Mark de Berg, Marc van Kreveld, Mark Overmars, and Otfried Schwarzkopf, "Computational Geometry: Algorithms and Applications". Springer-Verlag, 2000. ISBN: 3540656200.

Online Resources:

1. https://nptel.ac.in/courses/106104019
2. https://www.coursera.org/learn/advanced-algorithms-and-complexity

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC21CE011	High Performance Computing	L	T	P	L	T	P	Total
		2	--	2	2	--	1	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Lab	20	--	30	--	50	

Pre-requisite	Computer Organization and Architecture	
Course Outcomes	CO1	Explain the design principles and architecture of modern processors.
	CO2	Discuss about data classification and data access optimization techniques.
	CO3	Discuss shared- and distributed-memory parallel computer architectures and the most relevant network topologies
	CO4	Describe the parallel scalability metrics and performance models.
	CO5	Examine the performance issues in shared memory parallel programming using OpenMP.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Processors** **Stored Program Computer Architecture** - General purpose cache- based microprocessor- Performance based metrics and benchmarks- Moore's Law- Pipelining- Super scalarity SIMD Memory Hierarchies Cache	[1][2]	03
	1.2	**Multicore processors-** Multithreaded processors- Vector Processors- Design Principles- Maximum performance estimates- Programming for vector architecture.		03
2	2.1	**Data Access Optimization-** Balance analysis and lightspeed estimates- Storage order	[1][2][3]	02
	2.2	Algorithm classification and access optimizations		02
3	3.1	**Parallel Computers-** Taxonomy of parallel computing paradigms- Shared memory computers- Cache coherence- UMA – cc NUMA Distributed-memory computers.	[4][5]	03
	3.2	**Networks-Basic performance characteristics-** Buses- Switched and fat- tree networks- Mesh networks- Hybrids. Basics of parallelization- Data and Functional parallelism.		03

4	**4.1**	**Parallel Scalability-** Factors that limit parallel execution- Scalability metrics- Simple scalability laws- parallel efficiency	4][5]	03
	4.2	**Refined performance models-** Choosing the right scaling baseline.	4][5]	03
5	**5.1**	**Shared Memory Parallel Programming with OPENMP-** Introduction to OpenMp - parallel execution - data scoping- OpenMp work sharing for loops synchronization - reductions - loop scheduling – tasking.	[2][5][6]	04
			Total	**26**

Module No.	Sr.no	Suggested List of experiments
1	**1**	Write an algorithm and program to perform matrix multiplication of two n * n matrices on the 2-D mesh SIMD model, Hypercube SIMD Model or multiprocessor system.
	2	Implement Pipelines, memory, low level parallelization using OpenMp.
2	**3**	Study of the Jacobi algorithm and Dense matrix transpose-
	4	Study of the Sparse matrix-vector multiply
3	**5**	Study of the all pair shortest path All-pairs Dijkstra's algorithm
	6	Study of the all pair shortest path All-pairs Floyd's algorithm
4	**7**	Study of Scalability for Single board Multi-board, multi-core, multiprocessor using Simulator.
	8	Study of Stochastic Model of Diffusion
		Implementation of parallel Jacobi Algorithm using OpenMp.

Course Assessment:

Theory:

ISE-1:
Activity: Quiz and assignments 20 Marks
ISE-2: Two hours 20 Marks
Activity: Article Discussion, Quiz and Assignments
Outcome: Reflective Journal
MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Lab:

ISE:
1. ISE-1 will be conducted for four experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2

a. Four experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Simulation using modern tools to solve the given problem statement for 10 marks

Recommended Books:

[1] Georg Hager, Gerhard Wellein, Introduction to High Performance Computing for Scientists and Engineers, Chapman & Hall / CRC Computational Science series, 2011.

[2] Gene Wagenbreth and John Levesque, High performance Computing: Programming and Application,CRC press, Taylor and francis group, 2010.

[3] MaciejBrodowicz, Matthew Anderson, and Thomas Sterling, High Performance Computing: Modern Systems and Practices, Morgankaufmann publishers, 2017.

[4] High Performance Cluster Computing, Volume 1, Architecture and Systems, Rajkumar Buyya, Pearson Education. 1999.

[5] Berman, Fox and Hey, Grid Computing – Making the Global Infrastructure a Reality, Wiley India., 2003

[6] Hurwitz, Bllor, Kaufman, Halper, Cloud Computing for Dummies, Wiley India, 2010.

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC21CE012	Quantum Computing	L	T	P	L	T	P	Total
		2	--	2	2	--	1	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Lab	20	--	30	--	50	

Pre-requisite	Wave Function, Operator, Orthogonality and Normalization Condition	
Course Outcomes	CO1	Explain basic concepts of quantum computing
	CO2	Illustrate building blocks of quantum computing through architecture and programming models.
	CO3	Appraise various mathematical models required for quantum computing
	CO4	Discuss various quantum hardware building principles.
	CO5	Identify the various quantum algorithms
	CO6	Describe usage of tools for quantum computing

Module No.	Unit No.	Topics	Hrs.
1	**Introduction to Quantum Computing**		6
	1.1	Motivation for studying Quantum Computing Origin of Quantum Computing Quantum Computer vs. Classical Computer Introduction to Quantum mechanics Overview of major concepts in Quantum Computing	
	1.2	Qubits and multi-qubits states Bloch Sphere representation Quantum Superposition Quantum Entanglement Major players in the industry (IBM, Microsoft, Righetti, D-Wave etc.)	
2	**Building Blocks for Quantum Program**		7
	2.1	Architecture of a Quantum Computing platform Details of q-bit system of information representation: Block Sphere Multi-Qubits States Quantum superposition of qubits (valid and invalid superposition) Quantum Entanglement Useful states from quantum algorithmic perceptive e.g. Bell State Operation on qubits: Measuring and transforming using gates. Quantum Logic gates and Circuit No Cloning Theorem and Teleportation	
	2.2	Programming model for a Quantum Computing Program Steps performed on classical computer Steps performed on Quantum Computer Moving data between bits and qubits.	
3	**Building Blocks for Quantum Program**		7
	3.1	Architecture of a Quantum Computing platform Details of q-bit system of information representation: Block Sphere Multi-Qubits States Quantum superposition of qubits (valid and invalid superposition) Quantum	

		Entanglement Useful states from quantum algorithmic perceptive e.g. Bell State Operation on qubits: Measuring and transforming using gates. Quantum Logic gates and Circuit No Cloning Theorem and Teleportation	
	3.2	Programming model for a Quantum Computing Program Steps performed on classical computer Steps performed on Quantum Computer Moving data between bits and qubits.	
4	**Quantum Algorithm - I**		3
	4.1	Quantum parallelism, Quantum Evolution, Deutsch's Algorithm, Deutsch-Jozsa Algorithm, Simon's periodicity algorithm.	
5	**Quantum Algorithm - II**		3
	5.1	Grover's search algorithm, Shor's Factoring algorithm. Application of entanglement, teleportation, superdense coding.	
		Total	**26**

Suggested List of experiments:

Sr.no	Students are required to complete at least 10 experiments. Faculty may develop their own set of experiments for students. List below is only suggestive.
1	Building Quantum dice.
2	Building Quantum Random No. Generation.
3	Composing simple quantum circuits with q-gates and measuring the output into classical bits.
4	Implementation of Shor's Algorithms.
5	Implementation of Grover's Algorithm.
6	Implementation of Deutsch's Algorithm.
7	Implementation of Deutsch-Jozsa's Algorithm.
8	Quantum Circuits
9	Qubit Gates
10	Bell Circuit & GHZ Circuit
11	Accuracy of Quantum Phase Estimation
12	Mini Project such as implementing an API for efficient search using Grover's Algorithms or Integer factorization using Shor's Algorithm.

Course Assessment:

Theory:

ISE-1:
Activity: Quiz and assignments 20 Marks
ISE-2: Two hours 20 Marks
Activity: Article Discussion, Quiz and Assignments
Outcome: Reflective Journal
MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Lab:

ISE:

1. ISE-1 will be conducted for six experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

2. ISE-2

a. Remaining experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

b. Simulation using modern tools to solve the given problem statement for 10 marks

Textbooks:

1. Quantum computing explained, David McMahon, Wiley-interscience, John Wiley & Sons, 2008.
2. 2. Quantum computing for computer scientists, Noson S. Yanofsky, Mirco A. Mannucci, Cambridge University Press 2008.
3. Michael A. Nielsen, "Quantum Computation and Quantum Information", Cambridge
4. University Press.
5. Vladimir Silva, Practical Quantum Computing for Developers,2018
6. Qiskit textbook https://qiskit.org/textbook-beta/.

References:

1. Introduction to Quantum Mechanics, 2nd Edition, David J. Griffiths, Prentice Hall New Jersey 1995.
2. Supriyo Bandopadhyay and Marc Cahy, "Introduction to Spintronics", CRC Press, 2008.
3. Quantum computation and quantum information, Michael A. Nielsen and Isaac L. Chuang, Cambridge University Press 2010.
4. Bernard Zygelman, A First Introduction to Quantum Computing and Information,2018.
5. The Second Quantum Revolution: From Entanglement to Quantum Computing and Other Super-Technologies, Lars Jaeger.
6. La Guardia, Giuliano Gladioli "Quantum Error correction codes" Springer,2021.

Digital References:

1. https://onlinecourses.nptel.ac.in/noc21_cs103/preview.
2. https://www.coursera.org/courses?query=quantum%20computing.
3. https://www.cl.cam.ac.uk/teaching/1617/QuantComp/.

Useful Links:

1. IBM Experience: https://quantum-computing.ibm.com/.
2. Microsoft Quantum Development Kit https://azure.microsoft.com/en-us/resources/development-kit/quantum-computing/#overview.
3. Forest SDK PyQuil: https://pyquil-docs.rigetti.com/en/stable/.
4. Google Quantum CIRQ https://quantumai.google/cirq.
5. Qiskit Labs IBM https://learn.qiskit.org/course/ch-labs/lab-1-quantum-circuits.

Virtual Labs:

1. https://lab.quantumflytrap.com/lab/mach-zehnder?mode=waves.
2. https://home.iitd.ac.in/index.php.
3. https://quantumcomputing.negd.in/.
4. https://iitmandi.ac.in/CQST/.
5. https://learn-xpro.mit.edu/quantum-computing?.

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC21CE013	Embedded Systems and RTOS	L	T	P	L	T	P	Total
		2	--	2	2	--	1	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Lab	20	--	30	--	50	

Pre-requisite	Computer Hardware and Operating System	
Course Outcomes	CO1	Identify and describe various characteristic features and applications of embedded systems.
	CO2	Analyse and select suitable hardware and communication protocol for embedded systems implementation
	CO3	Analyse Task Scheduling Algorithms and Resource Access protocols for Real Time Applications.
	CO4	Compare GPOS and RTOS and Apply the concepts of RTOS to Real Time Applications

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to Embedded Systems**		
	1.1	Introduction, Definition, Characteristics & Salient Features, Classification, Application Areas, Overview of Embedded System Architecture & Recent Trends.	1,4, 5	6
	1.2	Design metrics of Embedded system and Challenges in optimization of metrics	1,4, 5	
2		**Embedded Hardware and Communication Protocol**		
	2.1	Features of Embedded cores- µC, ASIC, ASSP, SoC, FPGA, RISC and CISC cores. Types of memories.	1,6	
	2.2	Communication Interfaces: Comparative study of Serial communication Interfaces (RS-232, RS-485), SPI, I2C, CAN, USB (v2.0), Bluetooth, Zig-Bee. (**Frame formats of above protocols are not expected)**	1,4, 5	
3		**TASK Scheduling and Resource Access Protocols**		8
	3.1	PERIODIC TASK SCHEDULING :Timeline scheduling,Rate Monotonic scheduling,Earliest Deadline First,Deadline Monotonic, EDF with constrained deadlines ,Comparison between RM and EDF	3	
	3.2	LIMITED PREEMPTIVE SCHEDULING Introduction ,Non-preemptive scheduling, Preemption thresholds , Deferred Preemptions,Task splitting,Selecting preemption points, Assessment of the approaches	3	
	3.3	RESOURCE ACCESS PROTOCOLS	3	

		The priority inversion phenomenon , Terminology and assumptions, Non-Preemptive Protocol,Highest Locker Priority Protocol, Priority Inheritance Protocol,Priority Ceiling Protocol,Stack Resource Policy ,Schedulability analysis.		
4		**Real Time Operating Systems**		
	4.1	Foreground and Background Process – Resources – Tasks – Multitasking – Priorities – Schedulers – Real-time Operating system :- Need of RTOS in Embedded system software and comparison with GPOS, Task Kernel – Exclusion – Inter-task Communication – Interrupts – Clock Tick – MicroC/OS II Kernel Structure – MicroC/OS II initialisation – Starting MicroC/OS II.	2	8
	4.2	Task Management – Time Management – Semaphore Management – Mutual Exclusion - Semaphore. Event Management – Message Management – Memory Management – Porting MicroC/OS II.	2	
5		**Priority Servers**		4
	5.1	FIXED-PRIORITY SERVERS Introduction : Background scheduling , Polling Server, Deferrable Server. Priority Exchange, Sporadic Server, Slack stealing.	2	
	5.2	DYNAMIC PRIORITY SERVERS Introduction ,Dynamic Priority Exchange Server ,Dynamic Sporadic Server. Total Bandwidth Server,Earliest Deadline Late Server,Improved Priority Exchange Server.	2	
			Total	**26**

Module No.	Sr.no	Suggested List of experiments
3	**1**	Write the pseudo code in Linux using C/C++ to perform Priority Based scheduling
4	**2**	Porting of FreeRTOS to Arduino/STM32
4	**3**	Write a Program to Create Multiple Tasks and understand the Multitaskingcapabilities of RTOS(FreeRTOS)
4	**4**	Write a Program to illustrate the Queue Management Features of FreeRTOS.
4	**5**	Write a Program to illustrate the Event Management Features of FreeRTOS.
4	**6**	Write a Program to illustrate the use of Binary and Counting Semaphore for Task Synchronisation using FreeRTOS
4	**7**	Porting FreeRTOS on Rasberry Pi
4	**8**	Self-navigating robot in Pi FreeRTOS

Course Assessment:

Theory:

ISE-1:

Activity: Quiz and assignments 20 Marks

ISE-2: Two hours 20 Marks
Activity: Article Discussion, Quiz and Assignments
Outcome: Reflective Journal
MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Lab:

ISE:

1. ISE-1 will be conducted for four experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

2. ISE-2

a. Four experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Simulation using modern tools to solve the given problem statement for 10 marks

Recommended Books:

1. Dr. K.V. K. K. Prasad, "Embedded Real Time System: Concepts, Design and Programming", Dreamtech, New Delhi, Edition 2014.
2. Jean J Labrosse,"MicroC/OS II, The Real Time Kernel " 2nd edition, 2002
3. Georgio C. Buttazo,"Hard Real Time Computing Systems", Predictable Scheduling Algorithm and Applications,Springer,2nd edition, 2005
4. Rajkamal, "Embedded Systems: Architecture, Programming and Design", McGraw Hill Education (India) Private Limited, New Delhi, 3rd Edition,2015.
5. SriramIyer, Pankaj Gupta," Embedded Real Time Systems Programming", Tata McGraw Hill Publishing Company ltd., 2003.
6. Joseph Yiu,"The Definitive guide to ARM CORTEX-M3 & CORTEX, 2nd edition, 2013

Online Resources:

Lab Reference

1. Lab Workshop on Embedded RTOS – NPTEL+
2. https://github.com/feilipu/Arduino_FreeRTOS_Library
3. http://www.micropik.com/PDF/HCSR04.pdf
4. http://wiki.beyondlogic.org/index.php?title=Understanding_RaspberryPi_Boot_Process
5. **http://www.freertos.org/**

https://embeddedcomputing.com/technology/open-source/linux-freertos-related/using-freertos-with-the-raspberry-pi-pico

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned		
		L	T	P	L	P	Total
PEC21CE021	Geographical Information Systems	2	0	2	2	1	3
		Examination Scheme					
			ISE1	MSE	ISE2	ESE	Total
		Theory	20	30	20	100 (30% weightage)	100
		Lab	20		30		50

Pre-requisite	-	
Course Outcomes	CO1	Demonstrate GIS fundamentals with critical insights.
	CO2	Differentiate between different spatial data structures and formats
	CO3	Collect spatial data from diverse sources and integrate them into GIS projects.
	CO4	Apply GIS software proficiently to manipulate spatial data, execute analyses, and generate maps.
	CO5	Execute spatial data queries and geoprocessing tasks proficiently to extract significant information from spatial datasets and assess spatial relationships.

Module No.	code	Topics	Ref.	Hrs.
1		**Introduction to Geographic Information System:** Definition and history, recent trends and applications of GIS; purpose and benefits of GIS, functional components of GIS, importance of GPS and remote sensing data in GIS. **Geographic Phenomena:** defining geographic phenomena, types of geographic phenomena, Geographic fields, Geographic objects, Boundaries	1	4
2		**Data models and structure:** Vector and Raster model, TIN (Triangulated reregulated network) data model, comparison of Vector & raster data, Advantages and disadvantages associated with vector, raster and TIN, geodatabase and relational database, **i**ntroduction to toposheet. various open data sources.	1	5
3		**GIS input data:** **Vector Data: -s**ources for GIS Data Shape files, vector Data Input – georeferencing, map digitization and editing, topological Relationship.	2	5

		Raster Data Input – Digital Elevation Mode (DEM)-introduction to DEM, types of dem, uses of dem & different types of resolution, introduction to satellite images, image classification, quality assessment of freely available digital elevation model, raster data compression techniques, Different raster and vector data file formats, Raster to Vector and Vector to Raster Conversion, preprocessing of spatial data sets		
4		**GIS Data Analysis**: Introduction to GIS data Analysis – processes and steps, software and tools used, data selection, reclassification, overlaying analysis, buffer analysis, spatial analysis (Dem Analysis,) surface analysis, network analysis, proximity analysis, vector & raster analysis methods. **Error Propagation in spatial data processing:** how errors propagate, quantifying error propagation	3	8
5		**Data Visualization:** Qualitative and Quantitative data visualization, Map outputs and its basic elements, SDI concepts and its current trend	4	4
		Total		**26**

Module No.	Sr.no	Suggested List of experiments
1	**1**	Introduction to GIS software (QGIS, ArcGIS)
2	**2**	Geo referencing and projection of toposheet, Digitization of map/ Toposheet.
3	**3**	Spatial Data Analysis
	4	Preparation of Non-Spatial Data, Linking Spatial and Non-Spatial data
	5	Google earth integrations in GIS.
4	**6**	Spatial and Non spatial Query and Analysis
	7	Vector data analysis
	8	Watershed Analysis
	9	Terrain Analysis
	10	Network Analysis

Course Assessment:

Theory:

ISE-1:

Activity: Quiz & assignments-10Marks
Case study- 10Marks
ISE-2: Two hours 20 Marks
Activity: Article Discussion, Quiz and Assignments
Outcome: Reflective Journal

MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Lab

ISE:

1. ISE-1 will be conducted for five experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

2. ISE-2

a. Five experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Simulation using modern tools to solve the given problem statement for 10 marks

Recommended Books:

[1] Otto Huisman, Rolf A, "Principles of geographic information systems: An Introductory textbook", International Institute for Geo-information science and Earth observation,2009, 4th Edition
[2] Jonathan Campbell and Michael Shin, "Essentials of Geographic Information Systems", 2011, Saylor Foundation
[3] Chang Kang-tsung (Karl), "Introduction to Geographic Information Systems", McGrawHill,2013, 7th Edition
[4] Heywood, I., Cornelius, S., and Carver S, "An Introduction to Geographical Information Systems", Prentice Hall, U.S.A, 2012

Online Resources:

Esri Training course
IIRS-ISRO course on GIS
NPTEL course on GIS

Further Reading:

ESRI guide to GIS analysis Andy Mitchell, ESRI press, Red lands

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC21CE022	Agile Methodologies in Software Engineering	L	T	P	L	T	P	Total
		2	--	2	2	--	1	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Lab	20	--	30	--	50	

Pre-requisite		Foundations of Software Engineering
Course Outcomes	CO1	Analyze the principles and practices of agile software development methodologies, including Scrum, Kanban, and Extreme Programming (XP), to understand their applicability in various software development contexts.
	CO2	Evaluate the roles and responsibilities of team members within an agile development environment, emphasizing the importance of collaboration, communication, and self-organization for successful project outcomes.
	CO3	Implement agile project management techniques for scope and schedule.
	CO4	Apply agile engineering practices to enhance software quality.
	CO5	Evaluate challenges and propose strategies for agile adoption in diverse contexts.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction to Agile Software Development:** Overview of Agile Principles and Values, Comparison with Traditional Software Development Models, Agile Manifesto and its Principles, Popular Agile Methodologies: Scrum, Kanban, XP	1,2	4
2	2.1	**Agile Team Dynamics:** Roles and Responsibilities in Agile Teams, Characteristics of High-Performing Agile Teams, Communication and Collaboration Techniques, Self-Organization and Empowerment	2,3	4
3	3.1	**Agile Project Management:** Agile Project Lifecycle: Planning, Execution, Monitoring, and Delivery, User Stories and Product Backlog Management, Sprint Planning, Review, and Retrospective Meetings, Agile Metrics and Progress Tracking	3,4,5	6
4	4.1	**Agile Engineering Practices:** Test-Driven Development (TDD), Continuous Integration (CI) and Continuous Deployment (CD),	4,5	4

		Refactoring and Code Quality Improvement, Pair Programming and Code Reviews		
5	**5.1**	**Scaling Agile:** Challenges in Scaling Agile for Large Projects, Agile Frameworks for Scaling: SAFe, LeSS, Nexus, Distributed Agile Teams: Communication and Coordination Strategies, Agile Transformation: Organizational Change Management	5,6	4
6	**6.1**	**Agile Case Studies and Best Practices:** Real-world Case Studies of Successful Agile Implementations, Lessons Learned and Best Practices from Industry, Agile Maturity Models and Assessments, Continuous Learning and Improvement in Agile Teams	4,5,6	4
			Total	**26**

Module No.	Sr.no	Suggested List of experiments
1	**1**	**Scrum Framework Introduction Lab:** Students will be introduced to the Scrum framework, its roles, ceremonies, and artifacts.
	2	**Kanban Board Setup Lab:** Students will set up and use a Kanban board to manage project tasks and workflow
2	**3**	**Team Formation Simulation Lab:** Students will simulate team formation scenarios and assign roles based on Agile team dynamics.
	4	**Communication and Collaboration Exercise:** Students will participate in exercises to enhance communication and collaboration within Agile teams.
3	**5**	**User Story Creation Lab:** Students will create and prioritize user stories for a given project, emphasizing Agile requirements management.
	6	**Sprint Planning and Review Meeting Simulation:** Students will simulate sprint planning and review meetings to understand the Agile project management process.
4	**7**	**Test-Driven Development (TDD) Practice Session:** Students will practice Test-Driven Development (TDD) by writing tests before implementing features.
	8	**Continuous Integration Demonstration Lab:** Students will set up and demonstrate continuous integration practices using appropriate tools.
5	**9**	**Scaled Agile Framework (SAFe) Exploration Lab:** Students will explore and analyze the components of the Scaled Agile Framework (SAFe) for large-scale Agile implementations.

	10	**Distributed Agile Team Communication Exercise:** Students will engage in exercises to improve communication and coordination in distributed Agile teams.

Course Assessment:

Theory:

ISE-1:
Activity: Quiz and assignments 20 Marks
ISE-2: Two hours 20 Marks
Activity: Article Discussion, Quiz and Assignments
Outcome: Reflective Journal

MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Lab:

ISE:
1. ISE-1 will be conducted for five experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2
a. Five experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Simulation using modern tools to solve the given problem statement for 10 marks

Recommended Books:

[1] J. Sutherland, "*Scrum: The Art of Doing Twice the Work in Half the Time*", Crown Business, 2014.
[2] P. Lencioni, "*The Five Dysfunctions of a Team*", Jossey-Bass, 2002.
[3] K. Schwaber, "*Agile Project Management with Scrum*", Microsoft Press, 2004.
[4] K. Beck, "*Test-Driven Development: By Example*", Addison-Wesley, 2003.
[5] C. Larman and B. Vodde, "*Scaling Lean & Agile Development: Thinking and Organizational Tools for Large-Scale Scrum*", Addison-Wesley, 2008.
[6] E. Ries, "*The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses*", Currency, 2011.

Online Resources:

- Agile Manifesto: https://agilemanifesto.org/
- Scrum Guide: https://www.scrumguides.org/
- Tuckman's Stages of Group Development: https://www.verywellmind.com/tuckmans-stages-of-group-development-2795159
- Agile Project Management Tools: https://www.atlassian.com/agile
- TDD Basics: https://www.agilealliance.org/glossary/tdd/
- Scaled Agile Framework (SAFe): https://www.scaledagileframework.com/
- Agile Case Studies: https://www.agilealliance.org/resources/experience-reports/

Further Reading:

[1] M. Cohn, "Agile Estimating and Planning", Prentice Hall, 2006.
[2] D. Pink, "Drive: The Surprising Truth About What Motivates Us", Riverhead Books, 2011.
[3] D. J. Anderson, "Kanban: Successful Evolutionary Change for Your Technology Business", Blue Hole Press, 2010.
[4] N. Perkin and P. Abraham, "Agile Transformation: A Guide to Organizational Change", Kogan Page, 2018.
[5] A. Elssamadisy, "Agile Adoption Patterns: A Roadmap to Organizational Success", Addison-Wesley, 2007.
[6] Agile Maturity Models: https://agilemanifesto.org/

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC21CE023	Block chain Technology & DeFi	L	T	P	L	T	P	Total
		2	--	2	2	--	1	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes	Data Structures, Cryptography and System Security	
Course Outcomes	CO1	Illustrate the working of the of blockchain technology
	CO2	Explain the processes involved in public blockchain.
	CO3	Apply the concepts of private blockchain to Hyperledger fabric
	CO4	Discuss the infrastructure of the Defi and the latest development in the technology.
	CO5	Create the ERC tokens and share with the peers.
	CO6	Develop smart contracts for real world applications and mine a block.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction to blockchain:** What is blockchain, components of blockchain, Structure of a Block, The Genesis Block, Merkle Tree	1, online: 1	05
	1.2	**Types:** Public, Private, hybrid and Consortium		
	1.3	Decentralized Consensus, consensus algorithms		
2	2.1	**Public blockchain**: Introduction to Public Blockchain, basics of Bitcoin, Ethereum and its Components, Mining in Ethereum, Ethereum Virtual Machine (EVM), Transaction, Accounts, Architecture and Workflow, Comparison between Bitcoin and Ethereum	1, 3 Online: 3,4	08
	2.2	Introduction to Smart Contracts, Types of Smart Contracts		
	2.3	**Introduction to Programming:** Solidity Programming – Basics, functions, function identifiers, variable types, Bytes and Enums, Arrays-Fixed and Dynamic Arrays, Special Arrays-Bytes and strings, Structure, Mapping, Inheritance, Error handling		
3	3.1	**Private Blockchain:** Key characteristics, Consensus Algorithms for Private Blockchain - PAXOS and RAFT, Byzantine Faults: Byzantine Fault Tolerant (BFT) and Practical BFT	1, 2,4 Online: 2	05
	3.2	**Hyperledger:** Introduction to Hyperledger, Tools and Frameworks,		

		Hyperledger Fabric Architecture, Components of Hyperledger Fabric: MSP, Chain Codes, Transaction Flow, Working of Hyperledger Fabric		
4	**4.1**	**Decentralized Finance (Defi):** Introduction to decentralized finance, Problems with traditional finance that DeFi tries to solve: Centralized control; Limited access; Inefficiency; Lack of interoperability; Opacity	5	04
	4.2	**Defi infrastructure:** blockchain, cryptocurrency, smart contract platforms, Oracles, stablecoins, Uniswap		
5	**5.1**	**Defi Primitives:** Transactions, Fungible tokens, non-fungible tokens, custody, supply adjustment	5	04
	5.2	**Smart contracts in finance:** credit/lending, decentralized exchanges, derivatives, tokenization		
			Total	**26**

Module No.	Sr.no	Suggested List of experiments
1	**1**	Create the genesis block using Puppeth, a CLI tool
	2	Create Merkle tree and trace a transaction in the tree.
2	**3**	Write smart contract in solidity to transfer ethers to an external wallet
	4	Mine a block and check account balance
3	**5**	Implement PAXOS/RAFT/BFT/pBFT algorithm.
	6	Case Study of Supply Chain Management using Hyperledger
4	**7**	Paper presentations on Defi.
	8	Group discussion on whether Defi should be implemented in India and its effects on the economy of the nation.
5	**9**	Create ERC token and share it with the peers.
	10	Discuss use cases of decentralized finance.

Course Assessment:

Theory:

ISE-1: 20 Marks
Activity: Test/Quiz/Assignments
ISE-2: Two hours 20 Marks
Activity: Article Discussion/Quiz/Assignments/Test
MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Lab:

ISE:

1. **ISE-1** Quizzes/Assignments/Paper Presentation/Article Discussion
   Quizzes/Assignments based on 50% experiments
2. **ISE-2** Quizzes/Assignments/Paper Presentation/Article Discussion

Quizzes/Assignments based on 50% experiments

Recommended Books:

1. Blockchain Technology, Chandramouli Subramanian, Asha A. George, Abhillash K. A and Meena Karthikeyen, Universities Press.
2. Blockchain with Hyperledger Fabric, Luc Desrosiers, Nitin Gaur, Salman A. Baset, Venkatraman Ramakrishna, Packt Publishing
3. Mastering Ethereum, Building Smart Contract and Dapps, Andreas M. Antonopoulos Dr. Gavin Wood, O'reilly.
4. Blockchain with Hyperledger Fabric, LucDesrosiers, Nitin Gaur, Salman A. Baset, Venkatraman Ramakrishna, Packt Publishing
5. Defi and the Future of Finance, Campbell Harvey, Aswin Ramachandran, Joey Santoro, Wiley.

Online Resources:

1. https://www.geeksforgeeks.org/components-of-blockchain-network/
2. https://www.hyperledger.org/use/fabric
3. https://docs.soliditylang.org/en/v0.7.4/
4. https://youtube.com/playlist?list=PLO5VPQH6OWdVQwpQfw9rZ67O6Pjfo6q-p

Further Reading:

1. Blockchain enabled Applications, Vikram Dhillon, Devid Metcalf, Max Hooper, Apress
2. Building Blockchain Projects, Narayan Prusty, Packt

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
OE2111	Constitution of India and Professional Ethics	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	150	

Pre-requisite	-	
Course Outcomes	CO1	Adhere to the core rights and shape one's values.
	CO2	Display the role and responsibility of Engineering professionals
	CO3	Hold moral and Ethical solutions to problems through case studies.
	CO4	Apply the knowledge of human values to contemporary ethical and global issues.
	CO5	Compare the three-tier system of the local govt. under the Indian Constitution

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Background and Approach: Fundamental Rights and Duties**		
	1.1	Fundamental Rights and Duties, Right to Compensation for being Illegally Deprived of one's Right to Life or Liberty, Right to Travel Abroad and Return to one's Country	7	2
	1.2	Promotion of Inter-Religious harmony and inter-faith values, Composite Culture	8	1
	1.3	Local self- government in the Indian Constitution- Case Studies meaning-Three-tier-system-Village-panchayath-Taluka panchayath Zilla-panchayath -Local bodies -Municipalities and Corporations, Bruhath mahanagara Palike. Functions of Election commission, UPSC, MPSC. [Self-Study]	7	
2		**Professional Ethics and Human Values**		
	2.1	Sense of Engineering Ethics - Variety of moral issues- Types of inquiry- Moral dilemmas –Moral Autonomy Moral dilemmas, Moral Autonomy, Kohlberg's theory Gilligan's theory, Consensus and Controversy, Profession& Professionalism, Models of professional roles, Theories about right action	1,2, 3,4, 5	3

		Codes of Ethics, Plagiarism		
	2.2	Human Values. Morals, values, and Ethics – Integrity- Academic integrity- Work Ethics- Service Learning- Civic Virtue Respect for others- Living peacefully- Caring and Sharing- Honestly- Cooperation Commitment Empathy-Self Confidence -Social Expectations.	4,5	2
	2.3	Managing conflict- Respect for authority- Collective bargaining- Confidentiality, Role of confidentiality in moral integrity-Conflicts of interest	2,5	2
3		**Global Ethical Concerns**		
	3.1	Multinational Corporations- Environmental Ethics- Business Ethics- Computer Ethics	2	2
	3.2	Engineers as Expert witnesses and advisors-Moral leadership- case studies		1
			Total	**13**

Course Assessment:

Theory:

ISE-1: Activity: Quiz and assignments **20 Marks**
ISE-2: Article Discussion, Quiz and Assignments **20 Marks**
MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial

ISE-1: AICTE & UNESCO's certificate course on Self-directed Emotional Learning for Empathy and Kindness (SEEK) **20 marks**
Link : https://www.framerspace.com/course/seek (Select SEEK self- directed cohort under the category of youth courses)

ISE-2: AICTE & UNESCO'S certificate course on Social Emotional Learning for Youth Waging Peace (SEL4YWP)- UNESCO **20 Marks**
Link: https://www.framerspace.com/course/ywp?cid=5eaff2c239109c2c12ef8bd3

**Participants need to register themselves in the link https://docs.google.com/spreadsheets/d/1dECtZbAmcPhKKelSEimVv-hzPV7dA_g-Brty2rxC2vE/edit?usp=sharing, before accessing the course content.

Case Study: Module 1.3 **10 Marks**

Recommended Books:

[1] Mike W Martin and Roland Schinzinger, Ethics in Engineering,4th edition, Tata McGraw Hill Publishing Company Pvt Ltd, New Delhi,2014
[2] Charles D Fleddermann, Engineering Ethics, Pearson Education/ Prentice Hall of India, New Jersey,2004.
[3] Charles E Harris, Michael S Protchard and Michael J Rabins, Engineering Ethics- Concepts and cases, Wadsworth Thompson Learning, United States,2005.
[4] M Govindarajan, S Natarajan and V S Senthil Kumar, Engineering Ethics, PHI Learning Private Ltd, New Delhi,2012.
[5] R S Naagarazan, A textbook on professional ethics and human values, New Age International (P) limited,New Delhi,2006.
[6] http://www.slideword.org/slidestag.aspx/human-values-and-Professional-ethics.
[7] Subhash C. Kashyap, Indian Constitution, National Book Trust, New Delhi.
[8] Baden Powell, BH, The Indian Village Community.

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
OE2112	Digital Business Management	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	150	

Pre-requisite	-	
Course Outcomes	CO1	Identify drivers of digital business
	CO2	Illustrate various approaches and techniques for E-business and management
	CO3	Prepare E-business plan

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction to Digital Business-** Introduction, Background and current status, E-market places, structures, mechanisms, economics and impacts Difference between physical economy and digital economy	1	9
	1.2	**Drivers of digital business**- Big Data & Analytics, Mobile, Cloud Computing, Social media, BYOD, and Internet of Things(digitally intelligent machines/services) Opportunities and Challenges in Digital Business	1	
2	2.1	**Overview of E-Commerce** **E-Commerce-** Meaning, Retailing in e-commerce-products and services, consumer behavior, market research and advertisement B2B-E-commerce-selling and buying in private e-markets, public B2B exchanges and support services, e-supply chains, Collaborative Commerce, Intra business EC and Corporate portals Other E-C models and applications, innovative EC System-From E-government and learning to C2C, mobile commerce and pervasive computing EC Strategy and Implementation-EC strategy and global EC, Economics and Justification of EC, Using Affiliate marketing to promote your e-commerce business, Launching a successful online business and EC project, Legal, Ethics and Societal impacts of EC	1	6

3	**3.1**	**Digital Business Support services**: ERP as e –business backbone, knowledge Tope Apps, Information and referral system	1	6
	3.2	**Application Development:** Building Digital business Applications and Infrastructure	1	
4	**4.1**	**Managing E-Business-**Managing Knowledge, Management skills for e-business, Managing Risks in e –business Security Threats to e-business -Security Overview, Electronic Commerce Threats, Encryption, Cryptography, Public Key and Private Key Cryptography, Digital Signatures, Digital Certificates, Security Protocols over Public Networks: HTTP, SSL, Firewall as Security Control, Public Key Infrastructure (PKI) for Security, Prominent Cryptographic Applications	1	6
5	**5.1**	**E-Business Strategy**-E-business Strategic formulation- Analysis of Company's Internal and external environment, Selection of strategy, E-business strategy into Action, challenges and E-Transition (Process of Digital Transformation)	1	4
6	**6.1**	**Materializing e-business: From Idea to Realization**-Business plan preparation **Case Studies and presentations**	1	8
				39

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus
   Continuous pre-defined rubrics-based evaluation for 20 marks.
2. **ISE-2** Three Assignments based on remaining 50% Syllabus
   Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books: -

1. A textbook on E-commerce, Er Arunrajan Mishra, Dr W K Sarwade,Neha Publishers & Distributors, 2011
2. E-commerce from vision to fulfilment, Elias M. Awad, PHI-Restricted, 2002
3. Digital Business and E-Commerce Management, 6th Ed, Dave Chaffey, Pearson, August 2014
4. Introduction to E-business-Management and Strategy, Colin Combe, ELSVIER, 2006
5. Digital Business Concepts and Strategy, Eloise Coupey, 2nd Edition, Pearson
6. Trend and Challenges in Digital Business Innovation, VinocenzoMorabito, Springer

7. Digital Business Discourse Erika Darics, April 2015, Palgrave Macmillan
8. E-Governance-Challenges and Opportunities in : Proceedings in 2nd International Conference theory and practice of Electronic Governance
9. Perspectives the Digital Enterprise –A framework for Transformation, TCS consulting journal Vol.5
10. Measuring Digital Economy-A new perspective- DoI:10.1787/9789264221796-enOECD Publishing

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned		
OE2113	Design of Experiments	L	T	P	L	T	Total
		2	1	0	2	1	3
		Examination Scheme					
			ISE1	MSE	ISE2	ESE	Total
		Theory	20	30	20	100 (30% weightage)	100
		Tutorial	20	--	30	--	50

Pre-requisite	Engineering Mathematics - III	
Course Outcomes	CO1	Plan data collection, to turn data into information and to make decisions that lead to appropriate action
	CO2	Apply the methods taught to real life situations
	CO3	Plan, analyze, and interpret the results of experiments

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction** Strategy of Experimentation Typical Applications of Experimental Design Guidelines for Designing Experiments Response Surface Methodology	1-5	6
2	2.1	**Fitting Regression Models** Linear Regression Models Estimation of the Parameters in Linear Regression Models Hypothesis Testing in Multiple Regression Confidence Intervals in Multiple Regression Prediction of new response observation Regression model diagnostics Testing for lack of fit	1-5	8
3	3.1	**Two-Level Factorial Designs** The 2^2 Design The 2^3 Design The General 2^k Design A Single Replicate of the 2^k Design The Addition of Center Points to the 2^k Design, Blocking in the 2^k Factorial Design Split-Plot Designs	1-5	7
4	4.1	**Two-Level Fractional Factorial Designs** The One-Half Fraction of the 2^k Design The One-Quarter Fraction of the 2^k Design The General 2^{k-p} Fractional Factorial Design	1-5	7

		Resolution III Designs Resolution IV and V Designs Fractional Factorial Split-Plot Designs		
5	**5.1**	**Response Surface Methods and Designs** Introduction to Response Surface Methodology The Method of Steepest Ascent Analysis of a Second-Order Response Surface Experimental Designs for Fitting Response Surfaces	1-5	7
6	**6.1**	**Taguchi Approach** Crossed Array Designs and Signal-to-Noise Ratios Analysis Methods Robust design examples	1-5	4
				39

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus
   Continuous pre-defined rubrics-based evaluation for 20 marks.
2. **ISE-2** Three Assignments based on remaining 50% Syllabus
   Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:

1. Raymond H. Mayers, Douglas C. Montgomery, Christine M. Anderson-Cook, Response Surface Methodology: Process and Product Optimization using Designed Experiment, 3rd edition,John Wiley & Sons, New York, 2001
2. D.C. Montgomery, Design and Analysis of Experiments, 5th edition, John Wiley & Sons, New York, 2001
3. George E P Box, J Stuart Hunter, William G Hunter, Statics for Experimenters: Design, Innovation and Discovery, 2nd Ed. Wiley
4. W J Dimond, Peactical Experiment Designs for Engineers and Scintists, John Wiley and Sons Inc. ISBN: 0-471-39054-2
5. Design and Analysis of Experiments (Springer text in Statistics), Springer by A.M. Dean, and D. T.Voss

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
CCL21CE01	Data Science	0	0	2	0	0	1	1
		Examination Scheme						
		ISE1	MSE		ISE2	ESE		Total
		20	--		30	--		50

Pre-requisite	Python / R Programming	
Course Outcomes	On successful completion of the course, the learner will be able to	
Course Outcomes	CO1	Apply supervised and unsupervised ML algorithms to solve real-world problems.
	CO2	Implement Deep learning models for signal/image processing applications.
	CO3	Build a Reinforcement Learning system for sequential decision-making.
	CO4	Develop a federated learning system that can be tested in distributed machine learning settings.

Exp. No.	Name of the experiment	Ref.	Hrs.
1	**Machine Learning – Supervised Learning**	1,2	2
	Solving classification problems (Fraud detection, spam detection etc.) using supervised learning techniques such as Naïve base/SVM/Decision tree.		
2	**Machine Learning – Unsupervised Learning**	1,2	2
	Apply clustering techniques (K-Means clustering/DBSCAN) for a given dataset (for example customer segmentation, Disease diagnosis, etc.)		
3	**Machine Learning – Ensemble Learning**	1,2	2
	Implement ensemble Learning Techniques for a classification problem.		
4	**Deep Learning – Convolution Neural Networks**	3,4	2
	To build convolution Neural Networks and use them to classify images (Faces, melanomas, etc.)		
5	**Deep Learning – Recurrent Neural Networks**	3,4	2
	To build an application for Speech Recognition/Text Summarization or Video Transcription using Recurrent Neural Networks.		
6	**Deep Learning – Generative Adversarial Networks**	3,4	2
	To build an application for Image style transfer using GAN.		

7	**Reinforcement Learning**	**5,6**	**2**
	Automated Stock Trading Using Deep Reinforcement Learning		
8	**Reinforcement Learning – Game design**	**5,6**	**2**
	Design of small game using Reinforcement learning		
9	**Federated Learning**	**7,8**	**2**
	Implement Sentiment analysis using FedAvg Federated Learning algorithm.		
10	**Federated Learning**	**7,8**	**2**
	Implement Image classification using any two federated Learning Algorithms (Federated Averaging, Federated Stochastic Gradient Descent, or Federated Proximal methods) and compare their performance based on appropriate metrics.		

Course Assessment

ISE:

1. ISE-1 will be conducted 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

2. ISE-2

a. will be conducted reaming 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

b. Presentation /Simulation using modern tools to solve the given problem statement for 10 marks

Recommended Books:

1. Ethem Alpaydın, "Introduction to Machine Learning", MIT Press.
2. Tom M. Mitchell, "Machine Learning", McGraw Hill.
3. Ian Goodfellow and Yoshua Bengio and Aaron Courville. Deep Learning. An MIT Press book. 2016.
4. Buduma, N. and Locascio, N., "Fundamentals of deep learning: Designing next-generation machine intelligence algorithms" 2017. O'Reilly Media, Inc.".
5. Andrew Barto and Richard S. Sutton," Reinforcement Learning: An Introduction", Second Edition, The MIT Press.
6. Sudharsan Ravichandiran," Hands-On Reinforcement Learning with Python, 2nd edition, Packt Publishing.
7. Dinesh C. Verma, "Federated AI for Real-World Business Scenarios, 1st edition, CRC Press.
8. Kiyoshi Nakayama, George Jeno," Federated Learning with Python", Packt Publishing.

Online Resources:

1. https://www.simplilearn.com/tutorials/deep-learning-tutorial/guide-to-building-powerful-keras-image-classification-models
2. A ten-minute introduction to sequence-to-sequence learning in Keras
3. https://www.learndatasci.com/tutorials/reinforcement-q-learning-scratch-python-openai-gym/
4. https://neptune.ai/blog/the-best-tools-for-reinforcement-learning-in-python
5. https://www.tensorflow.org/federated/federated_learning
6. https://towardsdatascience.com/federated-learning-a-step-by-step-implementation-in-tensorflow-aac568283399

NPTEL links:

- NPTEL course on "Machine Learning And Deep Learning - Fundamentals And Applications" by Prof. M. K. Bhuyan.
  https://nptel.ac.in/courses/108103192
- NPTEL course on "Deep Learning":, by Prof. Prabir Kumar Biswas
  https://onlinecourses.nptel.ac.in/noc19_cs54/preview
- NPTEL course on "Reinforcement Learning" by Prof. Balaraman Ravindran
  https://onlinecourses.nptel.ac.in/noc19_cs55/preview

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
SBL21CE01	Full Stack Development	0	0	2	0	0	1	1
		Examination Scheme						
		ISE1	MSE		ISE1	ESE		Total
		25	--		25	--		50

Pre-requisite	C programming	
	On successful completion of the course learner will be able to	
Course Outcomes	CO1	Demonstrate Foundational Understanding of Web Technologies
	CO2	Develop Proficiency in Frontend Development with React.js and Angular.js
	CO3	Develop Backend Development with Node.js and Express.js
	CO4	Integrate Full-Stack Application Development with MongoDB
	CO5	Deploy the Web Applications

Exp. No.	Name of the experiment	Ref	Hrs
1	**Static Website Design:** Introduction to frontend and backend technologies, HTML5 and CSS3 fundamentals. CSS: web page using CSS (Cascading Style Sheets)	1,2	2
	Suggested Experiments (Any one) ● Build Real Estate Website by using HTML5, CSS3 ● Language Learning Platform ● Travel Planning Platform		
2	**Responsive Website Design** Javascript Essentials: JavaScript syntax and data types, DOM manipulation and event handling, Functions, closures, and scope.	2,5	2
	Suggested Experiments (Any one) ● Live Chat Application ● Live Sports Scoreboard ● Live Auction Platform		
3	**Angular Js:** Introduction to Angular, TypeScript, Features of Angular, How to build with Angular components, Responsive Web Designing, Forms in Angular, Angular Routing	3,4	2
	Suggested Experiments (Any one) ● Real time weather dashboard ● Live stock Market dashboard		

4	**Front End Web Development:** What is React? React.js VS Angular VS VUE.JS, React components, Use of Props, Statement management using Redux	3,4	2
	Suggested Experiments (Any one) ● Live Customer support chat ● Live Event Streaming Platform		
5	**Backend using Node JS and Express JS:** Installation and setup, Node.js Modules, Introduction to Express Framework, REST APIs Architecture, Microservices	4,5	2
	Suggested Experiments (Any one) ● Live Customer support chat ● Live Event Streaming Platform		
6	**SQL:** Relational Database, Querying, Joining Tables, Creating Database and adding business logic, MySQL tutorial + Normalisation. **NoSQL:** Introduction to Mongoose DB (Version of MongoDB), Creating Database, Creating Collections, CRUD Operations, Mongoose Schema and Models.	6,7	2
	Suggested Experiments (Any one) ● Group chat ● Portfolio website		
7	API Development and Documentation: **Learn how to use APIs to control and manage web applications, including best practices for API testing and documentation.**	8	2
	Suggested Experiments (Any one) ● Social Media Platform ● E-Commerce Platform		
8	**Identity Access Management**	4	2
	Implement authentication and authorization in Flask and understand how to design against key security principle.		
9	Spring Core and Spring Boot, Spring Framework, Spring Core Basics, Aspect-Oriented Programming (AOP), Spring Boot Configuration, Spring Boot Data Access, Spring Boot Web Development	9	2
	Suggested Experiment Experiment with creating RESTful APIs using Spring MVC and Spring Boot.		
10	Git and Version Control: Getting Started with Git, Installing Git In Linux, Installing Git In Windows, Working With A Local Repository, Branches and Merging, working With A Remote Repository		2

Course Assessment

ISE:

1. ISE-1 will be conducted 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

2. ISE-2

a. will be conducted reaming 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

b. Presentation /Simulation using modern tools to solve the given problem statement for 10 marks

Recommended Books:

1. TextBook-1: HTML & CSS: The Complete Reference Thomas A. Powell, Fifth Edition, Tata McGraw Hill
2. WEB PROGRAMMING with HTML5, CSS and JavaScript, John Dean, Jones & Bartlett Learning.
3. Full-Stack React Projects: Learn Mern Stack Development, Shama Hoque, Packt Publishing Limited
4. The Full Stack Developer, Chris Northwood, Apress publication.
5. Full Stack JavaScript: Learn Backbone.js, Node.js and MongoDB, AZAT MARDAN, Apress publication, Second Edition.
6. Learning SQL: Generate, Manipulate, and Retrieve Data, by Alan Beaulieu. O'Reilly publication. Third Edition
7. MongoDB: The Definitive Guide. Shannon Bradshaw, Kristina Chodorow, and Michael Dirolf. O'Reilly publication. Second Edition.
8. "RESTful API Design: Best Practices in API Design with REST", O'Reilly Media.
9. "Spring Boot in Action", Craig Walls, Manning
10. "Pro Git", Scott Chacon and Ben Straub|

Online Resources:

1. Web links and Video Lectures (e-Resources): https://onlinecourses.swayam2.ac.in/aic20_sp11/preview
2. https://www.w3.org/html/
3. http://www.htmlref.com/
4. http://w3schools.org/
5. http://www.tutorialspoint.com/css/

Society of St. Francis Xavier, Pilar's

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PSBC21CE02	Research Methodology and Intellectual Property Rights	L	T	P	L	T	P	Total
		2	--	--	2	--	--	2
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	

Pre-requisite	None required.	
Course Outcomes		*At the end of the course students will be able to*
	CO1	Formulate research problem formulation with appropriate selection of approaches for investigation of solutions for research problems
	CO2	Plan Experiments Scientifically for research
	CO3	Discover how IPR is regarded as a source of national wealth and mark of an economic leadership in context of global market scenario
	CO4	Perform prior art search and draft patent

Unit No.	Topics	Ref.	Hrs
1	Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations	2	5
2	Effective literature studies approach, analysis Use Design of Experiments /Taguchi Method to plan a set of experiments or simulations or build prototype Analyze your results and draw conclusions or Build Prototype, Test and Redesign	2,3,4,5	6
3	Introduction to the concepts Property and Intellectual Property, Nature and Importance of Intellectual Property Rights, Objectives and Importance of understanding Intellectual Property Rights	1,6,7,8, 9,11,15	2
4	Understanding the types of Intellectual Property Rights: -Patents-Indian Patent Office and its Administration, Administration of Patent System – Patenting under Indian Patent Act , Patent Rights and its Scope, Licensing and transfer of technology, Patent information and database. Provisional and Non Provisional Patent Application and Specification, Plant Patenting,	1,6,7,8, 9,11,15	6

	Integrated Circuits, Industrial Designs, Trademarks (Registered and unregistered trademarks), Copyrights, Traditional Knowledge, Geographical Indications, Trade Secrets, Case Studies Prior art search, Patent Drafting		
5	New Developments in IPR, Process of Patenting and Development: technological research, innovation, patenting, development, International Scenario: WIPO, TRIPs, Patenting under PCT	1,6,7,8, 9,10,11 ,15	5
	Total		24

Recommended Books:

1. *Aswani Kumar Bansal : Law of Trademarks in India*
2. *C.R.Kothari :Research Methodology*
3. *Hair,Black,Babin,Anderson: Multivariate Data Analysis*
4. *D.C. Montgomery, Design and Analysis of Experiments, 5th edition, John Wiley & Sons, New York, 2001*
5. *Madhav phadake: Quality Engineering Using Robust Design*
6. *Satyawrat Ponkse: The Management of Intellectual Property.*
7. *S K Roy Chaudhary & H K Saharay : The Law of Trademarks, Copyright, Patents*
8. *Intellectual Property Rights under WTO by T. Ramappa, S. Chand.*
9. *Manual of Patent Office Practice and Procedure*
10. *WIPO : WIPO Guide To Using Patent Information*
11. *Resisting Intellectual Property by Halbert ,Taylor & Francis*
12. *Industrial Design by Mayall, Mc Graw Hill*
13. *Product Design by Niebel, Mc Graw Hill*
14. *Introduction to Design by Asimov, Prentice Hall*
15. *Intellectual Property in New Technological Age by Robert P. Merges, Peter S. Menell, Mark A. Lemley*

Course Assessment:

Theory:

ISE-1:

Activity: Perform one scientific experiment with principles of Scientific Design of Experiments and analyse same. (20 Marks)

ISE-2:

Activity: Conduct Prior art search for product/design or any IPR instrument and make a draft of patent/design (20 Marks)

MSE: Two hours written examination based on 50% syllabus **(**30 Marks)

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PSBC21CE03	Effective Technical Communication	L	T	P	L	T	P	Total
		1	0	0	1	0	0	1
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	10	15	10	50 (30% weightage)	50	

Pre-requisite	--	
Course Outcomes	CO1	Produce effective dialogue for academic/business related situations.
	CO2	Use listening, speaking, reading and writing skills for communication purposes and attempt tasks by using functional grammar and vocabulary effectively
	CO3	Analyze critically different concepts / principles of communication skills.
	CO4	Demonstrate productive skills and have a knack for structured conversations.
	CO5	Appreciate, analyze, evaluate business reports and research papers.

Module No.	Topics	Ref.	Hrs.
1	The fundamentals of communication. The seven "Cs" of effective communication. Common errors in English. Enriching vocabulary, styles and registers.	1,2	4
2	Aural communication & Oral communication. The art of listening, stress and intonation, group discussion, oral presentation skills.	3,4	4
3	Types of reading, effective writing, business correspondence, interpretation of technical reports and research papers	4,5	5
Total			13

Course Assessment:

ISE 1 and 2: Based on Quiz /Assignment/ Group Discussion / Presentation (10 marks)

MSE: One hour 15 Marks written examination based on 50% syllabus

ESE: Two hours 50 Marks (30% weightage) written examination based on entire syllabus

Recommended Books:

1. Raman Sharma, "Technical Communication", Oxford University Press.
2. Raymond Murphy "Essential English Grammar" (Elementary & Intermediate) Cambridge University Press.
3. Mark Hancock "English Pronunciation in Use" Cambridge University Press.

4. Shirley Taylor, "Model Business Letters, Emails and Other Business Documents" (seventh edition), Prentise Hall
5. Thomas Huckin, Leslie Olsen "Technical writing and Professional Communications for Nonnative speakers of English", McGraw Hill.

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PCC21CE03	Operating Systems in Modern Era	L	T	P	L	T	P	Total
		2	--	2	2	--	1	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Lab	20	--	30	--	50	

Pre-requisite	Operating Systems, Computer Network	
Course Outcomes	CO1	Compare and contrast different OS architectures and technologies.
	CO2	Designing and developing applications for mobile platforms
	CO3	Implement real-time task scheduling algorithms for distributed environments, and analyze system performance under various workload conditions.
	CO4	Compare security and performance aspects of modern operating systems

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1	Introduction to Modern Operating Systems: Overview of Modern OS Concepts and Evolution, Design Principles and Goals, Comparison of Monolithic, Microkernel, and Hybrid OS Architectures. Case Studies: Linux, Windows, macOS		4
2	2	Distributed Operating Systems: Characteristics of Distributed Systems, Distributed System Architectures: Client-Server, Peer-to-Peer, Distributed Coordination and Consistency Models, Distributed File Systems: NFS, AFS, HDFS Case Study: Google File System (GFS), Apache Hadoop		6
3	3	Real-Time Operating Systems (RTOS): Characteristics of Real-Time Systems, Task Scheduling Algorithms: Rate-Monotonic, Earliest Deadline First (EDF),RTOS Kernel Design and Features, Applications of RTOS in Embedded Systems, IoT, and Automotive Case Study: FreeRTOS, QNX, RTLinux		6

4	**4**	Android Operating System: Android Architecture and Components, Application Framework and Development Environment, Process and Memory Management in Android, Android Security and Permissions Model. Case Study: Android Application Development		6
5	**5**	iOS Operating System: iOS Architecture: Kernel, Frameworks, and Services App Lifecycle and Multitasking, Memory Management and Performance Optimization, iOS Security Features and App Sandbox Case Study: iOS App Development with Swift		6
			Total	**28**

Module No.	Sr.no	Suggested List of experiments
2	**1**	Configure Distributed File System Setup
	2	Distributed System Fault Tolerance Testing
	3	Distributed System Communication Analysis:
3	**4**	Perform RTOS Task Scheduling Analysis:
	5	RTOS Kernel Configuration and Optimization:
4	**6**	Android App Development:
	7	Android Security Analysis:
5	**8**	iOS Performance Profiling and Optimization:
	9	iOS App Development:
	10	Presentation on Research papers based on modern OS.

Course Assessment:

Theory:

ISE-1:
Activity: Quiz/assignments/case study discussions 20 Marks
ISE-2: Two hours 20 Marks
Activity: Quiz/assignments/case study discussions 20 Marks

MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Lab:

ISE:
1. ISE-1 will be conducted for four experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2
a. Remaining experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Presentation on research papers for 10 marks

Recommended Books:

[1] "Modern Operating Systems" by Andrew S. Tanenbaum and Herbert Bos
[2] "Real-Time Systems Design and Analysis" by Phillip A. Laplante
[3] "Embedded Systems: Real-Time Interfacing to the MSP430 Microcontroller" by Jonathan W. Valvano

Online Resources:

https://pages.cs.wisc.edu/~remzi/OSTEP/
Andriod- https://www.youtube.com/user/androiddevelopers
iOS- https://www.youtube.com/watch?v=mG8A25FqLKQ
RTOS- https://www.freertos.org/Documentation/RTOS_book.html

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PCC21CE04	Emerging Paradigms in Communication	L	T	P	L	T	P	Total
		2	--	2	2	--	1	3
		Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Lab	20	--	30	--	50	

Pre-requisite	Computer Networks	
Course Outcomes	CO1	Analyze the challenges and solutions in routing for multiple applications.
	CO2	Examine the transition from IPv4 to IPv6 and its implications.
	CO3	Explore Software-Defined Networking (SDN) architectures and principles
	CO4	Investigate wireless communication technologies and their routing considerations
	CO5	Analyze the requirements and challenges of 5G networks
	CO6	Evaluate the role of edge computing and cross-layer design in routing for mobile networks.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Practical routing algorithms for the Internet:** Border Gateway Protocol (BGP), Open Shortest Path First (OSPF), Multiprotocol Label Switching (MPLS),	1,2	5
	1.2	Traffic Shaping and Quality of Service (QoS), Path Computation Element (PCE)		
	1.3	Routing algorithms optimized for efficient data streaming		
2	2.1	**IPV6:** IPv4 deficiencies, IPv6 addressing, Routing in IPv6 Networks	1,3	4
	2.2	Multicast, Anycast, ICMPv6, Neighbour discovery		
	2.3	Routing Security		
3	3.1	**SDN:** Routing in modern Internet architectures, Centralized and Distributed Control and Data Planes, SDN Controllers, Data Center Concepts,	1,6	6
	3.2	Network Function Virtualization, Mininet, Programming SDNs,		
	3.3	Openflow Switch, Wire Protocol, Openstack Neutron plug-in		
4	4.1	**Wireless Networks:** Ad Hoc Wireless Networks, MAC protocols, Routing Protocols	1,4	5
	4.2	Transport Layer and Security Protocols for Ad Hoc Wireless Networks, Quality of Service in Ad Hoc Wireless Networks.		

5	**5.1**	Mobile Ad Hoc Networks (MANETs), Mobile IP (MIP) and Dynamic Host Configuration Protocol (DHCP), Wireless Sensor Networks (WSNs),	5	6
	5.2	5G and Beyond, Mobile Edge Computing (MEC), Handover and Mobility Management, Mobile Cloud Computing (MCC)		
			Total	**26**

Module No.	**Sr.no**	**Suggested List of experiments**
1	**1**	Design a network scenario with multiple applications and devices using Cisco Packet Tracer
	2	Evaluate different routing algorithms for streaming applications using NS3/OMNeT
2	**3**	Simulate a wireless network scenario with mobile devices
	4	Set up a Mobile Ad Hoc Network (MANET) with nodes capable of dynamic communication using NS3/AODV Simulator
3	**5**	Integrate edge computing resources into a network design (Docker, Kubernetes, Wireshark.)
	6	Network Security Design and Analysis with Wireshark: • Capture and Analyze Network Traffic • Identify Normal Network Behaviour • Simulate Security Incidents • Capture and Analyze Anomalous Traffic • Explore the protocol details of captured packets. Identify any misuse or unusual behavior in protocols, such as HTTP, FTP, or DNS
4	**7**	Critically analyze research papers and industry literature in networking
		Mini project/presentation/Group activity/ Simulation using modern tools

Course Assessment:

Theory:

ISE-1:
Activity: Quiz and assignments 20 Marks
ISE-2: Two hours 20 Marks
Activity: Article Discussion, Quiz and Assignments
Outcome: Reflective Journal
MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Lab:

ISE:
1. ISE-1 will be conducted for four experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2

a. Four experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Simulation using modern tools to solve the given problem statement for 10 marks

Recommended Books:

[1] Olivier Bonaventure, "Computer Networking: Principles, Protocols, and Practice",CreateSpace Independent Publishing Platform
[2]. William Stallings, "High-Speed Networks and Internets", Pearson Education, 2nd Edition.
[3] Pete Loshin, "IPv6, Theory, Protocols and Practice", Morgan Kaufmann, 2nd Edition.
]4] C. Siva Ram Murthy, B.S. Manoj, "Ad Hoc Wireless Networks: Architectures and Protocols", Prentice Hall
[5] Jochen H. Schiller, "Mobile Communications", Pearson.
[6] Thomas D NAdeau and Ken Grey, Software Defined Networking, O'Reilly, 2013

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC21CE031	Optimization in Machine Learning	L	T	P	L	T	P	Total
		2	--	2	2	--	1	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Lab	20	--	30	--	50	

Pre-requisite	Basic linear algebra, probability, and knowledge of Python to conduct simulation exercises.	
Course Outcomes	CO1	Illustrate foundational optimization ideas including gradient descent, stochastic gradient methods
	CO2	Apply convex optimization algorithm
	CO3	Analyse and demonstrate several population methods in Evolutionary Computation
	CO4	Apply advanced evolutionary algorithms such as particle swarm and ant colony optimization

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction and Background to Optimization Theory**		02
	1.1	Basics of Linear Algebra and vector calculus, Singular Value Decomposition, PSD Matrices and Kernel Functions, Vector derivatives, Mean Value Theorem	1,3	
	1.2	Basic Ingredients of Optimization Problems, Optimization Problem Classifications, Optima Types, Optimization Method Classes, Overview of Unconstrained and Constrained Optimization	1,3	
2	2.1	**Derivative based Optimization**		08
		The Basics of Optimization (univariate, bivariate and multivariate optimization), Convex Functions, First and Second Order Conditions for Optimizations, Convex and Non-Convex Optimization problems in Machine Learning	3	
	2.2	First-Order optimization Methods: Gradient Descent, Conjugate Gradient, Momentum, Nesterov Momentum, Adagrad, RMSProp, learning rate optimization	1,3	
	2.3	Second order optimization: Newton method	3	
3		**Stochastic Methods**		02
	3.1	Noisy Descent, Mesh Adaptive Direct Search, Cross-Entropy Method, Natural Evolution Strategies, Covariance Matrix	1,2	

		Adaptation		
4		**Convex Optimization**		04
	4.1	Optimization problems, convex optimization, Linear optimization problems, Quadratic optimization problems, Geometric programming, Overview of Generalized inequality constraints and Vector optimization, nonconvex and submodular optimization.	3	
5	**5.1**	**Evolutionary Methods**		05
	5.2	Introduction to Evolutionary Computation: Generic Evolutionary Algorithm, Representation: The Chromosome, Initial Population, Fitness Function, Selection: Selective Pressure, Random Selection, Proportional Selection, Tournament Selection, Rank-Based Selection, Elitism and Evolutionary Computation versus Classical Optimization, Stopping conditions	1, 2	
	5.2	Canonical Genetic Algorithm, Binary Representations of Crossover and Mutation: Binary Representations, Control Parameters	1	
6		**Advance Evolutionary Methods**		05
	6.1	Basic Particle Swarm Optimization, Global Best PSO, Local Best PSO, g-best versus l-best PSO, Velocity Components, Geometric Illustration, Algorithm Aspects, Social Network Structures	1, 2	
	6.2	Ant Colony Optimization Meta-Heuristic, Foraging Behavior of Ants, Stigmergy and Artificial Pheromone, Simple Ant Colony Optimization, Ant System, Ant Colony System	2	
			Total	**26**

Module No.	**Sr.no**	**Suggested List of experiments**
2	**1**	To implement Gradient Descent algorithm
	2	To implement Newton method
3	**3**	To implement the Stochastic Gradient Descent algorithm
4	**4**	To apply convex optimization technique to solve the optimization problem for real world problem
5	**5**	To apply Genetic Algorithm for real world problem
	6	To compare and implement different selection mechanism using genetic algorithm
	7	To implement various mutation and crossover mechanisms

6	**8**	To implement Particles Swarm optimization
	9	To implement Ant colony optimization
	10	Mini project/presentation/Group activity/ Simulation using modern tools

Course Assessment:

Theory:

ISE-1:
Activity: Quiz and assignments 20 Marks
ISE-2: Two hours 20 Marks
Activity: Article Discussion, Quiz and Assignments
Outcome: Reflective Journal

MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Lab:

ISE:
1. ISE-1 will be conducted for four experiments. Continuous pre-defined rubrics-based evaluation for 15 marks.
2. ISE-2
a. Four experiments. Continuous pre-defined rubrics-based evaluation for 15 marks.
b. Mini project/Simulation using modern tools to solve the given problem statement for 20 marks

Recommended Books:

1. Mykel J. Kochenderfer, Tim A.Wheeler, "*Algorithms for Optimization",* MIT Press (2019)
2. Andries P Engelbrecht, "*Computational Intelligence-An Introduction*", Second-Edition,Wiley
3. Charu Aggarwal, "*Linear Algebra and Optimization for Machine Learning*", Springer,2020.
4. S. Bubeck, "*Convex Optimization: Algorithms and Complexity, Foundations and Trends in Optimization*", 2015.

Online Resources:

1. Convex optimization (NPTEL)
2. Constrained and Unconstrained optimization (NPTEL)
3. Machine-learning-model-performance (Coursera)
4. Deep-neural-network optimization (Coursera)

Further Reading:

[1] SuvritSra, Sebastian Nowozin, Stephen J. Wright, Optimization for Machine Learning, The MIT Press
[2] Xin-She Yang Middlesex, Optimization techniques and applications with examples, Wiley
[3] A.E. Eiben, J. E. Smith, Introduction to Evolutionary Computing, Springer
[4] F. Bach, "*Learning with Submodular Functions: A Convex Optimization Perspective", Foundations and Trends in Machine Learning*", Now Publishers Inc.

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC21CE032	Generative AI	L	T	P	L	T	P	Total
		2	--	2	2	--	1	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Lab	20	--	30	--	50	

Pre-requisite	Python Programming	
Course Outcomes	CO1	Explain the fundamental concepts and techniques of generative artificial intelligence.
	CO2	Apply generative models to create artistic outputs across various domains.
	CO3	Analyze and evaluate the performance and quality of generative models.
	CO4	Design and implement generative AI systems for specific creative tasks.
	CO5	Demonstrate proficiency in using tools and libraries for generative art.
	CO6	Critically assess the ethical implications and societal impacts of generative AI in art and design.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		Introduction to Generative Art and AI (5 hours)		
	1.1	Overview of Generative Art: Definition, history, and significance.	1,2	1
	1.2	Introduction to Generative AI: Basics of generative models, generative vs. discriminative models.	1,2	1
	1.3	Generative Models: Probabilistic models, autoregressive models, generative adversarial networks (GANs), and variational autoencoders (VAEs).	1,2	2
	1.4	Applications of Generative AI in Art: Image generation, music generation, text generation	1,2	1
2		Generative Image Synthesis (6 hours)		6
	2.1	Basics of Image Generation: Pixel manipulation, procedural generation techniques.	2	1
	2.2	Introduction to Generative Adversarial Networks (GANs): Architecture, training process, common variations (DCGAN, StyleGAN).	2	2
	2.3	Conditional Image Generation: Conditional GANs, pix2pix, CycleGAN.	2	2

	2.4	Evaluation of Generated Images: Metrics for image quality assessment, perceptual evaluation.	2	1
3		Generative Music and Audio (5 hours)		5
	3.1	Music Generation Techniques: Symbolic music generation, audio synthesis methods.	2,3	1
	3.2	Neural Network-based Music Generation: Recurrent neural networks (RNNs), LSTM networks for music generation.	2,3	1
	3.3	Audio Generation with GANs: WaveGAN, SpecGAN, and other GAN architectures for audio synthesis.	2,3	2
	3.4	Evaluation of Generated Music: Subjective and objective evaluation methods for musical output.	2,3	1
4		Text Generation and Natural Language Processing (5 hours)		5
	4.1	Introduction to Text Generation: Markov chains, recurrent neural networks (RNNs) for text generation.	3,4	1
	4.2	Long Short-Term Memory (LSTM) Networks: Architecture, training process, and applications in text generation.	3,4	1
	4.3	Generative Language Models: GPT (Generative Pre-trained Transformer) models, BERT (Bidirectional Encoder representations from Transformers).	3,4	2
	4.4	Evaluation of Text Generation Models: Coherence, fluency, and semantic evaluation metrics.	3,4	1
5		Advanced Topics and Applications (5 hours)		5
	5.1	Interactive Generative Systems: Interactive art installations, real-time generative art.	5	1
	5.2	Transfer Learning in Generative AI: Fine-tuning pre-trained models for specific tasks.	5	1
	5.3	Ethical Considerations in Generative AI: Bias, ownership, and authenticity in generative art.	5	2
	5.4	Creative Applications of Generative AI: Case studies in visual art, music composition, and literature.	5	1
			Total	**26**

Module No.	**Sr.no**	**Suggested List of experiments**
1	**1**	Experiment 1: Implement a simple generative art program using pixel manipulation techniques in Python, generating abstract patterns.
	2	Experiment 2: Train a basic generative adversarial network (GAN) using TensorFlow or PyTorch to generate synthetic images resembling handwritten digits from the MNIST dataset.
2	**3**	Experiment 3: Develop a conditional GAN (cGAN) to generate colored images of specific objects (e.g., cats, cars) from the CIFAR-10 dataset.

	4	Experiment 4: Explore the latent space of a pre-trained StyleGAN model and manipulate latent vectors to generate diverse and controllable images.
3	**5**	Experiment 5: Create a recurrent neural network (RNN) model using TensorFlow or PyTorch to generate MIDI music sequences based on a given set of input melodies.
	6	Experiment 6: Train a WaveGAN model to generate realistic audio samples of musical instruments or natural sounds (e.g., bird chirps, ocean waves).
4	**7**	Experiment 7: Implement a basic Markov chain text generator in Python to generate text based on a corpus of literature or song lyrics.
	8	Experiment 8: Fine-tune a pre-trained GPT model using the Hugging Face Transformers library to generate coherent and contextually relevant text passages on a given topic.
5	**9**	Experiment 9: Design an interactive generative art installation using Processing or p5.js, allowing users to influence the output through real-time interactions (e.g., mouse movements, keyboard inputs).
	10	Experiment 10: Investigate the transfer learning capabilities of a pre-trained VQGAN model by fine-tuning it on a custom dataset and generating novel images related to a specific theme or style.
		Mini project/presentation/Group activity/ Simulation using modern tools **Mini Project List -** "Artistic Image Generation using Conditional GANs" "Music Composition with Recurrent Neural Networks" "Text Generation with Pre-trained Language Models" "Real-time Interactive Generative Art Installation" "Character Animation Synthesis using GANimation" "Audio Synthesis and Sound Design with WaveGAN" "Generative Poetry Generation with LSTM Networks" "Exploring Style Transfer in Generative Art" "Creating AI-driven Abstract Paintings" "Generative Landscape Generation using Procedural Techniques" **Simulation Tool :** TensorFlow and Keras, PyTorch, GANimation,Magenta Studio, OpenAI's GPT-3 API: OpenAI's GPT-3 (Generative Pre-trained Transformer 3). Processing: Processing is a flexible software sketchbook and a language for learning how to code within the context of the visual arts. It can be used for creating interactive generative art installations and visualizations. p5.js: p5.js is a JavaScript library inspired by Processing, designed for artists, designers, educators, and beginners. It can be used for creating interactive visualizations and generative art projects directly in the web browser.

		Hugging Face Transformers Library: The Hugging Face Transformers library provides pre-trained models and tools for working with state-of-the-art natural language processing (NLP) models, including GPT-2, BERT, and more. It can be used for experimenting with text generation and other NLP tasks.

Course Assessment:

Theory:

ISE-1:
Activity: Quiz and assignments 20 Marks
ISE-2: Two hours 20 Marks
Activity: Article Discussion, Quiz and Assignments
Outcome: Reflective Journal

MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Lab:

ISE:
1. ISE-1 will be conducted for four experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2
a. Four experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Simulation using modern tools to solve the given problem statement for 10 marks

Recommended Books:

[1] "Generative Deep Learning: Teaching Machines to Paint, Write, Compose, and Play" by David Foster.
[2] "Artificial Intelligence and Creativity: An Interdisciplinary Approach" by Jon McCormack and Mark d'Inverno.
[3] "The Deep Learning Revolution" by Terrence J. Sejnowski.
[4] "Creative Code: Aesthetics + Computation" by John Maeda.
[5] "Artificial Unintelligence: How Computers Misunderstand the World" by Meredith Broussard.

Online Resources:

1. TensorFlow and Keras:
   - TensorFlow Tutorials: tensorflow.org/tutorials
   - Keras Documentation: **keras.io**
2. PyTorch:
   - PyTorch Tutorials: pytorch.org/tutorials
   - Fast.ai: **fast.ai**

3. Magenta Studio:
    - Magenta Studio: magenta.tensorflow.org/studio
    - Magenta GitHub Repository: github.com/magenta/magenta
4. OpenAI's GPT-3:
    - OpenAI GPT-3 Playground: **openai.com/gpt-3**
    - **Hugging Face Transformers Library: huggingface.co/transformers**
5. **Processing and p5.js:**
    - **Processing Foundation: processingfoundation.org**
    - **p5.js Website: p5js.org**
6. Google Colab:
    - Google Colab: colab.research.google.com
7. GitHub:
    - GitHub: **github.com**
    - **GitHub Generative AI Repository: github.com/topics/generative-ai**
8. **Coursera:**
    - **Coursera Deep Learning Specialization: coursera.org/specializations/deep-learning**
    - **Coursera Generative Adversarial Networks (GANs) Specialization: coursera.org/specializations/generative-adversarial-networks-gans**
9. **Papers with Code:**
    - **Papers with Code: paperswithcode.com**
    - **Generative Models Section: paperswithcode.com/area/generative-models**

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC21CE033	Deep Learning with Natural Language Processing	L	T	P	L	T	P	Total
		2	--	2	2	--	1	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Lab	20	--	30	--	50	

Pre-requisite	Linera Algebra, Statistics , Probability Theory and Python Programming	
Course Outcomes	CO1	Implement Deep learning models for signal/image processing applications.
	CO2	Implement sequence models for data-based time series processing applications.
	CO3	Develop applications using attention mechanism
	CO4	Implement large language models to solve real-world problems.
	CO5	Demonstrate proficiency in using tools and libraries for implementing Large Language Models.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	**1.1**	Deep Networks: Fundamentals, Brief History, Classes of Deep Learning Basic Terminologies of Deep Learning	1	1
	1.2	Training Feedforward DNN, Optimization Learning with backpropagation, Learning Parameters: Gradient Descent (GD), Stochastic and Mini Batch GD, Momentum Based GD, Adam, RMSProp	1	2
	1.3	Regularization Overview of Overfitting, Types of biases, Bias Variance Tradeoff Regularization Methods: L1, L2 regularization	1	1
2	**2.1**	Convolution Operation, Motivation, Basic structure of a convolutional neural network: Padding, strides, pooling, fully connected layers, interleaving between layers	2,3	2
	2.2	Training a convolutional network: Backpropagation through convolution, Backpropagation as convolution with inverted filter,	2,3	2
	2.3	Introduction to Transfer Learning and Domain Adaptation, Comparison of Domain Adaptation and transfer learning , Modern Deep Learning Architectures: LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet ,Mobile Net and DenseNet	2,3	4

3	**3.1**	Sequential Model: Introduction, Notations, Recurrent Neural Network Model, Different Types of RNNs, Vanishing Gradients with RNNs, Gated Recurrent Unit (GRU), Bidirectional RNN, Deep RNNs	2,3	2
	3.2	Long Short Term Memory (LSTM)-Need for memory in sequential data modeling, Architecture and components of LSTM networks Gating mechanisms: input gate, forget gate, output gate	2,3	2
4	**4.1**	Attention Mechanisms and Transformers-Introduction to attention mechanism, Taxonomy of attention, Self-attention and multi head attention, comparing CNN, RNN and Self-attention	4	2
	4.2	Transformers- Archiecture, ENCODER MODULE, DECODER MODULE, Deep learning transformer-based models- BERT, RoBERT and DistilBERT	4	2
5	**5.1**	**Generative Models**		
	5.3	Introduction to Generative AI: Basics of generative models, generative vs. discriminative models.	5	1
		Generative Models: Probabilistic models, autoregressive models, generative adversarial networks (GANs), and variational autoencoders (VAEs).	5	2
6		**Recent Trends and Applications**		
		Applications: Language Translation, Text Summarization Visual Question Answering, Image generation, music generation, code generation	5	2
			Total	**26**

Module No.	**Sr.no**	**Suggested List of experiments**
1	**1**	Apply 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. Adam Learning GD
	2	Design and implement a fully connected deep neural network with at least 2 hidden layers for a classification application
2	**3**	Design and implement a CNN model for digit recognition application.
	4	Design and implement a CNN model for image classification.

3	**5**	Design and implement RNN for Text classification
	6	Design and implement LSTM predicting data based on time series
4	**7**	Implement BERT for text summarization
	8	Compare the performance of BERT and its variations for text classification application
5	**9**	Implement text generation using any one of large language model
	10	Mini Project- Implement any one application of Deep learning

Course Assessment:

Theory:

ISE-1:
Activity: Quiz and assignments 20 Marks
ISE-2: Two hours 20 Marks
Activity: Article Discussion, Quiz and Assignments
Outcome: Reflective Journal

MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Lab:

ISE:
1. ISE-1 will be conducted for five experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2
a. Five experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Simulation using modern tools to solve the given problem statement for 10 marks

Recommended Books:

[1] Ian Goodfellow and Yoshua Bengio and Aaron Courville. Deep Learning. An MIT Press book. 2016.
[2] Li Deng and Dong Yu, "Deep Learning Methods and Applications", now publishers Inc (30 June 2014).
[3] Jon Krohn, Grant Beyleveld, Aglae Bassens, "Deep Learning Illustrated: A Visual, Interactive Guide to Artificial Intelligence", Pearson Education.
[4] Lewis Tunstall, Leandro von Werra, Thomas Wolf, "Natural Language Processing with Transformers: Building Language Applications with Hugging Face" O'Reilly Media, Inc
[5] Alger Fraley, "The Artificial Intelligence and Generative AI Bible: [5 in 1] The Most Updated and Complete Guide"

Online Resources:

- Natural Language Processing By Prof. Pawan Goyal, IIT Kharagpur https://onlinecourses.nptel.ac.in/noc21_cs102/preview

- Course: Applied Natural Language Processing by Prof. Ramaseshan R, CMI https://onlinecourses.nptel.ac.in/noc20_cs87/preview
- https://deeplearning.cs.cmu.edu/S21/index.html

Further Reading:

Kamath, U., Graham, K., & Emara, W. (2022). Transformers for Machine Learning: A Deep Dive (1st ed.). Chapman and Hall/CRC. https://doi.org/10.1201/9781003170082

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC21CE041	Data Architecture and Management	L	T	P	L	T	P	Total
		2	--	2	2	--	1	3
		Examination Scheme						
			ISE1	**MSE**	**ISE2**	**ESE**	**Total**	
		Theory	20	30	20	100 (30% weightage)	100	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes		
Course Outcomes	CO1	Explain the role of data Architecture in Enterprise
	CO2	Demonstrate the proficiency in SQL and NoSQL DB systems
	CO3	Explain Strategies for integrating data for various sources
	CO4	Implementation of Data security measures
	CO5	Implementation of Hadoop ecosystem
	CO6	Optimize data architectures that drive business success in today's data-driven world.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction to Data Architecture**- Understanding the role of a Data Architect, Enterprise Data architecture requirements	1	2
	1.2	Overview of data architecture components and principles.,		
2	2.1	**Data Modelling and Design**- Conceptual, logical, and physical data modelling techniques.	1	2
	2.2	Normalization and demoralization processes. - Best practices for designing effective data models		
3	3.1	**Database Management Systems (DBMS)** - Relational database fundamentals and advanced SQL querying and optimization.	2	3
	3.2	Introduction to NoSQL databases		
	3.3	NoSQL case studies		
4	4.1	**Data Integration and ETL Processes** - Strategies for integrating data from heterogeneous sources. -	4	3
	4.2	Extract, Transform, Load (ETL) processes and tools.		
	4.3	Real-time data integration techniques		
5	5.1	**Data Governance and Compliance-** Principles of data governance and stewardship. Data encryption methods and best practices. -	7	2
	5.2	Regulatory compliance requirements		

6	**6.1**	**Data Security and Privacy**- Data encryption, access control, and privacy-preserving techniques	6	2
7	**7.1**	Data Warehousing and Business Intelligence - Data warehouse architecture and design principles	3	3
		Online Analytical Processing (OLAP) and multidimensional data analysis, Developing interactive dashboards and reports		
8	**8.1**	**Big Data Technologies**- Introduction to Hadoop ecosystem components.	8	3
	8.2	Streaming data processing with Apache Kafka and Apache Flink		
	8.3	Implementing big data solutions for scalability and performance		
9	**9.1**	**Cloud Data Management** - Cloud storage and database services. (e.g., AWS S3, RDS, Azure SQL Database).	6	3
	9.2	Cloud-native data architectures and server less computing.		
	9.3	Multi-cloud and hybrid cloud strategies		
10	**10.1**	**Emerging Trends in Data Architecture**- Block chain technology and Internet of Things (IoT) data processing.		3
	10.2	Edge computing and distributed data architectures.	9	
Total				**26**

Course Assessment:

Theory:

ISE-1:
Activity: Quiz and assignments 20 Marks
ISE-2: Two hours 20 Marks
Activity: Article Discussion, Quiz and Assignments
Outcome: Reflective Journal

MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Lab:

ISE:
1. ISE-1 will be conducted 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2
a. will be conducted reaming 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Presentation /Simulation using modern tools to solve the given problem statement for 10 marks

Sr.no	Suggested List of experiments
1	Design and implement a relational database schema for a specific enterprise application
2	Use of advanced SQL, Group by, grouping sets, cube, rollup for given task

3	Data Security Experiment - Implement data encryption and access control mechanisms to protect sensitive data in a database
4	Data Warehouse Design and implementation Experiment- Design a dimensional model for a data warehouse based on given business requirements, Import and export data, analysis using pivot table
5	Big Data Experiment: - Set up and configure a Hadoop cluster, and implement a MapReduce algorithm to process large datasets.
6	Cloud Data Management Experiment: - Deploy a cloud-based database service and migrate data from an on-premises database.
7	Business Intelligence Experiment: - Develop interactive dashboards and reports using a business intelligence tool like Tableau or Power BI/other.
8	Data Governance Experiment: - Define data governance policies and procedures for managing data quality and compliance.
9	IoT Data Processing Experiment- Design and implement a data processing pipeline for IoT sensor data using cloud services.
10	Block chain Experiment:- Explore block chain technology and its applications in data management through case studies and simulations.
11	Research Paper Presentation and implementation/Simulation using modern tools

Recommended Books:

1. "Data Architecture: A Primer for the Data Scientist" by W.H. Inmon, Dan Linstedt, and Mary Levins
2. "Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Systems" by Martin Kleppmann
3. "The Data Warehouse Toolkit: The Definitive Guide to Dimensional Modeling" by Ralph Kimball and Margy Ross
4. "Enterprise Integration Patterns: Designing, Building, and Deploying Messaging Solutions" by Gregor Hohpe and Bobby Woolf
5. "Machine Learning: A Probabilistic Perspective" by Kevin P. Murphy
6. "Cloud Architecture Patterns: Using Microsoft Azure" by Bill Wilder
7. "The DAMA Guide to the Data Management Body of Knowledge (DAMA-DMBOK Guide)" by DAMA International
8. "Big Data Architect's Handbook", Syed Muhammad Fahad Akhtar, O'Reilly
9. Blockchain Technology, Chandramouli Subramanian, Asha A. George, Abhillash K. A and Meena Karthikeyen, Universities Press

Online Resources:

GitHub - raycad/stream-processing: Stream processing guidelines and examples using Apache Flink and Apache Spark-https://github.com/raycad/stream-processing

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
PEC21CE042	Bioinformatics	3	--	2	3	--	--	3
		Examination Scheme						
		ISE1		MSE	ISE2	ESE		Total
		20		30	20	100 (30% weightage)		100
		20		--	30	--		50

Pre-requisite	--	
Course Outcomes	CO1	Elaborate the components of Machine Vision Application
	CO2	Perform image ,video pre-processing operations
	CO3	Explain various transformations, interpolation.
	CO4	Elaborate motion tracking in video.
	CO5	Analyse and Implement appropriate filtering techniques for a given problem.
	CO6	Develop applications based on machine vision.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Fundamentals of Genes and Genomes**		4
		• Biological Macromolecules, Genomics, and Bioinformatics • DNA as the Universal Genetic Material • Typical Eukaryotic Gene Structure • Mutations in the DNA Sequence • Protein Structure and Function • Genome Structure and Organization	1,2,3	
2		**Fundamentals of Molecular Evolution**		4
		• Bioinformatics, Molecular Evolution, and Phylogenetics • Molecular Basis of Heritable Genetic Variations • Factors that Affect Gene Frequency in a Population • The Neutral Theory of Evolution • Molecular Phylogenetics • From Sanger Sequencing to Pyrosequencing • Pyrosequencing, Mutation Detection, and SNP Genotyping • Next-Generation Sequencing Platforms • High-Density Oligonucleotide-Probe-Based Array to Investigate Genome Expression	1,2,3	

		• Genome-Wide Mutagenesis, Genome Editing, and Interference of Genome Expression		

3		**The Beginning of Bioinformatics**		4
		• Definition of Bioinformatics • Bioinformatics Versus Computational Biology • Goals of Bioinformatics Analysis • Retrieving protein sequences • Retrieving DNA sequences	1,2,3	
4		**Database Search, Data Retrieval Systems**		4
		• Sequence Data Formats • Conversion of Sequence Formats Using Readseq • Primary Sequence Databases—GenBank, EMBL-Bank, and DDBJ • Making use of GenBank • Making use of Gene-Centric databases • Secondary Databases • Data Visualization in Genome Browsers • Data Retrieval	1, 2,3	
5		**Data Retrieval**		4
		• Simple alignments, Gaps, Scoring Matrices, Global and Local Alignments, Smith-Waterman Algorithm, • BLAST, FASTA, Multiple sequence Alignments, Gene Prediction, Statistical • Approaches to Gene Prediction, Spliced Alignment	1,2,3	
6		**Genome Algorithms**		6
	6.1	• The dawn of sequencing, the biological sequence or structure deficit, human genome project and its status, homology and analogy, web browsers. • Genome Rearrangements, Sorting by Reversals, • Block Alignment and the Four-Russians Speedup, Constructing Alignments in Sub-quadratic • Time, Protein Sequencing and Identification, the Peptide Sequencing Problem	1,2,3	
			Total	**26**

Course Assessment:

Theory:

ISE-1:
Two hours 20 Marks Activity: Quiz and assignments
ISE-2:
Two hours 20 Marks Activity: Quiz and assignments
MSE: Two hours 30 Marks written examination based on 50% syllabus.
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Lab:

ISE:

1. ISE-1 will be conducted 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

2. ISE-2

a. will be conducted reaming 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

b. Presentation /Simulation using modern tools to solve the given problem statement for 10 marks

Recommended Books:

1. Supratim Choudhuri, "Bioinformatics for Beginners", 2014 Elsevier
2. Dan E. Krane, Michael L. Raymer, "Fundamental Concepts of Bioinformatics,", Pearson Education, Inc. Fourth Edition, 9780805346336.
3. Harshawardhan P. Bal, "Bioinformatics Principles and Applications", Tata McGraw-Hill, seventh reprint, 9780195692303.

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC21CE043	Industrial Internet of Things (IIoT)	L	T	P	L	T	P	Total
		2	--	2	2	--	1	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Lab	20	--	30	--	50	

Pre-requisite	Embedded systems, Computer Networks, Web Technologies	
Course Outcomes	CO1	Explain the functional blocks and communication methodology relevant to IoT.
	CO2	Identify various components of IIoT
	CO3	Apply IIoT Protocols for Industrial automation/applications
	CO4	Explain aspects of control and supervisory level of automation
	CO5	Evaluate methods for data collection and analysis in IIoT-based systems.
	CO6	Analyze the various security issues in IIoT

Module No.	Unit No.	Topics	Ref.	Hrs.
1	Introduction to IoT			3
	1.1	Definition and Characteristics of IoT	1,2	
	1.2	IoT Protocols and Functional Blocks	1,2	
	1.3	IoT Communication Models	1,2	
	1.4	IoT Communication APIs:- REST and WebSockets	1,2	
2	IIoT Components			5
	2.1	Sensors and Interfacing: Introduction to Sensors, Classification, Role of Sensors in IIoT, Various types of Sensors, Special requirements for IIoT sensors	1,2,3,4	
	2.2	Role of Actuators, Types of Actuators.	1,2,3	
	2.3	Protocols such as HART, MODBUS-Serial & Parallel, Ethernet, BACnet, Current, M2M	1,2,3,5	
3	Communication Protocols in IIoT			5
	3.1	Web Communication Protocols for connected devices:- CoAP, LWM2M, MQTT, XMPP, HTTP, SOAP Protocols	1,2	
	3.2	LPWAN Fundamentals: LORA and NBIoT	1,2	
	3.3	Cloud / Server architectural requirements for IIOT Applications, Internet vs. Intranet	1,2,5	

4	Control & Supervisory Level of Automation			4
	4.1	Programmable logic controller (PLC)	3,7	
	4.2	Supervisory Control & Data Acquisition (SCADA)	3,7	
	4.3	Need of Human machine Interface (HMI) in Automation	3,7	
5	**Data Collection and Analysis**			4
	5.1	Data Acquiring and Storage, Organizing the Data, Transactions and Business Processes, Analytics	1,2	
	5.2	Introduction to Cloud Computing, Virtualization, Cloud Models, Cloud Services	1,2	
	5.3	IoT Cloud-based Data Collection, Storage, Computing using Xively	1,2	
6	Security Issues in IIoT			5
	6.1	Vulnerabilities of IIoT, Privacy, Security requirements, Threat analysis	1,2,6	
	6.2	IoT Security tomography and layered attacker model	1,2,6	
	6.3	Security model for IIoT, Network security techniques Management aspects of cyber security.	1,2,6	
			Total	26

Sr.no	Suggested List of experiments
1	To study and implement interfacing of different IoT sensors with Raspberry Pi/Arduino/NodeMCU and pushing data to the cloud using Thingspeak
2	To study and implement interfacing of actuators based on the data collected using IoT sensors (For eg. LED, Stepper motor/DC Motor)
3	To study MQTT Mosquito server and write a program on Arduino/Raspberry Pi to publish sensor data to MQTT broker.
4	ESP8266 Voice Control with Google Assistant and Adafruit IO
5	Interfacing Arduino/Raspberry PI with Bluetooth and send sensor data to smartphone using Bluetooth
6	To interface the DHT 11 sensor and display the values using the Node-red environment
7	To install MySQL database on Raspberry Pi and perform basic SQL queries for analysis data collected.
8	To study and implement IoT Data processing using Pandas
9	PLC programming and HMI
10	Publishing sensor data from ESP32 to AWS IoT Cloud.

Course Assessment:

Theory:

ISE-1:
Activity: Assignments
[20 Marks]

ISE-2: Case study and Seminar on IoT in any industry (should include study of all the sensors, communication protocols, data collection, analysis, data visualization, etc) [20 Marks]

MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Laboratory:

ISE:

1. ISE-1 will be conducted for five experiments.
   Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2 will be conducted for five experiments.
   Continuous pre-defined rubrics-based evaluation for 20 marks.
   Activity: Mini-project for10 marks

Recommended Books:

1. Raj Kamal, "Internet of Things: Architecture and Design Principles", McGraw Hill Education, 1st Edition
2. Vijay Madisetti, Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)",1st Edition
3. Sudip Misra, Chandana Roy and Anandarup Mukherjee, "Introduction to Industrial Internet of Things and Industry 4.0", Taylor & Francis Group,1 st Edition
4. D. Patranabis, "Sensor and Transducers" (2e) Prentice Hall,2nd Edition.
5. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, 1 st Edition.
6. Brian Russell, Drew Van Duren, "Practical Internet of Things Security", Packt Publishing,2nd Edition.
7. C.D. Johnson, "Process Control Instrumentation Technology", Pearson, 8 th Edition.

Online Resources:

1.https://spoken-tutorial.org/watch/Arduino/Introduction+to+Arduino/English/

2.https://pythonprogramming.net/introduction-raspberry-pi-tutorials/

3.https://iotbytes.wordpress.com/basic-iot-actuators/

4. https://mqtt.org/

5. https://www.coursera.org/specializations/developing-industrial-iot

6.https://www.coursera.org/lecture/advanced-manufacturing-enterprise/the industrial-internet-of-things-iiot-59EvI

7. https://how2electronics.com/connecting-esp32-to-amazon-aws-iot-core-using-mqtt/

8. https://www.solisplc.com/tutorials/how-to-read-ladder-logic

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
OE2121	Project Management	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE		Total
		Theory	20	30	20	100 (30% weightage)		100
		Tutorial	20	--	30	--		150

Pre-requisite Course Codes	-	
Course Outcomes	CO1	Apply selection criteria and select an appropriate project from different options.
	CO2	Write work break down structure for a project and develop a schedule based on it.
	CO3	Identify opportunities and threats to the project and decide an approach to deal with them strategically.
	CO4	Use Earned value technique and determine & predict status of the project.
	CO5	Capture lessons learned during project phases and document them for future reference

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Project Management Foundation:** Definition of a project, Project Vs Operations, Necessity of project management, Triple constraints, Project life cycles (typical & atypical) Project phases and stage gate process. Role of project manager, Negotiations and resolving conflicts, Project management in various organization structures, PM knowledge areas as per Project Management Institute (PMI)	1,2,3	5
2	2.1	**Initiating Projects:** How to get a project started, Selecting project strategically, Project selection models (Numeric /Scoring Models and Non-numeric models), Project portfolio process, Project sponsor and creating charter; Project proposal. Effective project team, Stages of team development & growth (forming, storming, norming &performing), team dynamics.	1,2,3	6
3	3.1	**Project Planning and Scheduling:** Work Breakdown structure (WBS) and linear responsibility chart, Interface Co-ordination and concurrent engineering,	1,2,3	8

		Project cost estimation and budgeting, Top down and bottoms up budgeting, Networking and Scheduling techniques. PERT, CPM, GANTT chart, Introduction to Project Management Information System (PMIS).		
4	**4.1**	**Planning Projects:** Crashing project time, Resource loading and levelling, Goldratt's critical chain, Project Stakeholders and Communication plan Risk Management in projects: Risk management planning, Risk identification and risk register, Qualitative and quantitative risk assessment, Probability and impact matrix. Risk response strategies for positive and negative risks	1,2,3	6
5	**5.1**	**Executing Projects:** Planning monitoring and controlling cycle, Information needs and reporting, engaging with all stakeholders of the projects, Team management, communication and project meetings	4,5	8
	5.2	**Monitoring and Controlling Projects:** Earned Value Management techniques for measuring value of work completed; Using milestones for measurement; change requests and scope creep, Project audit		
	5.3	**Project Contracting** Project procurement management, contracting and outsourcing		
6	**6.1**	**Project Leadership and Ethics:** Introduction to project leadership, ethics in projects, Multicultural and virtual projects	4,5	6
	6.2	**Closing the Project:** Customer acceptance; Reasons of project termination, Various types of project terminations (Extinction, Addition, Integration, Starvation), Process of project termination, completing a final report; doing a lessons learned analysis; acknowledging successes and failures; Project management templates and other resources; Managing without authority; Areas of further study.		
				40

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 20 marks.

2. **ISE-2** Three Assignments based on remaining 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books: -

1. Project Management: A managerial approach, Jack Meredith & Samuel Mantel, 7th Edition, Wiley India
2. A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 5th Ed, Project Management Institute PA, USA
3. Project Management,Gido Clements, Cengage Learning
4. Project Management,Gopalan, Wiley India
5. Project Management,Dennis Lock, 9th Edition, Gower Publishing England

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
OE2122	Finance Management	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	150	

Pre-requisite Course Codes	-	
Course Outcomes	CO1	Understand Indian finance system and corporate finance
	CO2	Take investment, finance as well as dividend decisions

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Overview of Indian Financial System:** Characteristics, Components and Functions of Financial System. Financial Instruments: Meaning, Characteristics and Classification of Basic Financial Instruments — Equity Shares, Preference Shares, Bonds-Debentures, Certificates of Deposit, and Treasury Bills. Financial Markets: Meaning, Characteristics and Classification of Financial Markets — Capital Market, Money Market and Foreign Currency Market Financial Institutions: Meaning, Characteristics and Classification of Financial Institutions — Commercial Banks, Investment-Merchant Banks and Stock Exchanges	1-4	6
2	2.1	**Concepts of Returns and Risks:** Measurement of Historical Returns and Expected Returns of a Single Security and a Two-security Portfolio; Measurement of Historical Risk and Expected Risk of a Single Security and a Two-security Portfolio.	1-4	6
	2.2	**Time Value of Money:** Future Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Present Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Continuous Compounding and Continuous Discounting.	1-4	
3	3.1	**Overview of Corporate Finance:** Objectives of Corporate Finance; Functions of Corporate Finance—Investment Decision, Financing Decision, and Dividend Decision.	1-4	9

	3.2	**Financial Ratio Analysis:** Overview of Financial Statements—Balance Sheet, Profit and Loss Account, and Cash Flow Statement; Purpose of Financial Ratio Analysis; Liquidity Ratios; Efficiency or Activity Ratios; Profitability Ratios; Capital Structure Ratios; Stock Market Ratios; Limitations of Ratio Analysis.	1-4	
4	**4.1**	**Capital Budgeting:** Meaning and Importance of Capital Budgeting; Inputs for Capital Budgeting Decisions; Investment Appraisal Criterion—Accounting Rate of Return, Payback Period, Discounted Payback Period, Net Present Value(NPV), Profitability Index, Internal Rate of Return (IRR), and Modified Internal Rate of Return (MIRR)	1-4	10
	4.2	**Working Capital Management:** Concepts of Meaning Working Capital; Importance of Working Capital Management; Factors Affecting an Entity's Working Capital Needs; Estimation of Working Capital Requirements; Management of Inventories; Management of Receivables; and Management of Cash and Marketable Securities.	1-4	
5	**5.1**	**Sources of Finance:** Long Term Sources—Equity, Debt, and Hybrids; Mezzanine Finance; Sources of Short Term Finance—Trade Credit, Bank Finance, Commercial Paper; Project Finance.	1-4	5
	5.2	**Capital Structure:** Factors Affecting an Entity's Capital Structure; Overview of Capital Structure Theories and Approaches— Net Income Approach, Net Operating Income Approach; Traditional Approach, and Modigliani-Miller Approach. Relation between Capital Structure and Corporate Value; Concept of Optimal Capital Structure	1-4	
6	**6.1**	**Dividend Policy:** Meaning and Importance of Dividend Policy; Factors Affecting an Entity's Dividend Decision; Overview of Dividend Policy Theories and Approaches—Gordon's Approach, Walter's Approach, and Modigliani-Miller Approach	1-4	3
				39

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus

   Continuous pre-defined rubrics-based evaluation for 20 marks.
2. **ISE-2** Three Assignments based on remaining 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:-

1. Fundamentals of Financial Management, 13th Edition (2015) by Eugene F. Brigham and Joel F. Houston; Publisher: Cengage Publications, New Delhi.
2. Analysis for Financial Management, 10th Edition (2013) by Robert C. Higgins; Publishers: McGraw Hill Education, New Delhi.
3. Indian Financial System, 9th Edition (2015) by M. Y. Khan; Publisher: McGraw Hill Education, New Delhi.
4. Financial Management, 11th Edition (2015) by I. M. Pandey; Publisher: S. Chand (G/L) & Company Limited, New Delhi.

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
OE2123	Environmental Management	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	150	

Pre-requisite Course Codes		
Course Outcomes	CO1	Understand the concept of environmental management
	CO2	Understand ecosystem and interdependence, food chain etc.
	CO3	Understand and interpret environment related legislations

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	Introduction and Definition of Environment: Significance of Environment Management for contemporary managers, Career opportunities, Environmental issues relevant to India, Sustainable Development, the Energy scenario	1	10
2	2.1	Global Environmental concerns : Global Warming, Acid Rain, Ozone Depletion, Hazardous Wastes, Endangered life-species, Loss of Biodiversity, Industrial/Man-made disasters, Atomic/Biomedical hazards, etc.	1	6
3	3.1	Concepts of Ecology: Ecosystems and interdependence between living organisms, habitats, limiting factors, carrying capacity, food chain, etc.	1	5
4	4.1	Scope of Environment Management, Role and functions of Government as a planning and regulating agency Environment Quality Management and Corporate Environmental Responsibility	1	10
5	5.1	Total Quality Environmental Management, ISO-14000, EMS certification.	1	5
6	6.1	General overview of major legislations like Environment Protection Act, Air (P & CP) Act, Water (P & CP) Act, Wildlife Protection Act, Forest Act, Factories Act, etc.	1	3
				39

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 20 marks.

2. **ISE-2** Three Assignments based on remaining 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:-

1. Environmental Management: Principles and Practice, C J Barrow, Routledge Publishers London, 1999
2. A Handbook of Environmental Management Edited by Jon C. Lovett and David G. Ockwell, Edward Elgar Publishing
3. Environmental Management V Ramachandra and Vijay Kulkarni, TERI Press
4. Indian Standard Environmental Management Systems — Requirements With Guidance For Use, Bureau Of Indian Standards, February 2005
5. Environmental Management: An Indian Perspective, S N Chary and Vinod Vyasulu, Maclillan India, 2000
6. Introduction to Environmental Management, Mary K Theodore and Louise Theodore, CRC Press
7. Environment and Ecology, Majid Hussain, 3rd Ed. Access Publishing.2015

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned		
		L	T	P	L	T	P	Total
CCL21CE02	Advanced Cloud Computing	0	0	2	0	0	1	1
		Examination Scheme						
		ISE	MSE		ISE	ESE		Total
		25	--		25	--		50

Pre-requisite	C programming, Operating Systems, Basics of Networking, Web Technology	
	On successful completion of the course learner will be able to	
Course Outcomes	CO1	Analyze cloud computing architectures, including virtualization, service models (IaaS, PaaS, SaaS), and deployment models (public, private, hybrid, community) to understand their applicability and implementation.
	CO2	Design scalable, secure, and efficient cloud-based solutions using AWS services such as EC2, S3, RDS, Lambda, and VPC.
	CO3	Deploy containerized applications using Docker and orchestrate them with Kubernetes to achieve high availability and scalability.
	CO4	Construct a private cloud infrastructure utilizing open-source tools like OpenStack/Cloud Foundry to offer computing capabilities and application services.
	CO5	Automate the software development lifecycle in cloud environments by applying DevOps practices, including continuous integration and continuous delivery (CI/CD), using tools like Jenkins and Docker.

Exp. No.	Name of the experiment	Ref	Hrs
Modules and Concepts: Virtualization - Study and Implementation of Hypervisors			
1	Understand the architecture and functionality of both Type 1 (bare metal) and Type 2 (hosted) hypervisors. Implement and compare their performance on the same hardware. Tools: Type 1 - Xen, Hyper-V, VMware ESX/ESXi; Type 2 - Oracle VirtualBox, VMware Workstation	1	2
Cloud Computing and AWS basics			
2	Introduction to cloud computing, understanding of service models (IaaS, PaaS, SaaS), and deployment models (public, private, hybrid, community).	2	2

3	AWS basics (EC2, EBS, S3, and DB): Learn to create and manage AWS EC2 instances, use EBS for persistent storage, S3 for object storage, and RDS for database services.	3	2
AWS Security			
4	Design and implement a secure VPC within AWS, including subnet creation, internet gateway setup, and route table configuration.	3	2
5	Explore Identity and Access Management (IAM) for managing permissions and Security Groups and Network Access Control Lists (NACLs) for securing VPCs.	3	
AWS services			
6	Server less Computing- AWS Lambda: Implement serverless architecture using AWS Lambda. Understand triggers, deployment, and use cases.	3	2
7	AWS messaging/notification service- SNS and SQS: Implement and differentiate between Simple Notification Service (SNS) for pub/sub messaging and Simple Queue Service (SQS) for message queuing.	3	2
DevOps/Containerization			
8	Docker: Introduction to containerization with Docker. Learn to create, manage, and deploy Docker containers. Tools: Docker	5	2
9	Kubernetes: Deploy and manage containerized applications with Kubernetes. Understand pods, deployments, services, and scaling. Tools: Minikube, Kubernetes	6	2
Machine Learning Operations			
10	Deploy a machine learning model and set up a CI/CD pipeline for continuous integration and delivery of ML projects. Tools: Jenkins, Docker, GitHub Actions	7	2
Private Cloud			
11	Install and configure a private cloud environment with computing capabilities using OpenStack. Tools: OpenStack	4	2
12	Deploy applications and services on a private cloud infrastructure. Implement service orchestration. Tools: Cloud Foundry, OpenStack	4	2
Mini Project: (Suggested list of Mini Project Topics)			

13	1. Deployment of a scalable web application on AWS using EC2, S3, and RDS. 2. Implementing a CI/CD pipeline for a machine learning project using Jenkins and Docker. 3. Building a serverless application using AWS Lambda for real-time data processing. 4. Developing a microservices architecture application deployed on Kubernetes. 5. Setting up and managing a multi-tier application on a private cloud using OpenStack.		

Course Assessment

ISE:

1. ISE-1 will be conducted 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

2. ISE-2

a. will be conducted reaming 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

b. Presentation /Simulation using modern tools to solve the given problem statement for 10 marks

Recommended Books:

1. Matthew Portnoy, Virtualization Essentials, 3rd Edition, Siley ISBN: 978-1-394-18157-5
2. Shailendra Singh, Cloud Computing, Oxford Higher Education, 2018.
3. Bernard Golden - Amazon Web Services for Dummies
4. Kevin Jackson , Cody Bunch, Open Stack Cloud Computing Cookbook, 2nd Edition, Packt Publishing, 978-1-78216-758-7
5. Sean P. Kane, Karl Matthias, Docker: Up & Running, 3rd Edition, O'Reilly
6. Brendan Burns, Joe Beda, Kelsey Hightower, Lachlan Everson, Kubernetes: Up and Running, 3rd Edition, O'Reilly
7. Vishwajyoti Pandey, Shaleen Bengani, Operationalizing Machine Learning Pipelines: Building Reusable and Reproducible Machine Learning Pipelines Using MLOps, 2022, BPB

Online Resources:

1. Introduction and overview of cloud computing: https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication500-292.pdf
2. AWS Documentation: https://docs.aws.amazon.com/
3. "OpenStack Docs: Current", http://docs.openstack.org/
4. https://docs.docker.com/manuals/
5. https://kubernetes.io/docs/home/

Further Reading:

1. "vSphere 5 Documentation Center:", http://pubs.vmware.com/vsphere-50/index.jsp.
2. "Google App Engine", https://developers.google.com/appengine/ .
3. "Windows azure: Microsoft's Cloud Platform| Cloud hosting |Cloud Service ", http://www.windowsazure.com/en-us/

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned		
		L	T	P	L	T	P	Total
SBL21CE02	Cyber Forensic	0	0	2	0	0	1	1
		Examination Scheme						
		ISE1	MSE		ISE2	ESE		Total
		25	--		25	--		50

Pre-requisite	Cryptography and Network Security	
	On successful completion of the course learner will be able to	
Course Outcomes	CO1	Demonstrate an understanding of different types of cybercrime.
	CO2	Apply knowledge of data acquisition methods using appropriate tools and techniques.
	CO3	Explore the functionality of tools for data analysis through practical demonstrations.
	CO4	Evaluate case studies and simulations to simulate forensic investigations of cybercrime incidents.

Exp. No.	Name of the experiment	Ref	Hrs
	Simulate the Network attacks		
1	Simulate DOS attack using HPing3	1, 2, Online 2	2
2.	To install and explore ARPWATCH and ETTERCAP.	1, 2 Online 2	2
	File System Forensics		
3	a. File system analysis using open-source tools like **Autopsy** and **Sleuth Kit**. b. Recovering deleted files and examining file metadata.	1, 2 Online 2	2
	Data Acquisition		
4	**a.** Performing disk imaging using open-source tools like dd and **FTK Imager** b. Verifying disk images using hashing algorithms	1, 2 Online 1,2	2
	Data Analysis		
5	Perform Forensic on image of disk captured for analyzing data using **Autopsy/ Volatility** tools.(can use DFIR challenges)	1, 2 Online 1,2	2
	Email and Social Media Forensics		

6	Extracting and analyzing email headers, attachments, and social media artifacts using **Autopsy/ Volatility** tools.	1, 2 Online 1,2	2
	Network Forensics		
7	a. Using **Wireshark** to capture and analyze network traffic b. Identifying suspicious network activities and potential security threats	1, 2 Online 1,2	2
8	Scan open ports, perform OS fingerprinting, do a ping scan, tcp port scan, udp port scan, xmas scan etc using NMAP	1, 2 Online 1,2	2
	Mobile Forensics		
9.	a. Demonstrate functionalities of Android and iOS forensics using open-source tools **Andriller and MobSF** b. Extracting data from mobile devices and analyzing mobile artefacts using open-source tools **Andriller and MobSF.**	1, 2 Online 1,2	2
	Mini Project (Suggested Topic List)		
10.	**1. Data Breach Investigation:** 1.1. Scenario: A large corporation experiences a data breach where sensitive customer information, including personal and financial data, is stolen by hackers. 1.2. Investigation: Forensic analysts are tasked with investigating the breach to determine the source of the attack, the extent of the data compromise, and the techniques used by the attackers to gain unauthorized access. 1.3. Tools and Techniques: Investigators may use network forensics tools to analyze network traffic logs, malware analysis tools to dissect malicious software used in the attack, and memory forensics tools to examine volatile memory for evidence of compromise. **2. Employee Misconduct:** 2.1. Scenario: An employee is suspected of engaging in unauthorized activities, such as accessing sensitive company data without permission or sharing confidential information with external parties. 2.2. Investigation: Digital forensic analysts are called upon to conduct an investigation to gather evidence of the employee's activities, including their digital footprint, communications, and file access history. 2.3. Tools and Techniques: Investigators may use email forensics tools to analyze the employee's email communications, endpoint forensics tools to examine their computer for	1, 2,3 Online 1,2	2

	unauthorized software or files, and social media forensics tools to uncover any relevant online activity. 3. **Ransomware Attack**: 3.1. Scenario: A company's computer systems are infected with ransomware, which encrypts critical data and demands a ransom for decryption. 3.2. Investigation: Cyber forensic experts are brought in to investigate the ransomware attack, identify the point of entry, and determine the scope of the infection. 3.3. Tools and Techniques: Investigators may use memory forensics tools to analyze volatile memory for signs of ransomware activity, disk forensics tools to examine infected systems for artifacts related to the attack, and network forensics tools to trace the origin of the malware infection. 4. **Intellectual Property Theft**: 4.1. Scenario: A company suspects that an employee or competitor has stolen intellectual property, such as trade secrets, patents, or proprietary software code. 4.2. Investigation: Forensic analysts are tasked with gathering evidence to support the company's suspicions and identify the individuals or entities involved in the theft. 4.3. Tools and Techniques: Investigators may use data recovery tools to retrieve deleted files or documents, metadata analysis tools to examine file properties and timestamps, and document analysis tools to compare versions of documents for evidence of tampering or unauthorized access. Mini project can be implemented and presented in groups of 2/3 students. Students can use Incident Response Playbooks: Customized based on scenarios, Open-Source Intelligence (OSINT)		

Course Assessment

ISE:

1. ISE-1 will be conducted 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

2. ISE-2

a. will be conducted reaming 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

b. Presentation /Simulation using modern tools to solve the given problem statement for 10 marks

Recommended Books:

1. Nina Godbole, Sunit Belapure, Cyber Security, Wiley India, New Delhi
2. Kevin Mandia, Chris Prosise, —Incident Response and computer forensics‖, Tata McGrawHill, 2006
3. Digital Forensics Basics A Practical Guide Using Windows OS — Nihad A. Hassan, APress Publication, 2019

Online Resources:

1. Course on Cyber Incident Response
   https://www.coursera.org/learn/incident-response
2. Course on —Penetration Testing, Incident Responses and Forensics‖
   https://www.coursera.org/learn/ibm-penetration-testing-incident-response-forensics

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MP22CE01	Major Project: Dissertation – I	--	--	28 #		--	--	14	14
		Examination Scheme							
		ISE1		MSE	ISE2	ESE		Total	
		20		--	30	50		100	

# indicates workload of Learner (Not Faculty)

Guidelines for Dissertation-I –Internship

Students should do literature survey and identify the problem for Dissertation and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the problem. Students should attempt solution to the problem by analytical/simulation/experimental methods. The solution to be validated with proper justification and compile the report in standard format. Guidelines for Assessment of Dissertation-I.

Dissertation-I should be assessed based on following points

- Quality of Literature survey and Novelty in the problem
- Clarity of Problem definition and Feasibility of problem solution
- Relevance to the specialization
- Clarity of objective and scope Dissertation-I should be assessed through a presentation by a panel of Internal examiners and external examiner appointed by the Head of the Department/Institute of respective Programme.

Course Assessment:

ISE-1:
Continuous Evaluation by project guide followed by presentation before a panel of examiners (20 marks)

ISE-2:
Continuous Evaluation by project guide followed by presentation before a panel of examiners (30 marks)

ESE: Continuous Evaluation by project guide followed by presentation before a panel of examiners (50 marks)

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MP22CE02	Major Project: Dissertation – II	--	--	40 #		--	--	20	20
		Examination Scheme							
		ISE1		MSE	ISE2	ESE		Total	
		50		--	50	100		200	

# indicates work load of Learner (Not Faculty)

Guidelines for Assessment of Dissertation II

Dissertation II should be assessed based on following points:

- Quality of Literature survey and Novelty in the problem
- Clarity of Problem definition and Feasibility of problem solution
- Relevance to the specialization or current Research / Industrial trends
- Clarity of objective and scope
- Quality of work attempted or learner contribution
- Validation of results
- Quality of Written and Oral Presentation

Students should publish at least one paper based on the work in referred National/ International conference/Journal of repute.

Course Assessment:

ISE-1: Continuous Evaluation by project guide followed by presentation before a panel of examiners based on predefined rubrics (50 marks)

ISE-2: Continuous Evaluation by project guide followed by presentation before a panel of examiners (50 marks)

ESE: Continuous Evaluation by project guide followed by presentation before a panel of internal examiners and external examiner (100 marks)