FIRST YEAR B.Tech. CURRICULUM 2026 (Common to all CS Streams) PHYSICS CYCLE

Year	FIRST SEMESTER						SECOND SEMESTER					
	Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
I	SMS 1102	Computational Mathematics - I	3	1	0	4	SMS 1202	Computational Mathematics - II	3	1	0	4
	SMS 1002	Applied Physics for Engineers	3	0	0	3	SMS 1004	Applied Chemistry for Engineers	3	0	0	3
	EES 1004	Fundamentals of Electronics	2	1	0	3	EES 1002	Fundamentals of Electrical Engineering	3	0	0	3
	CES 1102	Programming for Problem Solving	2	1	0	3	CCS 1002	Engineering Mechanics and Smart Buildings	2	1	0	3
	MES 1002	Fundamentals of Mechanical Engineering	3	0	0	3	CES 1201	Introduction to Object Oriented Programming	3	0	0	3
	SMS 1005	Communication Skills in English	1	0	2	2	CCS 1003	Environmental Studies	1	0	2	2
	MES 1011	Workshop Practice	0	0	3	1	CES 1211	Introduction to Object Oriented Programming Lab	0	0	3	1
	CES 1111	Programming for Problem Solving Lab	0	0	3	1	CES 1212	Data Visualisation	0	1	3	2
	SMS1006	Universal Human Values and Professional Ethics (MLC)	1	0	0	1	MES 1012	Computer Aided Engineering Graphics	0	0	3	1
	SMS 1007	Human Rights and Constitution (MLC)	1	0	0	1						
			17	**3**	**8**	**22**			**17**	**2**	**11**	**22**
	Total Contact Hours (L + T + P)		**28**				**Total Contact Hours (L + T + P)**		**30**			

FIRST YEAR B.Tech. CURRICULUM 2026 (Common to all CS Streams) CHEMISTRY CYCLE

Year	FIRST SEMESTER						SECOND SEMESTER					
	Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
I	SMS 1102	Computational Mathematics - I	3	1	0	4	SMS 1202	Computational Mathematics - II	3	1	0	4
	SMS 1004	Applied Chemistry for Engineers	3	0	0	3	SMS 1002	Applied Physics for Engineers	3	0	0	3
	EES 1002	Fundamentals of Electrical Engineering	2	1	0	3	EES 1004	Fundamentals of Electronics	3	0	0	3
	CES 1102	Programming for Problem Solving	2	1	0	3	MES 1002	Fundamentals of Mechanical Engineering	2	1	0	3
	CCS 1003	Environmental Studies	3	0	0	3	CES 1201	Introduction to Object Oriented Programming	3	0	0	3
	CCS 1002	Engineering Mechanics & Smart Building	1	0	2	2	SMS 1005	Communication Skills in English	1	0	2	2
	MES 1012	Computer aided Engineering Graphics	0	0	3		CES 1211	Introduction to Object Oriented Programming Lab	0	0	3	1
	CES 1111	Programming for Problem Solving Lab	0	0	3	1	CES 1212	Data Visualisation	1	0	3	2
	SMS1006	Universal Human Values and Professional Ethics (MLC)	1	0	0	1	MES 1011	Workshop Practice	0	0	3	1
	SMS 1007	Human Rights and Constitution (MLC)	1	0	0	1						
			17	**3**	**8**	**22**			**17**	**2**	**11**	**22**
	Total Contact Hours (L + T + P)		**28**				**Total Contact Hours (L + T + P)**		**30**			

Year	THIRD SEMESTER						FOURTH SEMESTER					
	Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	L	T	P	C
II	SMS 2101	Discrete Mathematical Structures	3	0	0	3	SMS 2201	Probability and Optimization	3	0	0	3
	CES 2101	Data Structures	3	1	0	4	CES 2201	Database Systems	3	1	0	4
	CES 2102	Data Communication and Computer Networks	3	1	0	4	CES 2202	Design and Analysis of Algorithms	3	1	0	4
	CES 2103	Data Analytics	3	1	0	4	CES 2203	Introduction to Artificial Intelligence	3	0	0	3
	CES 2104	Digital Systems and Computer Organization	3	1	0	4	CES 2204	Operating Systems	3	0	0	3
	CES 2111	Data Structures Lab	0	0	3	1	CES 2211	Operating Systems Lab	0	0	3	1
	CES 2112	Digital Systems lab	0	0	3	1	CES 2212	Database Systems Lab	0	0	3	2
							CES 2213	Object Oriented Software Development Lab	0	1	3	2
			15	**4**	**6**	**21**			**15**	**3**	**9**	**22**
	Total Contact Hours (L + T + P)		**25**				**Total Contact Hours (L + T+ P)**		**27**			
	FIFTH SEMESTER						**SIXTH SEMESTER**					
III	SMS 3003	Foundation of Technology Management	3	0	0	3	SMS 3004	Emerging Economic Landscape	3	0	0	3
	CES 3101	Finite Automata and Compiler Design	3	1	0	4	CEO 32xx	CS Specialization (S4)	3	0	3	4
	CEO 31xx	CS Specialization (S1)	3	0	3	4	CEO 32xx	CS Specialization (S5)	3	0	3	4
	CEO 31xx	CS Specialization (S2)	3	0	3	4	CEP 4401	Program Elective 1/ Minor 1	3	0	0	3
	CEO 31xx	CS Specialization (S3)	3	0	3	4	CEP 4402	Program Elective 2/ Minor 2	3	0	0	3
	IOE 3xxx	Open Elective 1 (MLC)	3	0	0	3	IOE 3xxx	Open Elective 2 (MLC)	3	0	0	3
			18	**1**	**9**	**22**			**18**	**0**	**6**	**20**
	Total Contact Hours (L + T + P)		**28**				**Total Contact Hours (L + T + P)**		**24**			
	SEVENTH SEMESTER						**EIGHTH SEMESTER**					
IV	CEP 44xx	Program Elective 3/ Minor 3	3	0	0	3	CES 4299	Internship (MLC)				1
	CEP 44xx	Program Elective 4/ Minor 4	3	0	0	3	CES 4999	Capstone Project				12
	CEP 44xx	Program Elective 5	3	0	0	3	CEH 5999	Capstone Project (Honours)^				20
	CEP 44xx	Program Elective 6	3	0	0	3	CEH 5xxx	Honours Course 1^				4
	CEP 44xx	Program Elective 7	3	0	0	3	CEH 5xxx	Honours Course 2^				4
	IOE 3xxx	Open Elective 3 (MLC)	3	0	0	3	CEH 5xxx	Honours Course 3^				4
	*** 4199	Minor Specialization Project *				8						
			18	**0**	**0**	**18/26***						**13/33^**
	Total Contact Hours (L + T + P)		**18**									

*Applicable to students who opted for minor specialization

^Applicable to eligible students who opted for and successfully completed the BTech – Honours requirements

List of Specializations

1. **ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING**
    - CEO 3101 Foundations of Computer Vision
    - CEO 3102 Machine Learning
    - CEO 3103 Parallel Computer Architecture and Programming
    - CEO 3201 Deep Learning and Applications
    - CEO 3202 Natural Language Processing

2. **NETWORKS AND IOT**
    - CEO 3104 Embedded Systems and IoT
    - CEO 3105 Network Protocols and Programming
    - CEO 3106 Cloud Computing
    - CEO 3204 Network Security
    - CEO 3205 Wireless Communication and Networking

3. **DATA SCIENCE**
    - CEO 3108 Data Privacy and Security
    - CEO 3109 Statistical Machine Learning
    - CEO 3110 Big Data Analytics
    - CEO 3207 Image and Video Analytics
    - CEO 3208 Generative AI

4. **SOFTWARE ENGINEERING**
    - CEO 3112 Software Engineering and Design Technology
    - CEO 3113 DevOps - Using AI
    - CEO 3114 Full Stack Application Development
    - CEO 3209 Software Testing and Analysis
    - CEO 3210 Software Project Management

5. **CYBER SECURITY**
    - CEO 3116 Number Theory and Cryptography
    - CEO 3117 Essentials of Cyber Security
    - CEO 3118 Incident Response and Threat Intelligence
    - CEO 3212 Cyber Law, Cyber Crime and Cyber Ethics
    - CEO 3213 Applied Cryptography

6. **QUANTUM COMPUTING**
    - CEO 3120 Fundamentals of Quantum Computing
    - CEO 3121 Quantum Algorithms
    - CEO 3122 Quantum Communications and Quantum Networks
    - CEO 3215 Advanced Quantum Algorithms
    - CEO 3216 Industrial Applications of Quantum Computing

7. **GAMIFICATION AND DIGITAL TWINNING**
    - CEO 3124 Fundamentals of Game Design
    - CEO 3125 Introduction to Digital Twin Technologies
    - CEO 3126 Game Engine Architecture
    - CEO 3218 Game Programming and Development
    - CEO 3219 Gamification and Digital Twin System

8. **ROBOTICS AND ARTIFICIAL INTELLIGENCE**
    - CEO 3128 Fundamentals of Robotics
    - CEO 3129 Robot Sensing and Vision
    - CEO 3130 Robot Operating System
    - CEO 3220 Deep Learning for Robotics
    - CEO 3221 Advanced Robotics Programming

List of Program Electives

CEP 4401 Internet of Things and its Applications
CEP 4402 Augmented and Virtual Reality
CEP 4403 Conversational AI
CEP 4404 Fundamentals of iOS
CEP 4405 iOS Application Development
CEP 4406 Blockchain Technology
CEP 4407 Wireless Technologies
CEP 4408 Foundations of Quantum Computing
CEP 4409 Reinforcement Learning
CEP 4410 Mobile Application Development
CEP 4411 Foundations and Ethics of Generative AI
CEP 4412 Prompt Engineering
CEP 4413 Product Management
CEP 4414 Enterprise Data Architecture
CEP 4415 Optimization Techniques
CEP 4416 Cyber Forensics
CEP 4417 Deep Learning
CEP 4418 Machine Learning Tools and Technology
CEP 4419 Web Technologies
CEP 4420 Game Theory and Applications
CEP 4421 Explainable AI
CEP 4422 User Interface Engineering
CEP 4423 Semantic Web
CEP 4424 Graph Database

III SEMESTER

SMS 2101 DISCRETE MATHEMATICAL STRUCTURES [3 0 0 3]

Abstract syllabus:

Boolean Algebra: Partial ordering sets, Lattices–simple properties, Boolean algebras, Boolean polynomials: Disjunctive normal form (DNF) and Conjunctive normal form (CNF). Elementary configuration: Permutations and Combinations (basics), Generating function, Applications of Principle of inclusion and exclusion, Partitions, compositions, Fikes ordering of permutations. Graph theory: Basic definitions, properties, Eulerian graphs, Hamiltonian graphs, Trees and Properties, Matrices associated with graphs, Algorithms for finding shortest path. Group theory: Groups-subgroups, group of symmetries and applications, Cyclic groups, Cosets, Lagrange's Theorem. Propositional and Predicate Calculus: Well-formed formula, Connectives, Quantifications, Inference theory of Propositional and Predicate calculus. Matrix Decompositions: Prerequisites, QR, LU and SVD, and Applications.

References:

1. C. L. Liu, *Elements of Discrete Mathematics*, (2e) 2007, Mc Graw Hill, New Delhi.
2. J. P. Trembaly and R. Manohar, *Discrete Mathematics Structures with application to Computer Science*, 2012,Tata Mc Graw Hill.
3. E. S. Page and L. B. Wilson, *An introduction to Computational Combinatorics*, 1979 edn, Cambridge Univ. Press.
4. Narasingh Deo, *Graph theory with Applications to Computer Science*, Dover Publications, 2016. Originally published: Englewood Cliffs, New Jersey: Prentice-Hall, Inc.,1974.
5. F. Harary, *Graph Theory*, Narosa Publishing House, New Delhi, Second edition, 1990, Reprint 2013.
6. David C. Lay, *Linear Algebra & Its Applications*, Pearson Pub. 2016.
7. Alan Tucker, *Applied Combinatorics*, Wiley Publishers, 2012.
8. https://onlinecourses.nptel.ac.in/noc24_ma26/preview Introduction to Group Theory
9. https://nptel.ac.in/courses/111106086 Discrete Mathematics

CES 2101 DATA STRUCTURES [3 1 0 4]

Abstract syllabus:

Arrays, Sparse Matrix, Pointers and array of Pointers, Recursion, Memory allocation functions, Structures and array of structures, Linear Search, Binary Search, Merge sort and quick sort, Singly Linked List and Chains, Doubly Linked Lists, Circular Linked Lists, Linked Lists with Header Node, Applications using linked lists, Polynomials, Additional List Operations, Stacks, Queues, Circular Queues, Priority Queues and their Representation, Double Ended Queue, Input/Output Restricted Queues, Evaluation of Expression, Infix, Postfix and Prefix expressions and their conversions, Linked stacks and Linked Queues. Representation of Trees, Binary Trees, Expression tree, Binary Tree Traversals, Additional Binary Tree Operations, Threaded Binary Trees, Binary Search Trees - Definition, searching a Binary Search Tree, Inserting into

and Deletion from Binary Search Tree, AVL trees, Red-Black Trees, Introduction, Definitions, Graph Representations, Depth First Search, Breadth First Search.

References:

1. Behrouz A. Forouzan, Richard F. Gilberg, *A Structured Programming Approach Using C,* (3e), Cengage Learning India Pvt. Ltd, India, 2007.
2. Ellis Horowitz, Sartaj Sahani, *Susan Anderson and Freed, Fundamentals of Data Structures in C*, (2e), Silicon Press, 2007.
3. Richard F. Gilberg, Behrouz A. Forouzan, *Data structures, A Pseudocode Approach with C*, (2e), Cengage Learning India Pvt. Ltd, India, 2009.
4. Tenenbaum Aaron M., Langsam Yedidyah, Augenstein Moshe J., *Data Structures using C,* Pearson Prentice Hall of India Ltd., 2007.
5. Debasis Samanta, *Classic Data Structures*, (2e), PHI Learning Pvt. Ltd., India, 2010.
6. https://onlinecourses.swayam2.ac.in/cec25_hs62/preview [Introduction to Data Structures, Punjabi University, Patiala].

CES 2102 DATA COMMUNICATION AND COMPUTER NETWORKS [3 1 0 4]

Abstract syllabus:

Introduction to data communication, Digital and analog signals, Line coding, Modulation schemes, Multiplexing, Transmission media. Introduction to computer network, Protocol, Layered architecture, Topology and network devices, Data link layer services, Error detection and correction, Flow control, Access control: CSMA/CD, Ethernet Frame, Network layer services, IP addressing, IP datagram, Fragmentation, Options. Routing protocols. ARP, ICMP, Transport layer services-TCP, UDP. Application layer services- DNS, DHCP, HTTP, etc.

References:

1. Behrouz A. Forouzan, *TCP/IP Protocol Suite, (4e),* Tata McGraw Hill 2017.
2. Behrouz Forouzan, *Introduction to Data Communication & Networking*, *(5e),* Tata McGraw Hill, New Delhi-2017.
3. William Stallings, *Data & Computer Communications, (10e),* Pearson Education Inc., Noida, 2017.
4. Andrew S. Tanenbaum, *Computer Network, (5e),* Prentice Hall of India Pvt Ltd 2016.
5. Larry L. Peterson, Bruce S. Davie, *Computer Networks*, *(6e),* 2020.
   NPTEL LINK:https://nptel.ac.in/courses/106105183

CES 2103 DATA ANALYTICS [3 1 0 4]

Abstract syllabus:

Introduction to Analytics: Descriptive, Predictive, Prescriptive Analytics, steps in data analytics projects. **Data exploration:** Data sources, data collection, sampling distributions, data

types, describing data using measures of central tendency, distributions, data tabulation, and visualization. case studies. **Data Preparation:** Data Cleaning, Data Imputation, Multivariate data analysis using- correlation, hypothesis tests, ANOVA, and confidence intervals. Feature Engineering, Data Integration, Data Transformations, Dimensionality reduction, PCA **Recommender Systems:** Generating Association Rules using Apriori Algorithm, Measures of Pattern Interestingness, Metrics-Support, Confidence, Lift, cosine similarity. Collaborative Filtering Techniques- User-based Similarity and Item-based Similarity. **Time Series:** basics, time zones, period arithmetic, moving window functions. Case studies

References:

1. Glenn J. Myatt, Wayne P. Johnson, *Making Sense of Data: A Practical Guide to Exploratory Data Analysis and Data Mining*, John Wiley Publication, Second Edition, 2014.
2. Jiawei Han, Micheline Kamber, Jian Pei, *Data Mining Concepts and Techniques* Morgan Kaufmann Publishers, Third Edition, 2012.
3. U. Dinesh Kumar, *Business Analytics: The Science of Data-Driven Decision Making*, Second Edition, Wiley Publications, 2021
4. Joel Grus, "Data Science from Scratch: First Principles with Python", O'Reilly Media, 2019.
5. Anil Maheshwari, *Data analytics: A comprehensive guide to data analysis and decision-making*, Wiley Publications, 2021.
6. https://archive.nptel.ac.in/courses/110/106/110106072/ Introduction to Data Analytics.
7. https://onlinecourses.nptel.ac.in/noc21_cs45/preview Data Analytics with Python.

CES 2104 DIGITAL SYSTEMS AND COMPUTER ORGANIZATION [3 1 0 4]

Abstract syllabus:

Digital Systems: Simplification of logical expressions-K-Map simplification, Incompletely specified functions, Multilevel NAND and NOR Circuits. Arithmetic operations-addition of unsigned and signed numbers, BCD adder, Fast adder, Array multiplier. Combinational circuits- Multiplexer, Decoder, Encoder, Arithmetic comparison circuits. Sequential circuits- Flip-Flops, Design of synchronous sequential circuits, Ripple counter, Registers, Shift registers, Ring counter, Johnson counter, Programmable Logic Devices

Computer Organization: Instruction Set Architecture- Memory location, addresses and operations, Instructions and Instruction Sequencing, Addressing modes, RISC and CISC. Arithmetic Logic Unit- Multiplication of signed numbers, Booth's algorithm, Division, IEEE standard floating-point representation, Floating point arithmetic. Control Unit- Hardwired and micro-programmed approach for booths multiplier. Memory System- Cache memories, Magnetic hard disk. Basic Input/Output- I/O Device Interface, Program-Controlled I/O, Interrupts. Parallel processing- Pipelining, Hardware Multithreading, Vector Processing, Shared-Memory Multiprocessors, Cache Coherence.

References:

1. Stephen Brown and Zvonko Vranesic, *Fundamentals of Digital Logic with Verilog Design*, *(3e),* Tata McGraw Hill 2014.
2. Morris Mano M. and Michael D. Ciletti., *Digital Design: With an introduction to the Verilog HDL, (5e),* PHI Learning 2007.
3. Carl Hamacher, Zvonko Vranesic and Safwat Zaky, *Computer Organization and Embedded Systems*, *(6e),* McGraw Hill Publication, 2017.
4. Mohammed Rafiquzzaman and Rajan Chandra, *Modern Computer Architecture*, Galgotia Publications Pvt. Ltd., 2015.
5. Ronald J. Tocci, Neal S. Widmer and Greegory L Moss, *Digital Systems: Principles and Applications (12e),* Pearson Education India, 2017.
6. William Stallings, *Computer Organization and Architecture, (10e),* Pearson, 2017

CES 2111 DATA STRUCTURES LAB [0 0 3 1]

Abstract Syllabus:

Solving Problems Using Arrays, Pointers and Dynamic Memory Allocation Functions, Ragged Arrays, Structures, Solving Problems Using Recursion (Sorting And Searching), Linked List Concepts - Singly And Doubly Linked Lists, Circular Singly And Circular Doubly Linked Lists, Linked List Applications, Implementation of Stack Using Arrays And Linked Lists, Stack Applications, Implementation of Queue Using Arrays And Linked Lists, Queue Applications, Tree Concepts - Binary Tree And Binary Search Tree, AVL Tree , and Tree Applications.

References:

1. Behrouz A. Forouzan, Richard F. Gilberg, *A Structured Programming Approach Using C, (3e),* Cengage Learning India Pvt. Ltd, India, 2007.
2. Ellis Horowitz, Sartaj Sahani, Susan Anderson and Freed, *Fundamentals of Data Structures in C, (2e),* Silicon Press, 2007.
3. Richard F. Gilberg, Behrouz A. Forouzan, *Data structures, A Pseudocode Approach with C, (2e),* Cengage Learning India Pvt. Ltd, India, 2009.
4. Tenenbaum Aaron M., Langsam Yedidyah, Augenstein Moshe J., *Data structures using C*, Pearson Prentice Hall of India Ltd., 2007.
5. Debasis Samanta, *Classic Data Structures, (2e),* PHI Learning Pvt. Ltd., India, 2010.

CES 2112 DIGITAL SYSTEMS LAB [0 0 3 1]

Abstract Syllabus :

Simulation of Logic Circuits Using Verilog: Simplification of Expressions using Kmap: SOP and POS Forms, Multilevel NAND, NOR Circuits, Arithmetic Circuits: Half Adder, Full Adder, Multi-Bit Adder/Subtractor, BCD Adder, Multiplexers, Decoders and Encoders, Latches and Flip-Flops: D, JK, and T Flip-Flops, Registers: Shift Register, Design of sequential circuits.

References :

1. Stephen Brown and Zvonko Vranesic, *Fundamentals of Digital Logic with Verilog Design, (3e),* Tata McGraw Hill, 2014
2. Morris Mano M., *Digital Design, (5e),* PHI Learning 2007

IV SEMESTER

SMS 2201 PROBABILITY AND OPTIMIZATION [3 0 0 3]

Abstract syllabus :

Axioms of probability, Baye's theorem - Applications, One dimensional and Two-dimensional random variables, mean and variance, properties, Chebyshev's inequality, Correlation Coefficient, Markov Chains, Distributions: Discrete and Continuous, Binomial, Poisson, exponential, Normal and Chi-square, Moment generating function, properties. Functions of random variables - One-Two dimensional, Jacobians. Sampling theory: Central limit theorem, Point estimation, Maximum Likelihood Estimator. Hypothesis: significance level, Chi square test. Gradients of Matrices: Useful Identities for Computing Gradients, Backpropagation and Automatic Differentiation. Constrained Optimization.

References:

1. P. L. Meyer, *Introduction to Probability and Statistical Applications, (2e)*, Oxford and IBH Publishing, Delhi, 1980
2. Miller, Freund and Johnson, *Probability and Statistics for Engineers*, *(8e),* PHI, 2011.
3. Hogg and Craig, *Introduction to Mathematical Statistics, (6e),* Pearson education, New Delhi, ,2012
4. Ross Sheldon M, *Introduction to Probability and Statistics for Engineers and Scientists,* Elsevier, 2010.
5. Marc Peter Deisenroth, a. Aldo Faisal, Cheng Soon Ong, *Mathematics for Machine Learning*, Cambridge University Press, 2020.
6. J. Medhi, *Stochastic Processes, (3e),* New Age International, 2009.
7. https://nptel.ac.in/courses/111101004 Introduction to Probability Theory
8. https://onlinecourses.nptel.ac.in/noc22_ma81/preview Introduction to Probability Theory and Statistics
9. https://nptel.ac.in/courses/111105039 Optimization.

CES 2201 DATABASE SYSTEMS [3 1 0 4]

Abstract syllabus:

Database-System Applications, Database Languages, Relational Databases, Database Design, Data Storage and Querying, Database Architecture, Database Schemas, Keys, File Organization , Organization of Records in Files, Relational Query Languages, Relational Operations, SQL Data Definition, SQL Data Types and Schemas, Integrity Constraints, Set Operations,

Aggregate Functions, Overview of SQL Query Language, Basic Structure of SQL Queries, Join Expressions, Overview of Query Processing, Measure of Query Cost, Selection Operation, Sorting, Join Operation, Other Operations, Overview of the Design Process, The Entity-Relationship Model, Extended E-R Features, Reduction to Relational Schemas, Features of Good Relational Design, Atomic Domains and Normalization, Transaction Concept, Failure Classification, Storage, Recovery and Atomicity, Recovery algorithm.

References:

1. Silberschatz, Korth, Sudarshan, *Database System Concepts, (7e)*, McGrawHill,New York, 2011.
2. Pramod J Sadalage, Martin Fowler, *NoSQL Distilled,* Addison-Wesley, 2013.
3. Ramez Elmasri and Shamkant Navathe, Durvasula V L N Somayajulu, Shyam K Gupta, *Fundamentals of Database Systems, (6e),* Pearson Education, United States of America, 2011.
4. Thomas Connolly, Carolyn Begg, Database Systems – *A Practical Approach to Design, Implementation and Management, (4e)*, Pearson Education,England, 2005.
5. Peter Rob, Carlos Coronel, Database Systems–*Design, Implementation and Management, (10e),* Course Technology, Boston, 2013.
6. https://onlinecourses.nptel.ac.in/noc25_cs40/preview Introduction to Database Systems

CES 2202 DESIGN AND ANALYSIS OF ALGORITHMS [3 1 0 4]

Abstract syllabus:

Fundamentals of Algorithms, Important Problem Types, Analysis of algorithm efficiency. Analysis Framework: Asymptotic Notations and Basic Efficiency Classes, Mathematical Analysis of Non-recursive and Recursive Algorithms. Brute force Techniques, Divide and Conquer, Decrease and Conquer: Insertion Sort, Depth First Search, Breadth First Search, Topological Sorting. Transform and Conquer: Presorting, BST, Heapsort. Space and Time tradeoffs: Input Enhancement in String Matching. Dynamic Programming: Warshall's and Floyd's Algorithms, The Knapsack Problem. Greedy Techniques: Prim's, Kruskal's and Dijkstra's Algorithm, Huffman Trees. Coping with limitations of algorithmic power, P, NP, and NP-complete Problems, Backtracking: n–Queens problem, Hamiltonian Circuit Problem, Subset–Sum Problem. Branch and Bound: Assignment Problem, Knapsack Problem, TSP.

References:

1. Anany Levitin, *Introduction to the Design and Analysis of Algorithms, (3e),* Pearson Education, 2017
2. Ellis Horowitz and Sartaj Sahni, *Computer Algorithms/C++, (2e),* University Press, 2007.
3. Thomas H. Cormen, Charles E. Leiserson, Ronal L, Rivest, Clifford Stein, *Introduction to Algorithms, (2e),* PHI, 2006
4. Kleinberg, Jon, and Tardos, Éva. Algorithm Design. United Kingdom, Pearson, 2013.
5. https://archive.nptel.ac.in/courses/106/105/106105164/

CES 2203 INTRODUCTION TO ARTIFICIAL INTELLIGENCE [3 0 0 3]

Abstract syllabus:

Introduction: What is Artificial Intelligence (AI)? Turing test, history and the state of the art of AI. Intelligent Agents: How agents should act, mapping, agents and environments, structure of intelligent agents. Problem Solving and Search Techniques: Search state space representation, production systems, problem and production system characteristics, uninformed and heuristic search techniques. Logical Agents: The wumpus world environment, propositional logic, propositional theorem proving, agents based on propositional logic. Using Predicate Logic: Representing instances and ISA relationship, compatible functions and predicates. Knowledge Representation: Ontological engineering, knowledge representation using predicate calculus, knowledge engineering process. Quantifying Uncertainty and Probabilistic Reasoning: Probability and Bayes' theorem, design and development of tutorials on expert systems, expert system shells, knowledge acquisition.

References:

1. Stuart Russell and Peter Norvig, *Artificial Intelligence A Modern Approach (3e),* Pearson Education, Third Edition, 2010.
2. Elaine Rich, Kevin Knight, Shivashankar B. Nair, *Artificial Intelligence (3e),* Tata McGraw Hill, 2010.
3. Saroj Kaushik, *Artificial Intelligence*, Cengage Learning Publications, First Edition, 2011.
4. Don W. Patterson, *Introduction to Artificial Intelligence and Expert Systems*, PHI Publication, 2006.
5. https://nptel.ac.in/courses/106105079 [Title of NPTEL Course: Artificial Intelligence (Prof. P. Dasgupta), IIT Kharagpur, India]
6. https://nptel.ac.in/courses/106102220 [Title of NPTEL Course: An Introduction to Artificial Intelligence (Prof. Mausam), IIT Delhi, India]

CES 2204 OPERATING SYSTEMS [3 0 0 3]

Abstract syllabus:

Introduction to operating systems, Operating system services, Operating system structure, System calls, Process management: Process concept, Threads, Inter-process communication, CPU Scheduling, Process synchronization, Handling deadlocks: Deadlock characterization, Deadlock detection, Prevention, Avoidance and recovery, Memory management: Main memory, Swapping, Contiguous memory allocation, Paging, Segmentation, Virtual memory: Demand paging, Page replacement, Thrashing, Allocating kernel memory, Storage management: File management, Disk scheduling, Case study on Unix based operating system: Design principles, Kernel modules, Basic concepts of real time operating systems: Classification of real time systems, Microkernels, Scheduling.

References:

1. Abraham Silberschatz, Peter Baer Galvin and Greg Gagne, *Operating System Concepts, (10e),* Wiley, 2018.
2. William Stallings, *Operating Systems: Internals and Design Principles (9e),* Pearson, 2017.
3. Phillip A Laplante, Seppo J Ovaska, *Real time systems design and analysis, (4e),* Wiley, 2013.
4. Rajib Mall, *Real time systems: Theory and Practice, (2e),* Pearson, 2009.
5. https://onlinecourses.nptel.ac.in/noc24_cs108/preview Operating System Fundamentals.

CES 2211 OPERATING SYSTEMS LAB [0 0 3 1]

Abstract Syllabus:

Demonstrate the working of UNIX-based operating systems by experimenting with shell commands and developing shell scripts. This includes file handling and advanced searching tools, combining the preliminary shell commands to create useful scripts. Develop applications that utilize POSIX inter-process communication system calls. Implement CPU scheduling algorithms, synchronization, memory and deadlock management tools.

References:

1. Richard Blum, Christine Bresnahan, *Linux Command Line Shell Scripting Bible, (3e),* Wiley, 2018.
2. Silberschatz A., Galvin P.B.& Gagne G.*, Operating System Concepts, (10e)* Wiley, 2012.

CES 2212 DATABASE SYSTEMS LAB [0 0 3 2]

Abstract Syllabus:

Data Definition Language, Data manipulation language, Basic database query operations, Integrity Constraints in SQL, Nested subqueries, Join Operations, Views, PL/SQL Basics, Exception Handling, Cursors, Stored procedures, Functions, Packages, Trigger, and project on design and development of application based on database concepts.

References:

1. Silberschatz, Korth, Sudarshan, *Database System Concepts, (7e)* McGrawHill, 2011.
2. Ivan Bayross, *SQL, PL/SQL, (3e)* , BPB Publications
3. Satish Asnani, *Oracle Database 11g*, PHI, 2010.
4. Scott Urman, *ORACLE – PL/SQL Programming*, Oracle Press.

CES 2213 OBJECT-ORIENTED SOFTWARE DEVELOPMENT LAB [0 1 3 2]

Abstract
Overview of Object-Oriented Programming concepts; Inheritance, and Interfaces, Packages; Exception handling; Java Library: Wrapper classes, Enumeration and autoboxing; Multithreaded programming; File handling: File I/O stream, FileReader/Writer; Random Access File, Serialization; Generics: Two type parameters, Bounded types, Generic method; Collection Framework: Collection interfaces-list interface, Array list, Iterator; Basic Java FX GUI Programming.

Course Outcomes
After studying this course, students will be able to:
CO1: Apply inheritance, interfaces, packages, and generics to develop optimized, and reusable software solutions for real-world problems.
CO2: Analyze and implement exception handling, multithreading, file handling, wrapper classes, and the Collection framework to enhance application performance and data management.
CO3. Design and develop interactive, user-centric graphical applications using JavaFX while incorporating UI/UX best practices.

References
1. Schildt H., *Java-The Complete Reference*, 13th Edition,Tata McGraw-Hill 2023.
2. Horstmann C. S. & Cornell G., *Core Java Volume I – Fundamentals, 13*th Edition*,* Prentice Hall 2024.
3. Horstmann C. S. & Cornell G., *Core Java Volume II – Advanced Features*, 13th Edition, Prentice Hall 2024.
4. NPTEL Course: Programming in Java By Prof. Debasis Samanta | IIT Kharagpur.

V SEMESTER COMMON COURSES

SMS 3003 FOUNDATION OF TECHNOLOGY MANAGEMENT [3 0 0 3]

Abstract Syllabus:
Role of technology in modern organizations, Business Strategy and Technology Alignment, IT Infrastructure and Cloud Computing, Enterprise Systems and ERP, Knowledge Management Systems, Data Resource Management, Database Design and ER Modeling, Introduction to Big Data and Analytics, Business Models and Technology Innovation, IT Project Management, Information Security and Privacy, Ethical and Social Implications of Technology, Emerging Trends in Technology Management.

References

- Laudon & Laudon. Management Information Systems: Managing the Digital Firm (17th ed., Pearson)
- Rahul De. MIS: Managing Information Systems in Business, Government, and Society (2nd ed., Wiley).

References:

CES 3101 FINITE AUTOMATA AND COMPILER DESIGN [3 1 0 4]

Abstract syllabus:

Languages, Regular Expressions, Finite Automata – DFA, NFA. Conversion of Regular Expression to NFA, NFA to DFA. Context Free Grammars and Parsing, Derivation, Parse Trees, Push Down Automata, Introduction to Language Processors, The Structure of a Compiler, Lexical Analysis: Role of the Lexical Analyzer, Input Buffering, Specifications and Recognition of Tokens, Writing a Grammar, Top Down Parsing, Bottom Up Parsing, Introduction to LR parsing, More powerful LR Parsers, Syntax-Directed Translation: Syntax-Directed Definitions, Application of Syntax-Directed Translation, Intermediate Code Generation: Variants of Syntax Trees, Three Address Code, Code Generation: Issues in Design of Code Generator, Basic Blocks and Flow Graphs, Introduction to LEX and YACC.

References:

1. Peter Linz*, an Introduction to Formal Languages and Automata, (6e),* Jones & Bartlett Learning, 2019.
2. Alfred V. Aho, Monica S. Lam, Ravi Sethi, Jeffrey D. Ullman*, Compilers Principles, Techniques and Tools, (2e)*, Pearson Education, 2010.
3. J E Hopcroft, Rajeev Motwani & Jeffrey D Ullman, *Introduction to Automata Theory, Languages and Computation*, (3e), Pearson Education, 2006.
4. Kenneth C. Louden*, Compiler Construction - Principles and Practice, (1e)*, Thomson, 2007.
5. John R. Levine, Tony Manson, Doug Brown, *LEX & YACC, (2e),* O Reilly Media, 2012.
6. https://onlinecourses.nptel.ac.in/noc21_cs07/preview Compiler Design
7. https://onlinecourses.nptel.ac.in/noc21_cs19/preview: Introduction to Automata, Languages and Computation

VI SEMESTER COMMON COURSE

SMS 3004 Emerging Economic Landscape [3 0 0 3]

Abstract Syllabus:

Microeconomics (consumer behavior, firm decision-making, market structures) and macroeconomics (national income, inflation, monetary and fiscal policy, business cycles, global developments : globalization, digital economies, sustainability, geopolitical risks, and policy shifts across major economies, real-world applications, and interpreting economic signals relevant to technology-driven industries, market dynamics, policy impacts, and strategic decision-making in an increasingly interconnected economic landscape.

References

- Mishkin, F. S. (2012). Macroeconomics: Policy and Practice. Pearson Education.
- Blanchard, O. (2017). Macroeconomics (7th ed.). Pearson.

References:

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING SPECIALIZATION

V SEMESTER

CEO 3101 FOUNDATIONS OF COMPUTER VISION [3 0 3 4]

Abstract syllabus (theory):

Introduction to computer vision and its applications, Components of an Image Processing System, Elements of Visual Perception, Gray level transformations Filtering in spatial and frequency domain, Image transformations and Colour models, Edge Detection methods (Laplacian detectors and Canny edge detector), Points and patches, Harris corner detector, Histogram of Gradients, Difference of Gaussian detector, SIFT, Colour and Texture, Feature based alignment, least squares and RANSAC, Camera models, Camera calibration, Stereo vision, Stereo correspondence, Epipolar geometry, Optical flow, Lucas Kanade method, KLT tracking method, Mean shift method, Dense motion estimation, object detection and recognition, OCR – case study.

Abstract Syllabus (Integrated lab):

Introduction to Computer Vision Library: OpenCV Installation, Basics of Library, Image and Video Data Manipulation: Reading Images and Videos, Image Enhancement Techniques: Filtering in spatial Domain, Feature Extraction: Edge Detection, Image Descriptors such as ORB, LBP, SIFT. Finding Correspondence, Camera Calibration, Stereo Vision: Depth Estimation, Tracking: Optical Flow, KLT, Mean shift.

References:

1. Richard Szeliski, *Computer Vision: Algorithms and Applications*, *(2e),* Springer 2022
2. Rafael C. Gonzalez, Richard E. Woods, *Digital Image Processing*, *(4e),* Pearson 2018
3. David A. Forsyth and Jean Ponce, *Computer Vision: A Modern Approach*, PHI learning, 2015
4. Jan Erik Solem, *Programming Computer Vision with Python*, O'Reilly, 2012
5. Prof. M. K. Bhuyan, Computer Vision and Image Processing - Fundamentals And Applications ,NPTEL course noc25_ee13. *https://onlinecourses.nptel.ac.in/noc25_ee13/preview*

6. Prof. Vineeth N Balasubramanian, Deep Learning for Computer Vision, NPTEL course noc21_CS93. https://onlinecourses.nptel.ac.in/noc21_cs93/preview

CEO 3102 MACHINE LEARNING [3 0 3 4]

Abstract syllabus (theory):

An Overview of Statistical Learning. The Trade-Off Between Prediction Accuracy and Model Interpretability, Supervised Versus Unsupervised Learning, Regression Versus Classification Problems, Assessing Model Accuracy, Overfit, Underfit. Simple Linear Regression, Gradient Descent Method, Multiple Linear Regression. An Overview of Classification, Logistic Regression, Sigmoid Function, Cost Function, Gradient Descent, Naïve Bayes, K-NN, Performance metrics: Confusion Matrix, Precision and Recall & ROC curve. Well-Posed ML problems, Data representation, The Crisp-DM Model. The Basics of Decision Trees, Measures of Impurity for Evaluating Splits in Decision Trees, ID3, C4.5, and CART Decision Trees. Maximal Margin Classifier, Support Vector Classifiers, Support Vector Machines, Support Vector Machines and Kernels and Numerical examples. Clustering Methods. Rationale, Generating Diverse Learners, Voting, Bagging, Boosting.

Abstract syllabus (Integrated lab):

Understanding basics of Machine Learning programming using python, Fundamental mathematical concepts required for Machine Learning, Preparation of data for Machine Learning algorithms and Principal Component Analysis (PCA), Naïve Bayes classifier, K-Nearest Neighbour classifier, Linear, Multilinear and Polynomial Regressions, Logistic Regression, Support Vector Machines, K-Means Clustering, Hierarchical Clustering, Decision Trees.

References:

1. Gareth James, Daniela Witten, Trevor Hastie, and Robert Tibshirani, *An Introduction to Statistical Learning with Applications in Python*, *(2e),* Springer, New York, 2021
2. Gopinath Rebala · Ajay Ravi, Sanjay Churiwala, *An Introduction, to Machine Learning*, Springer 2019.
3. M. Gopal, *Applied Machine Learning*, McGraw Hill Education, 2018
4. Trevor Hastie, Robert Tibshirani, and Jerome Friedman, *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*, *(2e),* Springer, 2008.
5. Parteek Bhatia, *Machine Learning with Python Principles and Practical Techniques*, Cambridge University Press, 2024.
6. https://nptel.ac.in/courses/106106139 NPTEL: Introduction to Machine Learning, by Dr. Balaraman Ravindran IIT Madras

CEO 3103 PARALLEL COMPUTER ARCHITECTURE AND PROGRAMMING [3 0 3 4]

Abstract syllabus (theory):

Introduction: Need of Parallelism; Forms of Parallelism (SISD, SIMD, MISD, MIMD); Moore's Law and Multicore; Amdahl's Law; Speedup and performance; Programming paradigms: Shared and Distributed; PRAM Architecture Model. Shared Memory Programming: Introduction to OpenMP; OpenMP Program constructs; Execution Model and Directives; Message Passing Programming: MPI Basics; Point-to-point communications; Collective Communications; GPU Architecture: Architecture of modern GPU; Kernel function and thread organization; CUDA program structure; Transparent Scalability and Synchronization; GPU memory organization; Memory optimizations in CUDA.

Abstract Syllabus (Integrated lab):
Implement shared memory programs using OpenMP; Implement distributed memory programs using MPI; Implement GPU programs using CUDA.

References:

1. V.Rajaraman, C. Siva Ram Murthy, *Parallel Computers Architecture and Programming* Prentice-Hall India, 2016.
2. D. Kirk and W. Hwu, *Programming Massively Parallel Processors –A Hands-on approach, (4e),* Elsevier Inc., 2023.
3. Michael J. Quinn, *Parallel Programming in C with MPI and OpenMP,* McGraw Hill Edition, 2003.
4. Michael J. Quinn, *Parallel Computing*, McGraw Hill Edition, 2005

NPTEL Links:

1. **https://www.open-mpi.org/doc/**
2. **https://www.openmp.org/**
3. **https://developer.nvidia.com/**

VI SEMESTER

CEO 3201 DEEP LEARNING AND APPLICATIONS [3 0 3 4]

Abstract syllabus (theory):
Introduction to Deep Learning & Architectures, Machine learning basics, Neural Networks basics, Feed Forward Neural Networks, Machine Learning Vs. Deep Learning, Representation Learning, Width Vs. Depth of Neural Networks. Activation Functions, Regularization and Optimization for Deep Learning, Convolutional Neural Networks Architectural, Popular CNN Architectures: ResNet, AlexNet. Transfer Learning: Transfer learning Techniques, Variants of CNN: DenseNet, PixelNet. Sequence Modelling: Recurrent and Recursive Nets, Recurrent Neural Networks, Bidirectional RNNs. Encoder-decoder sequence to sequence architectures, BPTT for training RNN, Long Short Term Memory Networks. Auto Encoders, Regularized Autoencoders , stochastic Encoders and Decoders, Contractive Encoders, Variational Auto Encoders, Deep Generative Models, Introduction to Transformers

Abstract Syllabus (Integrated lab):
Introduction to tensors, Computational graphs, Deep Learning Library in PyTorch, Deep Feed-forward Neural Networks, Convolutional Neural Network, Transfer Learning, Regularization for Deep Neural Networks, Recurrent Neural Networks, Long-Short Term Memory (LSTM), Encoder-Decoders, Variational Auto Encoders, Generative Adversarial Networks (GANs)

References:

1. Ian Goodfellow, Yoshua Bengio and Aaron Courville, *Deep Learning*, MIT Press, 2017.
2. Eli Stevens, Luca Antiga, and Thomas Viehmann, *Deep Learning with PyTorch, Manning, 2020*
3. Josh Patterson, Adam Gibson, *Deep Learning: A Practitioner's Approach*, O'Reilly Media, 2017
4. Umberto Michelucci, *Applied Deep Learning. A Case-based Approach to Understanding Deep Neural Networks,* Apress, 2018.
5. Kevin P. Murphy, *Machine Learning: A Probabilistic Perspective*, The MIT Press, 2012.
6. Deep Learning - Course, By Prof. Prabir Kumar Biswas | IIT Kharagpur, 12 Weeks
7. Deep Learning - IIT Ropar - Course, By Prof. Sudarshan Iyengar, Prof. Padmavati | IIT Ropar, Punjab Engineering College (Deemed to be University), 12 Weeks
8. Machine Learning And Deep Learning - Fundamentals And Applications - Course, By Prof. M. K. Bhuyan | IIT Guwahati, 12 Weeks

CEO 3202 NATURAL LANGUAGE PROCESSING [3 0 3 4]

Abstract syllabus (theory):
Introduction, Text Normalization, Edit Distance, N-gram Language Models, Part-of-Speech Tagging, Hidden Markov Models, Formal Grammars of English, Parsing with Context-Free Grammars, Statistical Parsing. Naive Bayes, Text Classification, and Sentiment, Logistic Regression, Vector Semantics and Embeddings, Neural Networks and Neural Language Models, Sequence Labeling for Parts of Speech and Named Entities, RNNs and LSTMs, Transformers and Large Language Models, Fine-tuning and Masked Language models, Prompting, In-Context Learning, and Instruct Tuning, Applications: Machine Translation and Question answering.

Abstract Syllabus (Integrated lab):
Text Normalization, Edit Distance, N-gram Language Models, Part-of-Speech (POS) Tagging, Formal Grammar and Parsing with Context-Free Grammars, Statistical Parsing, Text Classification, Vector Semantics and Embeddings, Neural Language Models, Sequence Labeling for POS and Named Entity Recognition (NER), RNNs and LSTMs, Transformers and Large Language Models

References:

1. Daniel Jurafsky & James H. Martin, *Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition with Language Models, (3e),* Pearson, 2024.
2. Nitin Indurkhya, Fred J. Damerau, *Handbook of Natural Language Processing,* Second Edition, Chapman & Hall/CRC, 2010
3. Eisenstein, Jacob, *Introduction to Natural Language Processing*, *(1e),* MIT Press, 2019.
4. Uday Kamath, John Liu, and James Whitaker, *Deep Learning for NLP and Speech Recognition*, *(1e),* Springer, 2019.
5. NPTEL: Natural Language Processing By Prof. Pawan Goyal, IIT Kharagpur
6. NPTEL: Deep Learning for Natural Language Processing By Prof. Pawan Goyal, IIT Kharagpur

NETWORKS AND IOT SPECIALIZATION

V SEMESTER

CEO 3104 EMBEDDED SYSTEMS AND IOT [3 0 3 4]

Abstract Syllabus :

An overview of Computer Architecture, overview of ARM-Cortex- M Architecture, CISC versus RISC, The RISC and ARM design philosophy, ARM addressing modes, Data transfer instructions, Arithmetic and logical instructions, Shift and rotate instructions, Branch and conditional branch instructions, Function call and return, Stack, Recursive functions, Conditional execution, Assembly language programming, Input/output I/O) programming, Timer/counter programming, I/O interfacing : LED, LCD, Keyboard, Stepper motor, ADC, PWM, UART, Nested Vectored Interrupt Controller (NVIC), External hardware interrupts, IO interrupts. Basic building blocks of an IOT Device, Exemplary Device: Raspberry Pi, interfaces, Programming Raspberry Pi with Python, IOT communications.

Abstract Syllabus (Integrated lab):

Familiarization of data transfer from code segment to data segment and from data segment to data segment, Arithmetic operations, Logical instructions, Branch instructions, Code conversion from hexadecimal to decimal and decimal to hexadecimal, Packing and unpacking of ASCII digits, Sorting using selection sort and bubble sort techniques, Searching using linear and binary search techniques, Recursion, I/O interfacing of LEDs, LCD, keyboard, 7 segment display, ADC, PWM., I2C and RTC In addition to the above list of experiments, students are required to develop a mini project using mbed LPC1768board, Programming Raspberry Pi with Python, IOT communications.

References:

1. Jonathan W.V., *Embedded systems: Real-time interfacing to ARM Cortex-M microcontrollers, (8e),* Createspace Independent Publishing Platform, 2021.
2. Wilmshurst T., *Fast and Effective Embedded System Design applying the ARM mbed*, Elsevier, 2017.

3. Jonathan W.V., *Embedded systems: Introduction to Arm(r) Cortex-M Microcontrollers*, *(6e),* Createspace Independent publishing platform, 2019.
4. UM10360, *LPC 176x/5x User Manual*, NXP Semiconductors, Rev. 3.1, 2014.
5. Joseph V., *A definitive Guide to ARM Cortex-M3 and Cortex-M4 processors*, *(3e),* Elsevier, 2014.
6. Muhammad A.M, Sarmad N., Sepehr N., Shujen C., *ARM Assembly Language Programming & Architecture*, *(2e),* Wiley, 2016.
7. NPTEL/SWAYAM Reference*: https://onlinecourses.nptel.ac.in/noc22_cs93/preview*

CEO 3105 NETWORK PROTOCOLS AND PROGRAMMING [3 0 3 4]

Abstract Syllabus :

Queuing model, Switching, VLAN, Inter VLAN Routing, STP, Ether channel, Stateless Address Autoconfiguration, First Hop Redundancy Protocol, WLAN, IPV6, WAN, Integrated and Differentiated Services, Multiprotocol Label Switching, Socket Introduction, Socket Address Structures, Value-Result Arguments, Elementary TCP Sockets, Network Security, Virtual Private Network and IP Security.

Abstract Syllabus (Integrated lab):

Packet Tracer- Introduction to CISCO Packet Tracer, Basic Configuration, Routing Protocols, DHCP and NAT; Socket programming-Basic, Files, Database, Multi Client- Server Environment and Application Development.

References:

1. W. Richard Stevens, Bill Fenner, Andrew M. Rudoff, *UNIX Network Programming Volume 1, (3e),* Addison Wesley 2011.
2. William Stallings, *High Speed Networks and Internet, (2e),* Pearson Education New Delhi 2002.
3. James F. Kurose and Keith W. Ross, *Computer Networking: A Top-Down Approach*, *(7e),* 2017
4. Scott Empson and Cheryl Schmidt, *Routing and Switching Essentials,* 2014
5. Todd Lammle, *CCNA Routing and Switching Study Guide,* John Wiley & Sons,2013
6. NPTEL/SWAYAM Reference * *https://onlinecourses.nptel.ac.in/noc21_cs18/preview & NPTEL :: Computer Science and Engineering - NOC:Computer Networks and Internet Protocol*

CEO 3106 CLOUD COMPUTING [3 0 3 4]

Abstract Syllabus :

Introduction: Cloud computing delivery models and services, Challenges, Cloud Infrastructure: Amazon, Google, Microsoft Azure, Open Source Platforms, Services in Cloud: Service Oriented Architecture, REST, Cloud resource virtualization: Types of virtualization,

Understanding hypervisors, Virtual Machines, Dockers Containers, Virtualization at Compute, Storage and Network level, Resource Management and Scheduling: Policies and Mechanisms, Scheduling, Business Continuity and Cloud management: Fault Tolerance, Replication Methods, Cloud Security: Virtual machine security, Access control and identity management, Cloud Tools: Eucalyptus, OpenNebula/OpenStack, CloudSim,

Abstract Syllabus (Integrated lab):
Introduction to the AWS, GoogleCloud and Microsoft Azure Portal and Services ;Setting up account and basic navigation, creation of a VM on each of the platforms and installing and running a High Level Language Program, Developing a web application and hosting on cloud. Running a database, deploying an application, creating a network on any one of these 3 platforms. Openstack, Eucalyptus installation and working. Introduction to cloud sim and installation, Running built in examples and analyzing. Running SJF Scheduling algorithm on cloud simulator.

References:

1. Dan C Marinescu, *Cloud Computing Theory and Practice*, *(2e),* 2017
2. Rajkumar Buyya, Christian Vecchiola, S. Thamarai Selvi, *Mastering Cloud Computing*, *(2e),* McGraw Hill 2017
3. Sehgal, Naresh Kumar, and Pramod Chandra P. Bhatt, *Cloud Computing: Concepts and Practices*, *(1e),* Springer, 2018
4. Barrie Sosinsky, *Cloud Computing Bible,* 1st Edition, Wiley Publishing Inc., 2011.
5. Anthony T. Velte, Toby J. Velte, Robert Elsenpeter, *Cloud Computing: A Practical Approach*, *(1e),* McGraw Hill 2017
6. Mark C Chu-Carroll, *Code in the Cloud, (1e),* Pragmatic Bookshelf, 2011.
7. NPTEL/SWAYAM *https://onlinecourses.nptel.ac.in/noc21_cs14/preview*

VI SEMESTER

CEO 3204 NETWORK SECURITY [3 0 3 4]

Abstract Syllabus :
Introduction to Information and Network Security, Symmetric-Key Ciphers: Classical and Modern encryption techniques, Block ciphers, Advanced Encryption Standard, Uses block ciphers, Asymmetric-Key Cryptographic Ciphers, Principles of public key cryptosystems, Number theory concepts, Uses of primes, Message Integrity and Message Authentication, Cryptographic hash functions, Application of cryptographic hash functions, Digital Signature, Key Management, Entity Authentication, Transport Level Security, IP security, VPN, System Security concepts, Firewalls, Network Intrusion detection and prevention systems, SET, Multimedia Security ,Advanced Encryption Concepts.

Abstract Syllabus (Integrated lab):

Explore vulnerabilities of Windows, and Linux, Installation and maintenance of firewalls, Network-based and host-based intrusion detection systems (IDS) and prevention, Developing a security policy for an enterprise network to enable students to acquire the experience of starting from scratch and designing a functioning security system for an enterprise. Create network scenario on various smart city models and check for vulnerability.

References :

1. William Stallings, *Cryptography and Network Security: Principles and Practice , (7e),* Pearson Publications, 2016.
2. Behrouz A. Forouzan, Debdeep Mukhopadhyay, *Cryptography and Network Security , (2e revised),* Tata McGraw-Hill Education India, 2010.
3. Borko Furht, Darko Kirovski, Multimedia *Encryption and Authentication Techniques and Applications, (1e),* Taylor and Francis,2019.
4. Xun Yi, Russell Paulet, and Elisa Bertino*, Homomorphic Encryption and Applications, (1e),* Springer Publishing Company, Incorporated, 2014.
5. Brij B. Gupta, Mamta, *Secure Searchable Encryption and Data Management, (1e),* Taylor and Francis,2021.
6. NPTEL / SWAYAM course: https://onlinecourses.nptel.ac.in/noc25_ee54/preview

CEO 3205 WIRELESS COMMUNICATION AND NETWORKING [3 0 3 4]

Abstract Syllabus :

Introduction to Wireless Systems, Electromagnetic (EM) Spectrum, Antenna and Propagation, Line of Sight and Non Line of Sight, Fading, Link Budget Analysis, Cellular Concepts, 5G Networks, Architecture of 5G Networks, 5G Spectrum, Channel assignments, Handoff strategies, Improving Coverage & Capacity, Wireless channels, Statistical channel models, Channel Coding- forward error correction (FEC) coding, Advanced Modulation and Coding techniques (MFSK, QPSK, OFDM, NOMA), Multiple access techniques, OFDM, Diversity, Beamforming, Modelling of MIMO fading channels, LPWAN - Emerging Wireless Technologies: LoRa, Sigfox, IoT, NB-IoT.

Abstract Syllabus (Integrated lab):

Basics of Network Simulation - Platform required to run network simulator; Simulating a Local Area Network ; Measuring Network Performance- Network Performance Evaluation ; Simulating a Wi-Fi Network ; Simulating a WiMAX Network; Simulating a Mobile Adhoc Network; Simulating a Wireless Sensor Network ; Setting up a Bluetooth Network ; Setting up a ZigBee Network

References:

1. Harri Holma, Takehiro Nakamura, and Antti Toskala, *5G Technology 3GPP New Radio*, JohnWiley & Sons Ltd, 2020.
2. Larry Peterson and OMguz Sunay, *5G Mobile Networks: A Systems Approach,* Morgan & Claypool 2020.

3. Upena Dalal, *Wireless communication and Networks (1e),* Oxford 2015.
4. Andrea Molisch , *Wireless Communications (3e),* John Wiley & Sons Ltd. 2022.
5. Andrea Goldsmith, *Wireless Communications (2e),* Cambridge University press. 2012.
6. Theodore S. Rappaport, *Wireless Communications Principles and Practice, (2e),* Pearson Education India, 2010.
7. NPTEL/SWAYAM Reference*: https://onlinecourses.nptel.ac.in/noc21_ee66/preview*

DATA SCIENCE SPECIALIZATION

V SEMESTER

CEO 3108 DATA PRIVACY AND SECURITY [3 0 3 4]

Abstract Syllabus:

Security: Security Architecture, Security Attacks, Services and Mechanisms, Model for Data Security, Introduction to Cryptography: Classical Encryption techniques, Symmetric Encryption, Number Theory: Divisibility, Modular arithmetic, Congruences, Chinese Reminder Theorem, Public-key cryptography and Message Authentication, Hash Functions, Digital Signatures, Key Distribution and Authentication, System Security, Key Distribution and Authentication, Intrusion Prevention and Detection Systems, Cyber Security. Secure Software Development Life Cycle. **Data Privacy:** Introduction to data privacy, privacy attacks and types, access control models and types, privacy policies, their specifications, privacy in different domains-medical, financial, Anonymization and Differential Privacy: Introduction, Differential Privacy with Laplace Mechanism and Gaussian noise, Building Privacy into Data Pipelines: Design privacy measures, Data sharing workflow, Data Collection, Privacy-Aware Machine Learning and Data Science: Introduction, usage and open source libraries.

Abstract syllabus (Integrated lab):

Applied exercises in modular arithmetic, congruences, and Chinese Reminder Theorem using python libraries. Lab-based experimentation with public-key cryptography algorithms. Practical applications of message authentication, hash functions, digital signatures, and secure key distribution methods. Designing threat modelling and incident responses. Practical application of machine learning for data security using open-source python libraries

References :

1. William Stallings, *Cryptography and Network Security: Principles and Practice, (7e),* Pearson Education, 2017.
2. William Stallings, *Network Security Essentials: Applications and Standards*, *(6e),* Pearson Education, 2014.
3. Atul Kahate, *Cryptography and Network Security*, *(3e),* Tata McGraw-Hill Publishing Company Limited, 2013.
4. Katharine Jarmul, *Practical Data Privacy-Enhancing Security and Privacy of Data*, O'Reilly Media, Inc, April 2023.

5. Ronald Leenes, Rosamunde van Brakel, Serge Gutwirth, De Hert, Paul, *Data Protection and Privacy: The Age of Intelligent Machines (Computers, Privacy and Data Protection),* Hart Publishing, 2017.
6. Altice labs, *Secure Software Development Life Cycle*, White paper, Version 1.0, 2023.
7. Patrick McBride and Edward P. Moser, *Secure System Development Life Cycle* (SDLC), security staff, 2000.

NPTEL courses:

1. *Cryptography and Network Security*, by Dr. Debdeep Mukhopadhyay, IIT Kharagpur: https://nptel.ac.in/courses/106105031
2. *NOC: Cyber Security and Privacy,* by Prof. Saji K Mathew, IIT Madras: https://nptel.ac.in/courses/106106248

CEO 3109 STATISTICAL MACHINE LEARNING [3 0 3 4]

Abstract Syllabus:

Visualisation and dimensionality reduction: principal components analysis, biplots and singular value decomposition. Multidimensional scaling. K-means clustering. Introduction to supervised learning. Evaluating learning methods with training/test sets. Bias/variance trade-off, generalisation and overfitting. Cross-validation. Regularisation. Performance measures, ROC curves. K-nearest neighbours as an example classifier. Linear models for classification. Discriminant analysis. Logistic regression. Generative vs Discriminative learning. Naive Bayes models. Decision trees, bagging, random forests, boosting. Neural networks and deep learning.

Abstract syllabus (Integrated lab):

Applied exercises in Visualisation and dimensionality reduction: principal components analysis, biplots and singular value decomposition. Multidimensional scaling. K-means clustering. Evaluating learning methods with training/test sets. Cross-validation. Regularisation. Performance measures, ROC curves. K-nearest neighbours. Linear models for classification. Discriminant analysis. Logistic regression. Naive Bayes models. Decision trees, bagging, Random forests, boosting. Practical application of machine learning for data Science using open-source python libraries

References :

1.C. Bishop, Pattern Recognition and Machine Learning, Springer, 2017.
2.T. Hastie, R. Tibshirani, J Friedman, Elements of Statistical Learning, Springer, 2019.
3. K. Murphy, Machine Learning: a Probabilistic Perspective, MIT Press, 2022.
4. B. D. Ripley, Pattern Recognition and Neural Networks, Cambridge University Press, 1996.
5. G. James, D. Witten, T. Hastie, R. Tibshirani, An Introduction to Statistical Learning, Springer, 2013.

NPTEL courses:

1. *Introduction to Machine Learning*, by Prof. Balaraman Ravindran, IIT Madras: https://nptel.ac.in/courses/106106139

Introduction to Machine Learning, by Balaraman Ravindran, IIT Madras:
https://wsai.iitm.ac.in/~ravi/nptel-courses/intro-to-machine-learning/

CEO 3110 BIG DATA ANALYTICS [3 0 3 4]

Abstract Syllabus:

Overview of Big Data: Big Data Definition, Big Data Types, Analytics, Industry Examples of Big Data. Distributed and Parallel Computing for Big Data, Hadoop, Cloud Computing and Big Data, In-memory Computing Technology for Big Data, Big Data Stack, Virtualization and Big Data. Hadoop: Hadoop & Hadoop EcoSystem, Moving Data in and out of Hadoop, Inputs and outputs of MapReduce, Hadoop Architecture, HDFS, Common Hadoop Shell commands, NameNode, Secondary NameNode, and DataNode. Hadoop MapReduce paradigm, Map and Reduce tasks, Job, Task trackers , Algorithms using map reduce, Examples of Map Reduce (Word count problem, Matrix-Vector Multiplication), YARN & Zookeeper, Hadoop Cluster Setup & Hadoop Configuration. Hive Architecture, Comparison with Traditional Database, HiveQL - Querying Data - Sorting and Aggregating, Map Reduce Scripts, Joins & Subqueries, HBase concepts, Advanced Usage, Schema Design & Indexing - PIG, Zookeeper. Spark: RDD's in Spark, Data Frames & Spark SQL, Spark Streaming, MongoDB, NoSQL

Abstract syllabus (Integrated lab)

Tutorial on tools for Big Data tools and technologies. Apache Hadoop Cluster Based Distributed Processing. Platforms: PIG, HIVE, Spark Scala, Python based experiments with big datasets to be defined in lab manual, to implement machine learning algorithms in Hadoop and spark ecosystem. Analysis: To implement statistical inferences, recommendations, comparative statistics, MapReduce, Recommendation, Anonymous Functions, Method Overloading, Filtering, Classification, Clustering. Case studies.

Reference:

1. Chris Eaton, Dirk Deroos et al., “Understanding Big data”, McGraw Hill, 2012.
2. Boris lublinsky, Kevin t. Smith, Alexey Yakubovich, “Professional Hadoop Solutions”, Wiley, ISBN: 9788126551071, 2015.
3. Tom White, “HADOOP: The definitive Guide”, O Reilly 2012.
4. Aven Jeffrey, “Data Analytics with Spark Using Python”, Big Data, First Edition, Pearson Paperback, November 2018

NPTEL:
1. Prof. Rajiv Misra, IIT Patna, “Big Data Computing”, https://onlinecourses.nptel.ac.in/noc20_cs92/preview
2. Prof. Sandeep Singh Rawat, Indira Gandhi National Open University, New Delhi, “Data Science and Big Data”, https://onlinecourses.swayam2.ac.in/nou25_ma07/preview

VI SEMESTER

CEO 3207 IMAGE AND VIDEO ANALYSIS [3 0 3 4]

Abstract syllabus:

Introduction to Digital Image Processing: Image Formation, Sampling, and Quantization, Image representation, Color models, Color transformations; **Operations on Images** Basic Gray Level Transformations, Histogram Processing, Convolution, Linear and Non-Linear filter, Fourier Transforms, Morphological Image processing; **Feature extraction and Matching:** Edge and Corner detection, Scale Invariant Features, Feature Descriptors, Feature Matching; **Image Segmentation:** Thresholding, Region-based Segmentation, Color-Based and Texture-Based Image Segmentation, Advanced Image Segmentation Techniques; **Introduction to Digital Video Processing:** Video representation and formats, Compression Techniques, Motion Estimation and Optical flow, Background subtraction; **Video Segmentation and Tracking:** Background Modeling, Motion Segmentation; Tracking algorithms; Kalman Filter, Mean-shift; **Video Analysis and Action recognition**: Scene understanding, motion-based recognition, and video-based rendering. **Case studies on:** Medical Image Segmentation, Autonomous Driving, Traffic Monitoring, Human Activity Recognition.

Abstract syllabus (Integrated lab)

Operation on images, Gray Level Transformations, Histogram Processing Feature extraction, Edge and Corner detection , Image Segmentation, Thresholding, Region-based Segmentation, Color-Based and Texture-Based Image Segmentation, Advanced Image Segmentation Techniques, Video Segmentation and Tracking, Tracking algorithms; Kalman Filter, Mean-shift, Video Analysis and Action recognition.

References:

1. Rafael C. Gonzalez, Richard E. Woods, *Digital Image Processing*, *(4e),* Pearson Education, 2018.
2. Richard Szeliski, *Computer Vision: Algorithms and Applications*, *(2e),* Springer, 2022.
3. David A. Forsyth, Jean Ponce, Computer Vision: A Modern Approach, *(2e),* Prentice Hall, 2002.
4. A Murat Tekalp, *Digital Video Processing*, Prentice Hall, *(2e),* 2015.
5. Mark Nixon and Alberto S. Aquado, *Feature Extraction & Image Processing for Computer Vision*, *(3e),* Academic Press, 2012
6. https://onlinecourses.nptel.ac.in/noc25_ee13, Computer Vision and Image Processing - Fundamentals And Applications by Prof. M. K. Bhuyan, IIT Guwahati

CEO 3208 GENERATIVE AI [3 0 3 4]

Abstract Syllabus:

Introduction to Natural Language Processing: Overview of NLP and its applications, Challenges in language understanding. Basic Text Processing: Tokenization, Text Normalization, Edit-Distance, Regular Expressions. Morphology and Syntax: English Morphology, Finite-State Morphological Parsing, Stemming, Lemmatization. Language Models and Smoothing: N-gram Language Models, Evaluating Language Models, Smoothing Techniques. Vector Semantics and Word Embeddings: Word Vectors, Word2Vec, GloVe, Semantic Similarity. Parts of Speech and Tagging: English Word Classes, Part-of-Speech Tagging, Hidden Markov Models. Named Entity Recognition (NER): NER Tagging, Sequence Labeling Models. Transformer Architecture: Self-Attention Mechanism, Positional Encoding, Multi-head Attention. Pre-trained Language Models: BERT, GPT Series, T5, Large Language Models. Fine-Tuning and Transfer Learning: Fine-Tuning Strategies, Parameter-Efficient Methods, Domain Adaptation. Prompt Engineering and In-Context Learning: Prompt Design, Zero-Shot and Few-Shot Learning, Instruction Tuning. Applications of Large Language Models: Chatbots and Dialogue Systems, Question Answering Systems, Summarization, Machine Translation, Text Generation. Advanced Topics in Large Language Models: Scaling Laws, Efficient Training and Inference, Reinforcement Learning from Human Feedback (RLHF), Model Compression (Knowledge Distillation, Quantization, Pruning), Retrieval-Augmented Generation (RAG), Multimodal Models. Ethical Considerations and Responsible AI: Bias and Fairness in LLMs, Privacy Concerns, Model Explainability. Case Studies and Projects: Developing a Custom Chatbot using GPT Models, Fine-Tuning BERT for NER, Implementing Machine Translation with Transformers.

Abstract Syllabus (Integrated lab):

Introduction to tensors, Computational graphs, Text preprocessing using Pytorch libraries, Simple NLP applications like sentiment analysis, named entity recognition, text summarization. Implement basic Transformer model in PyTorch for Neural Machine Translation, Fine-tuning Hugging Face transformer models for NLP tasks. Experiments with prompt structures, contextual cues, and few-shot learning techniques to improve pre-trained LLM model responses. Updating the knowledge base of a pretrained LLM using RAG.

References:

1. Daniel Jurafsky and James H Martin, *Speech and Language Processing, (2e)*, Pearson Education, 2009
2. Jay Alammar and Maarten Grootendorst , *Hands-On Large Language Models*, O'Reilly Media, 2024
3. Lewis Tunstall , Leondro von Werra ,Thomas Wolf *, Natural Language Processing with Transformers: Building Language Applications with Hugging Face*, O'Reilly Media, 2023
4. Denis Rothman, *Transformers for Natural Language Processing,* Packt Publishing, 2024
5. Steven Bird, Ewan Klein and Edward Loper, *Natural Language Processing with Python*, *(1e),* O'Reilly Media, 2009

NPTEL Course:

1. Generative AI and Large Language Models by Naveen Kumar Bhansali, IIM Bangalore, https://onlinecourses.swayam2.ac.in/imb24_mg116/preview

SOFTWARE ENGINEERING SPECIALIZATION

V SEMESTER

CEO 3112 SOFTWARE ENGINEERING AND DESIGN TECHNOLOGY [3 0 3 4]

Abstract syllabus (Theory):
Evolution of software development from an art form to an engineering discipline, software development projects, exploratory style of software development, emergence of software engineering, notable changes in software development practices. Computer systems engineering. Waterfall model and its extensions, Rapid Application Development, Agile development models, Spiral model, comparison of different life cycle models. Cohesion and coupling, layered arrangement of modules, approaches to software design. Overview of SA/SD methodology, structured analysis, developing the DFD model of a system, structured design. Basic object-orientation concepts, UML diagrams, use case model, class diagrams, interaction diagrams, activity diagrams, state chart diagrams, package diagrams, component diagrams, deployment diagrams, object-oriented analysis and design (OOAD) methodology. Software documentation. Software project management concepts, project planning and scheduling, cost estimation techniques including Lines of Code (LOC), Function Point Analysis and COCOMO model, project monitoring, risk management and software configuration management.

Abstract Syllabus (Integrated lab):
StarUML, preparation of Software Requirements Specification (SRS), SRS of case study, requirement modelling, use cases, SOLID principles, class diagrams, interaction diagrams, package diagrams, component diagrams, deployment diagrams, code generation, project implementation, project planning and cost estimation report, version control using Git or similar tools.

Course outcomes:
After studying this course, students will be able to:
CO1: Develop and compare different software life cycle models.
CO2: Analyse and document software requirements for a project.
CO3: Design and implement software systems using appropriate design principles.
CO4: Model software systems using UML diagrams.
CO5:Apply software project management and cost estimation techniques in software development.

References:
1. Rajib Mall, Fundamentals of Software Engineering (5e), PHI Learning, 2019.
2. Roger S. Pressman, Software Engineering - A Practitioner’s Approach (9e), McGrawHill International Edition, 2023.
3. Mark Richards and Neal Ford, Fundamentals of Software Architecture: An Engineering Approach (2e), Oreily, 2025
4. Bernd Bruegge, Allen H. Dutoit, Object-Oriented Software Engineering using UML Patterns and Java (2e), Pearson Publication, 2011.
5. Ian Sommerville, Software Engineering (10e), Addison-Wesley, 2017.

NPTEL Links :
https://onlinecourses.nptel.ac.in/noc20_cs68/preview

CEO 3113 DEVOPS - USING AI [3 0 3 4]

Abstract Syllabus :
Introduction to DevOps life cycle, DevOps tools, AI in DevOps, Version Control System, GIT, workflow, commands, GITHUB, branching and merging, collaborating, Continuous Integration, Jenkins, creating and scheduling job, Jenkins pipeline, Jenkinsfile, Containerizing the applications, Docker life cycle, commands, dockerhub, dockerfile, Docker volume, Docker Networking, Docker compose, Kubernetes components, Kubernetes architecture, commands, Namespace, ingress, Application deployment in kubernetes, Configuration management, Ansible architecture, Setting up master slave using ansible, Ansible playbook, modules, Vault, Notify and handler, Roles, Continuous Monitoring, AI in DevOps lifecycle, AI tools in DevOps, AI-driven Testing, AI-powered Predictive Analytics.

Abstract Syllabus (Integrated lab):
Setting up a public Git repository and exploring key Git commands such as clone, fork, pull, push, and commit for effective version control, Implementation of a continuous integration (CI) pipeline using Jenkins for web applications. Containerizing applications with Docker and deploying them on a Kubernetes cluster, Automation using Ansible, creating playbooks to configure servers for application deployment.

References:

1. Pradeep chintale, *DevOps Design Patterns*, *(1e),* BPB Publications, 2024.
2. Scott Chacon and Ben Straub, *Pro Git*, *(2e),* Apress, 2024.
3. Mitesh Soni, *Jenkins Essentials(2e)*, Packt Publishing Limited, 2017.
4. Rafal Leszko, *Continuous Delivery with Docker and Jenkins, (2e)*, Packt Publications, 2019.
5. Jamon Camisso, Hanif Jetha, Katherine Juell, *Kubernetes for Full-Stack Developers,2020*
6. Gaurav shah*, ansible Playbook Essentails,* Packt Publishing Limited,2015

NPTEL Links :
https://nptel.ac.in/courses/128106012

CEO 3114 FULL STACK APPLICATION DEVELOPMENT [3 0 3 4]

Abstract Syllabus :
Front-End Web UI frameworks and Tools: Bootstrap 4, CSS and JavaScript component, Node.js, NPM and task runners, Progressive Web Applications, Front-End Web Development

with React: JavaScript ES6, Reactstrap for Bootstrap 4-based responsive UI design, react router, Flux architecture, redux, REST API, Front-End JavaScript Framework with Angular: Typescript, Angular material, Flex-layout for responsive design, components, Data binding, Angular router, Angular animation support and Angular testing, Server-side development with NodeJS, Express and MongoDB.

Abstract Syllabus (Integrated lab):
Bootstrap 4, CSS, Task runners, Progressive Web Application with Next.js, Front-End Web Development with React, Integration of REST API, Front-End JavaScript Framework with Angular, Angular application, Data binding and components, Angular router, Angular animation, RxJS, HTTP Client in Angular with REST API, Server-side development with NodeJS, Express and MongoDB-CRUD operations and authentication.

References:

1. Shama Hoque, *Full-Stack React Projects: Modern web development using React 16, Node, Express, and MongoDB*, Ingram Publishers, 2018
2. Chris Northwood, *The Full Stack Developer: Your Essential Guide to the Everyday Skills Expected of a Modern Full Stack Web Developer, (1e),* 2018
3. Frank Zammetti, *Modern Full-Stack Development: Using TypeScript, React, Node.js, Webpack, and Docker*, *(1e),* 2020
4. Ethan Brown, *Learning JavaScript: JavaScript Essentials for Modern Application Development*, O'Reilly Media, 2020.
5. Tal Ater, *Building Progressive Web Apps*, O'Reilly Media, 2017.
6. Jayden Reed, *Next.js by example: Step-by-step guides to building modern web apps*, Kindle ed. Independently published, 2024.

NPTEL Links:

1. Introduction to Modern Application Development, https://nptel.ac.in/courses/106106156
2. Modern Application Development, Persistent Computing Systems & CMI, https://nptel.ac.in/courses/106106222
3. Web Technology, https://onlinecourses.swayam2.ac.in/nou25_cs09/preview
4. Web Based Technologies and Multimedia Applications, https://onlinecourses.swayam2.ac.in/nou25_cs03/preview

VI SEMESTER

CEO 3209 SOFTWARE TESTING AND ANALYSIS [3 0 3 4]

Abstract Syllabus (Theory) :
Introduction to software testing, Software Quality, Behaviour and Correctness, Correctness versus Reliability, Testing and Debugging, V-Model of testing. Functional testing techniques including Boundary Value Analysis, Robustness testing, Worst Case testing, Special Value testing, Random testing, Equivalence Class testing. Decision tables and test cases based on decision tables. Test adequacy basics, adequacy criteria based on control flow, data flow concepts, adequacy criteria based on data flow. Test assessment using mutation testing.

Regression testing process and techniques for selecting regression tests. Test design and automated testing concepts. Unit testing using JUnit frameworks, use of stubs and mocks. Integration errors and dependency issues, testing object-oriented versus non-object-oriented programs, integration hierarchy, and automated test generation techniques.

Abstract Syllabus (Integrated lab):
Design and execution of test cases using functional and structural testing techniques. Development of unit tests using JUnit, with stubs and mocks for dependent modules. Implementation of integration, mutation, and regression testing. Use of automated testing tools and documentation of test results and defects for a small software application.

Course outcomes:
After studying this course, students will be able to:

CO1: Analyze software testing processes and quality improvement practices.
CO2: Evaluate and apply functional testing techniques to improve software quality.
CO3: Design effective test cases using structural testing techniques.
CO4: Assess the adequacy of test suites using mutation testing techniques.
CO5: Develop and implement testing strategies for software projects.

References:
1. Paul C. Jorgensen, Software Testing: A Craftsman's Approach (4e), CRC Press, 2020.
2. Aditya P. Mathur, Foundations of Software Testing (2e), Pearson Education, 2013.
3. Mauro Pezze and Michal Young, Software Testing and Analysis: Process, Principles and Techniques, Wiley, 2008.
4. Glenford J. Myers, Corey Sandler, Tom Badgett, The Art of Software Testing (3e), Wiley, 2015.
5. Mauricio Aniche, Effective Software Testing: A Developer's Guide, Manning Publications, 2022.

CEO 3210 SOFTWARE PROJECT MANAGEMENT [3 0 3 4]

Abstract Syllabus (theory):
Introduction to software project management, importance of project management in software development, roles and responsibilities of a project manager, project life cycle and project management activities. Overview of software development process models and criteria for selecting an appropriate development approach. Project estimation techniques including size estimation, effort estimation, Lines of Code (LOC), Function Point Analysis, and COCOMO model. Project planning activities, Work Breakdown Structure (WBS), project scheduling using Gantt charts, PERT and CPM, milestone planning and critical path analysis. Project organization structures, team management and communication in software projects. Risk management including risk identification, risk assessment, risk mitigation and contingency planning. Resource allocation strategies and resource leveling. Project monitoring and control, performance measurement, software configuration management and change management. Software quality management and project closure activities including project review and documentation.

Abstract Syllabus (Integrated Lab):

Preparation of a Software Project Plan for a small software project. Effort and cost estimation using LOC, Function Point Analysis, and COCOMO. Development of Work Breakdown Structure (WBS) and project scheduling using Gantt charts, PERT, and CPM. Risk identification and mitigation planning. Use of version control and project tracking tools for monitoring project progress and documentation.

Course outcomes:
After studying this course, students will be able to:
CO1: Analyze software project management activities and development approaches.
CO2: Evaluate project size, effort and cost using estimation techniques.
CO3: Design project plans and schedules using standard project management tools.
CO4: Assess risks and resource requirements in software projects.
CO5: Develop strategies for monitoring, controlling and successfully completing software projects.

References:
1. Rajib Mall, Software Engineering, 5th Edition, PHI Learning, 2019.
2. Bob Hughes, Mike Cotterell and Rajib Mall, Software Project Management, 6th Edition, McGraw Hill, 2017.
3. Ian Sommerville, Software Engineering, 10th Edition, Pearson, 2021.
4. Roger S. Pressman and Bruce Maxim, Software Engineering: A Practitioner's Approach, 9th Edition, McGraw Hill, 2020.

NPTEL Link:
https://nptel.ac.in/courses/106105218

CYBER SECURITY SPECIALIZATION

V SEMESTER

CEO 3116 NUMBER THEORY AND CRYPTOGRAPHY [3 0 3 4]

Abstract Syllabus:
INTRODUCTION: Number Theory Concepts, Divisibility and Factorization: Divisibility, Greatest Common Divisors, Euclidean Algorithm, Primes: Prime Numbers, Unique Prime Factorization. The Theory of Congruences: The concept of congruences, Congruence Classes, Applications of Congruences, solving (single) linear congruence, Solving system of linear congruence, the Chinese Remainder Theorem. Fermat's Theorem and Euler's Generalization: Fermat's Little Theorem. The general case: Euler's theorem. Algebraic structures: The Euclidean Algorithm, Finite Fields of The Form GF(p). Linear Congruence. Cryptography: Introduction Terminology, Classical Cryptography, types of traditional ciphers, Introduction to security and security of traditional ciphers, Introduction to security issues of modern ciphers, Symmetric-key cryptography, Information Security - Confidentiality, Integrity & Availability – Authentication, Authorization & Non- Repudiation, Symmetric Ciphers:: Conventional

Encryption: Attacks on Encryption Schemes, Modes of Operation, Multiple Encryption, Introduction to DES, Triple- DES, AES,RC4.

Abstract Syllabus (Integrated lab):

Implementation of selected number theory algorithms and traditional ciphers such as shift cipher, affine cipher, vignere cipher etc.,,Demonstration of symmetric conventional cryptographic techniques, Demonstration of symmetric classic cryptographic techniques ,Traditional Ciphers, Design and implementation of homomorphic encryption techniques, Demonstration and implementation of secure communication using standard

References :

1. William Stallings, *Cryptography and Network Security: Principles and Practice, (7e),* Prentice Hall, 2020.
2. Behrouz A. Forouzan and Debdeep Mukhopadhyay, *Cryptography and Network Security, (2e),* McGraw Hill, 2008.

CEO 3117 ESSENTIALS OF CYBER SECURITY [3 0 3 4]

Abstract Syllabus:

Introduction to Security Trends: The Computer Security Problem - Targets and Attacks - Approaches to Computer Security - Ethics - Basic Security Terminology - Security Models. Operational and Organizational Security: Policies, Procedures, Standards, and Guidelines - Security Awareness and Training - Interoperability Agreements - The Security Perimeter - Physical Security - Environmental Issues - Wireless -Electromagnetic Eavesdropping - People—A Security Problem - People as a Security Tool. Cryptography: introduction to modern cryptographic Algorithms – Introduction to Hashing Functions - Symmetric Encryption - Asymmetric Encryption - Quantum Cryptography- Introduction to crypto analysis. Authentication and Remote Access: User, Group, and Role Management - Password Policies - Single Sign-On - Security Controls and Permissions - Preventing Data Loss or Theft. The Remote Access Process - Remote Access Methods. Intrusion detection. Standards/frameworks for cyber security, security standards, risk management, cyber security strategic thinking and incident handling

Abstract Syllabus (Integrated lab):

Understanding Cybersecurity Tools, Packet Sniffing and Analysis, Intrusion Detection and Prevention, Implementing Hashing Algorithms, Quantum Cryptography Simulation, Password Cracking and Security Analysis, Web Application Security Testing.

References :

1. Anand Shinde, *Introduction to Cyber Security Guide to the World of Cyber Security*, Notion Press, 2021.
2. Nina Godbole, Sunit Belapure, *Cyber Security: Understanding Cyber Crimes, Computer Forensics and Legal Perspectives*, Wiley Publishers, 2011.

CEO 3118 INCIDENT RESPONSE AND THREAT INTELLIGENCE [3 0 3 4]

Abstract Syllabus:

Introduction to Incident Response and Threat Landscape: Overview of IR lifecycle phases, Incident classification and severity levels, Legal and regulatory considerations. Types of threats: APTs, ransomware, insider threats, Threat intelligence sources and feeds, Case studies of notable incidents. Log Analysis and Event Correlation: Identifying anomalies and patterns. SIEM tools and log aggregation, Collecting volatile data, Memory analysis and timeline creation, Prioritizing incidents, Assessing impact and scope. Developing hypotheses, Leveraging threat intelligence, Conducting network and host-based hunts. Containment and Eradication: Isolating affected systems. Removing malware and persistence mechanisms. Attribution and TTPs: Understanding nation-state adversaries. Tactics, techniques, and procedures (TTPs). Creating Incident Reports: Communicating findings to stakeholders. Legal and compliance requirements.

Abstract Syllabus (Integrated lab):

Case studies of notable incidents. Log Analysis and Event Correlation: Identifying anomalies and patterns. SIEM tools and log aggregation, Collecting volatile data, Memory analysis and timeline creation.

References :

Jason T. Luttgens, Matthew Pepe, Kevin Mandia, *Incident Response & Computer Forensics, (3e)*, McGraw-Hill Education, 2014, ISBN-10: 0071798684

VI SEMESTER

CEO 3212 CYBER LAW, CYBER CRIME AND CYBER ETHICS [3 0 3 4]

Abstract Syllabus:

Cybercrimes and related offences and penalties: Introduction to Cybercrimes, Classification of cybercrimes, Distinction between cyber-crime and conventional crimes, Provisions in Indian Laws in dealing with Cyber Crimes and its critical analysis, Information Technology Act, 2000, Penalties under IT Act, Offences under IT Act. Legal Recognition of Electronic Records and Electronic Evidence, Digital Signature Certificates, Securing Electronic records and secure digital signatures, Duties of Subscribers - Role of Certifying Authorities. Cyber- crimes under the Information Technology Act,2000 - Cyber-crimes under International Law - Hacking Child Pornography, Cyber Stalking. Copyrights, Software, Copyrights vs Patents debate, Authorship and Assignment Issues, Copyright in Internet, Multimedia and Copyright issues - Software Piracy. History, Overview of developments in Information Technology and Defining E-Commerce, Understanding Ethical, Social and Political issues in E- Commerce.

Abstract Syllabus (Integrated lab):
Legal Analysis of Digital Contracts, Tracing Cybercrime Incidents, Analyzing Digital Evidence, Simulating a Phishing Attack Scenario, Analyzing Ethical Issues in E-Commerce, Understanding Copyright and Piracy

References :

1. *The Information Technology Act, 2000 Bare Act with Short Notes*, Universal Law Publishing Co., New Delhi
2. Justice Yatindra Singh, *Cyber Laws*, Universal Law Publishing Co., New Delhi
3. Farouq Ahmed, *Cyber Law in India*, New Era publications, New Delhi

CEO 3213 APPLIED CRYPTOGRAPHY [3 0 3 4]

Abstract Syllabus:
ASYMMETRIC ENCRYPTION: Asymmetric key generation techniques – Public key cryptographic systems, Applications of asymmetric encryption methods – RSA and variants, Attacks on RSA, Rabin Cryptosystem, Elgamal Cryptosystem, Elliptic Curve Cryptography, Homomorphic encryption and types. Key Establishment and Key Management, Diffie-Hellman Key Exchange, Attacks on Diffie Hellman, Digital Signatures, Elgamal Digital Signature Scheme, RSA Digital Signatures Scheme, Schnorr Digital Signature Scheme, NIST Digital Signature Algorithm, Elliptic Curve Digital Signature Algorithm, RSA-PSS Digital Signature Algorithm, Authentication Protocol, Hash Functions and MAC: Standard hashes (MD5, SHA-1, SHA-256/384/512, RIPEMD-160), Birthday Attack, Collision freeness and recent attacks, Message Authentication Code (MAC) Algorithms. Network and Internet Security: Transport Layer Security, IP Security, Email Security, SECURITY PRACTICE & SYSTEM SECURITY

Abstract Syllabus (Integrated lab):
Implementation and demonstration of asymmetric cryptographic systems, Demonstration of hashing and message digest techniques. Design and implementation of homomorphic encryption techniques. Demonstration and implementation of secure communication using standard crypto libraries. Implementation of smart card-based server/client applications Demonstration of authentication techniques. Developing cryptographic algorithms for industrial applications. Developing cryptographic algorithms for innovative applications.

References :

1. William Stallings, *Cryptography and Network Security: Principles and Practice, (7e),* Prentice Hall, 2017.
2. Behrouz A. Forouzan and Debdeep Mukhopadhyay, *Cryptography and Network Security, (2e)*, McGraw Hill, 2008.

QUANTUM COMPUTING SPECIALIZATION

V SEMESTER

CEO 3120 FUNDAMENTALS OF QUANTUM COMPUTING [3 0 3 4]

Abstract Syllabus (theory):

Essential Mathematics and Quantum Mechanics: linear algebra and complex numbers for quantum information processing, Understand the principles of quantum mechanics: wave functions and operators, Qubits and Quantum Computers: qubit states, operations, multi-qubit systems, superposition and entanglement properties of qubits, Quantum Gates and Circuits: basic quantum gates, Design quantum circuits, Basic Quantum Algorithms: basic application of superposition, interference, and entanglement in algorithm design, Deutsch-Jozsa Algorithm, Bernstein Vazirani Algorithm.

Abstract Syllabus (Integrated Lab):

Linear Algebra & Complex Arithmetic, Probability Amplitudes & Born Rule, Qubit States & Bloch Sphere, Single-Qubit Gates & State Evolution, Multi-Qubit Systems & Entanglement, Quantum Circuit Design & Transpilation, SVD — Fundamentals & Geometry, Solving Linear Systems, Applications & Quantum Connection, Numerov — Algorithm & Validation, Schrödinger's Equation

References:

1. Nielsen, M. A., & Chuang, I. L. (2010). *Quantum computation and quantum information*. Cambridge university press.
2. Harris, E. G. (1995). Introduction to Quantum Mechanics by David J. Griffiths. *AMERICAN JOURNAL OF PHYSICS*, *63*, 767-767.
3. Strubell, E. (2011). *An Introduction to Quantum Algorithms*. *COS498* Chawathe Spring, 13, 19.
4. Kaye, P., Laflamme, R., & Mosca, M. (2006). *An Introduction to Quantum Computing*. OUP Oxford.
5. Rajasekar, S., & Velusamy, R. (2022). *Quantum Mechanics I: The Fundamentals*. CRC Press.

CEO 3121 QUANTUM ALGORITHMS [3 0 3 4]

Abstract Syllabus (theory):

Quantum Optimization: classical methods vs quantum optimization algorithms, quantum optimization techniques to solve complex optimization problems, **Quantum Machine Learning (QML) and Quantum Neural Networks (QNNs):** QML algorithms to enhance machine learning tasks, QNN architectures - pattern recognition and data analysis, **Quantum Approximate Optimization Algorithm (QAOA):** QAOA to approximate solutions for combinatorial optimization problems, applications of QAOA in solving practical optimization tasks, **Variational Quantum Eigensolver:** VQE for finding ground state energies of quantum systems, Integration of VQE techniques with classical optimization methods, **Quantum**

Annealing: principles and applications of quantum annealing in optimization, solve real-world problems using quantum annealing techniques.

Abstract Syllabus (Integrated Lab):

Deutsch-Jozsa Algorithm , Bernstein-Vazirani Algorithm & Hardware Run, QUBO Formulation & Ising Model , QAOA — Circuit & Angle Optimisation, Benchmarking & Barren Plateaus, H_2 Molecule, Noise Robustness & ZNE, Quantum Neural Networks — Classification, Quantum Kernel Methods, Quantum Annealing on D-Wave, D-Wave vs Classical Solver Comparison.

References:

1. Combarro, E. F., González-Castillo, S., & Di Meglio, A. (2023). *A Practical Guide to Quantum Machine Learning and Quantum Optimization: Hands-on Approach to Modern Quantum Algorithms*. Packt Publishing Ltd.
2. Bhattacharyya, S., Pan, I., Mani, A., De, S., Behrman, E., & Chakraborti, S. (Eds.). (2020). *Quantum machine learning* (Vol. 6). Walter de Gruyter GmbH & Co KG.
3. Sharkey, K. L., Chancé, A., & Khan, A. (2022). *Quantum Chemistry and Computing for the Curious: Illustrated with Python and Qiskit® code*. Packt Publishing Ltd.
4. Das, A., & Chakrabarti, B. K. (Eds.). (2005). *Quantum annealing and related optimization methods* (Vol. 679). Springer Science & Business Media.

CEO 3122 QUANTUM COMMUNICATIONS AND QUANTUM NETWORKS [3 0 3 4]

Abstract Syllabus (theory):

Quantum Communication: quantum communication protocols, principles of quantum communication systems, challenges, **Quantum Key Distribution:** quantum key distribution (QKD) techniques, theoretical foundations of QKD, practical implementations, **BB84 Protocol:** Introduction to Secure Key Exchange, Implementing the BB84 protocol, potential vulnerabilities, **E91 Protocol:** Introduction to secure communication, e role of entanglement in quantum communication, advantages over other protocols, **Quantum Secure Networks:** Introduction to quantum secure networks, integration of quantum communication with classical networks.

Abstract Syllabus (Integrated Lab):

Quantum Channel Characterisation & Process Tomography, No-Cloning Theorem & Eavesdropping Detection, BB84 Protocol — State Preparation & Sifting, QBER, Reconciliation & Privacy Amplification , Security Analysis — Attack Comparison, E91 Protocol — Entanglement-Based QKD, QKD Security Comparison: BB84 vs E91, Practical QKD over Noisy Fibre, Quantum Repeater Networks, Post-Quantum Cryptography — Kyber & Dilithium, Secure Communication System Integration.

References:

1. Cariolaro, G. (2015). *Quantum communications* (Vol. 2). Berlin: Springer.

2. Pathak, A. (2013). *Elements of quantum computation and quantum communication* (pp. 92-98). Boca Raton: CRC Press.
3. Djordjevic, I. B. (2022). *Quantum Communication, Quantum Networks, and Quantum Sensing*. Academic Press.
4. Bloch, M., & Barros, J. (2011). *Physical-layer security: from information theory to security engineering*. Cambridge University Press.

VI SEMESTER

CEO 3215 ADVANCED QUANTUM ALGORITHMS [3 0 3 4]

Abstract Syllabus (theory):

Quantum Fourier Transform: QFT techniques - quantum states, precision measurements, QFT principles - advanced quantum algorithms and quantum phase estimation tasks**, Quantum Phase Estimation:** algorithms to estimate phase in quantum systems, Estimate eigenvalues, perform unitary operations using QPE subroutines, **Shor's Algorithms:** problem of integer factorization, Analyze Shor's Algorithm for cryptographic applications, **Grover's Algorithm:** quantum search methods, Grover's algorithm for unstructured database search, applications in various optimization problems, **Applications of Quantum Computers:** practical applications of quantum computing in cryptography, optimization, and simulation, prototype for optimization problems using quantum computing methods.

Abstract Syllabus (Integrated Lab):

Advanced Quantum Fourier Transform & Phase Estimation, Hamiltonian Simulation Techniques, HHL Algorithm Implementation & Analysis, Quantum Walk Algorithms, Amplitude Amplification & Variants of Grover, Variational Algorithms Beyond VQE (VQA frameworks), Quantum Approximate Counting, Quantum Machine Learning – Advanced Models, Quantum Error Mitigation Techniques, Fault-Tolerant Algorithm Design, Large-Scale Algorithm Simulation & Benchmarking.

References:

1. Lipton, R. J., & Regan, K. W. (2014). *Quantum algorithms via linear algebra: a primer*. MIT Press.
2. Luongo, A. (2020). Quantum algorithms for data analysis.
3. Pittenger, A. O. (2012). *An introduction to quantum computing algorithms* Springer Science & Business Media.
4. Norlén, H. (2020). *Quantum Computing in Practice with Qiskit® and IBM Quantum Experience®: Practical recipes for quantum computer coding at the gate and algorithm level with Python*. Packt Publishing Ltd.

CEO 3216 INDUSTRIAL APPLICATIONS OF QUANTUM COMPUTING [3 0 3 4]

Abstract Syllabus (theory):

Quantum Computing in Finance: quantum computing techniques to optimize financial portfolios, Analyze quantum machine learning algorithms for credit scoring applications, **Quantum Computing in Healthcare and Drug Discovery:** quantum simulations for molecular simulations in drug discovery, quantum algorithms for processing large-scale genomic data, **Quantum Computing in Logistics and Supply Chain:** quantum techniques to optimize vehicle route planning and scheduling, quantum solutions for enhancing inventory management and resource allocation, **Quantum Communication in Cybersecurity:** quantum key distribution (QKD) simulations for realistic environments, quantum-safe cryptographic methods, applications, **Quantum Computing in Energy:** Optimize power grid operations for efficient energy resource management, **Emerging Industry Use Cases:** applications of quantum computing in emerging industries, future impact of quantum technologies, industry challenges and opportunities.

Abstract Syllabus (Integrated Lab):

Quantum Computing in Finance (Portfolio Optimization), Supply Chain Optimization using QAOA, Drug Discovery & Quantum Chemistry Simulations, Quantum Machine Learning in Industry, Cryptography & Post-Quantum Security Applications, Smart Grid Optimization using Quantum Methods, Quantum Optimization for Logistics & Routing, Hybrid Quantum-Classical Workflows, Quantum Cloud Platforms (IBM, D-Wave), Industry Case Studies & Benchmarking, Prototype Development for Real-World Problem

References:

1. Hidary, J. D., & Hidary, J. D. (2019). Quantum computing: an applied approach (Vol. 1). Cham: Springer.
2. Khang, A. (Ed.). (2024). Applications and principles of quantum computing. IGI Global.
3. Chaubey, N. K., & Prajapati, B. B. (Eds.). (2020). Quantum Cryptography and the Future of Cyber Security. IGI Global.
4. Williams, C. P. (2010). Explorations in quantum computing. Springer Science & Business Media.

GAMIFICATION AND DIGITAL TWINNING

CEO 3124 Fundamentals of Game Design [3 0 3 4]

Abstract Syllabus (theory):

History and Evolution of Video Games, Game Genres and Platforms, Game Design Principles and Mechanics, The Anatomy of a Game Designer. Understanding Your Player, Understanding Your Machine, Game Concepts, Game Worlds, Creative and Expressive Play, Character Development, The Storytelling Engine, Linear Stories, Nonlinear Stories, Granularity, Creating the User Experience, Interaction Models, Camera Models, Game Play, Core Mechanics, Random Numbers and the Bell-Shaped Curve, Game Monetization Techniques.

Abstract Syllabus (Integrated Lab):

Create a one-page game concept document and Moodboard. Design a simple prototype

(paper or digital) for a chosen genre. Create player personas and motivation maps. Implement a branching narrative or dialogue system. Game design document (GDD) can be the outcome of this game concept development.

Textbooks:

Fundamentals of Game Design, Third Edition, by Ernest Adams, Released December 2013, Publisher(s): New Riders, ISBN: 9780133435726.

Reference Books:

1. Designing Games, A Guide to Engineering Experiences by Tynan Sylvester, March 2013, O'Reilly Media.
2. Game Design Essentials by Briar Lee Mitchell, March 2012, sybex.
3. 'Advanced Game Design: A Systems Approach', 2017, by Michael Sellers (Author)

CEO 3125 Introduction to Digital Twin Technologies [3 0 3 4]

Abstract Syllabus:

Introduction to Digital Twin Concepts, Definition and evolution of Digital Twins, Key components: physical entity, virtual model, and data connections, Historical context and development, Enabling Technologies, Internet of Things (IoT), Big Data Analytics, Artificial

Intelligence and Machine Learning, Simulation and Modeling, Tools, Digital Twin Development and Implementation, Modeling techniques: physics-based and data-driven approaches, Integration of real-time data, Case studies in manufacturing and construction, Applications Across Industries, Challenges and Future Trends, Data security and privacy concerns, Standardization efforts, Emerging trends and research directions, Hands-On Workshop and Case Studies.

Abstract Syllabus (Integrated lab): Identify physical–virtual relationships from case studies (factory, building, city). Build a simple digital-physical mapping using sensors (temperature, motion). IoT data streaming using live sensor dashboard MQTT / Node-RED / ThingsBoard. Model a system (e.g., motor, HVAC unit) and simulate its physical behavior. Use Unity / MATLAB / Simulink / Blender to create a virtual model of a real object and integrate IoT data.

Textbook:

1. "Digital Twin Technology: Fundamentals and Applications" by Manisha Vohra
2. "Digital Twin: A Dynamic System and Computing Perspective" by R. Ganguli et al.
3. "Digital Twins: Enhancing Model-Based Design with AR, VR, and MR" – Oxford University Course Materials

4. "Digital Twins: State of the Art Theory and Practice, Challenges, and Open Research Questions" by A. Sharma et al.

CEO 3126 Game Engine Architecture [3 0 3 4]

Abstract Syllabus:

Introduction to Game Engine, 3D Math for Games, Time and the Game Loop, Human Interface Devices, Introduction to 3D Rendering, Fundamentals of Character Animation, Collision Detection, Introduction to Game Physics and Rigid Body Dynamics, , Introduction to Unity and Unreal Engine, Scripting Basics C#, Asset management, Introduction to Game Object Models, The Resource Manager, Events and Scripting, Game Audio.

Abstract Syllabus (Integrated lab): Unity3D Basic: IDE, Components, Concepts - Assets, Scenes, Game Objects, Scripts, Prefabs, Camera Settings, Audio, Animation Basics, Build and Deployment, C# Scripting Basics, MonoBehaviour. Basic game prototype using Unity. Implementing simple game mechanics and physics using Unity. Unity profiler tool and identifying bottlenecks in a game project

Textbook:

- Jason Gregory. Game Engine Architecture. AK Peters. ISBN 978-1-56881-413-1.
- Unity Game Development in 24 Hours, Sams Teach Yourself 4th Edition by Mike Geig (Author)
- Learn Unity: https://unity.com/learn

VI SEMESTER

CEO 3218 Game Programming and Development [3 0 3 4]

Abstract Syllabus:

Structure of a typical game development team, Overview of the technologies that comprise a typical 3D game, Advanced Game Engines Features: Asset Creation: 2D/3D Modeling, Textures, Audio, Game Physics and Animation Basics, Introduction to UI/UX in Games. Artificial Intelligence and Game Logic, Game Configuration Management can be added, Real-time multiplayer games, social features in the games, Version control and Subversion, Microsoft Visual Studio tips and tricks, Game Optimization, memory management, Profiling tools, Memory leak / corruption, Game Testing and Deployment.

Abstract Syllabus (Integrated lab): Basic game prototype using a game engine- Unreal Engine to demonstrate the understanding of asset creation, textures, audio. Implementing

simple game mechanics, animations and physics using Unity/Unreal Engine. Implementing AI behavior in a game project. Build the project and test it to deploy to the end-user target machines.

Reference Textbooks

1. "Game Engine Architecture" by Jason Gregory, 3rd Edition, 2018.
2. "Introduction to Game Development" by Steve Rabin, 2nd Edition, 2010.
3. Game Development with Unreal Engine 5: Learn the Basics of Game Development in Unreal Engine 5 (English Edition) by Mitchell Lynn, Cliff Sharif
4. "Game AI Pro: Collected Wisdom of Game AI Professionals" by Steve Rabin, ~~2013.~~ 3rd Edition, 2023
5. "Game Design Workshop: A Playcentric Approach to Creating Innovative Games" by Tracy Fullerton, 5th Edition, 2024.

CEO 3219 Gamification and Digital Twin Systems [3 0 3 4]

Abstract Syllabus:

Introduction to Gamification: MDA Framework (Leaderboard, Achievements / Badges, Player Gratification), Architecture of Digital Twins in Games, Core components of Digital Twins in gaming, Integration of Gamification with Digital Twining, Human Twin Interactions Model, Incorporating virtual agents and avatars, AR/VR Integration, Digital Twin Development Approaches – Using Unity, Digital Twins in Institutional Context, Modelling the Digital Twin, Governance, Security, and Non-functional Aspects, Applications of Digital Twins in military, medical, and industrial training, Case studies: Flight simulators, factory simulations, and smart city models. AI and Machine Learning in Digital Twins, Predictive and AI-driven behaviour for Digital Twins in games, training virtual entities using reinforcement learning, Use cases: Autonomous NPCs, dynamic environments.

Abstract Syllabus (Integrated lab): Implementing digital twin prototype using a simple game engine (e.g., Unity). Implementing AR/VR using Unity. Implementing AI behaviour in a game and digital twin project.

Books:

1. “Digital Twin Fundamentals and Applications” by Soheil Sabri Kostas Alexandridis Newton Lee
2. “Building Digital Twins with Unity and IoT Data Integration: Creating Virtual Replicas of Physical Systems for Predictive Maintenance, Real-Time Simulation, and Data-Driven Decision-Making"– by Greyson Chesterfield- 29 October 2024
3. Immersive Enterprise: Navigating AR and VR in Business (2030 - 2035): Harnessing Augmented and Virtual Reality to Transform the Future of Work, Design, Training, and Commerce- Dr Israel Carlos Lomovasky– 29 May 2025
4. “Digital twins technologies and smart cities” by Maryam Farsi, Alireza

Daneshkhah Amin Hosseinian-Far, Hamid Jahankhani

5. NPTEL: https://onlinecourses.nptel.ac.in/noc25_cs80/preview

ROBOTICS AND ARTIFICIAL INTELLIGENCE

CEO 3128 Fundamentals of Robotics [3 0 3 4]

Evolution of robotics and AI in robotics, Components of a robotic system: Sensors, actuators, controllers, and computation units, Types of robots: Manipulators, mobile robots, humanoids, and soft robots, Applications of AI in robotics: Industry 4.0, autonomous vehicles, medical robotics, Overview of Robot Operating System (ROS), Forward and inverse kinematics (Denavit-Hartenberg convention), Velocity kinematics (Jacobian matrices), Motion planning: A, RRT, PRM algorithms, Trajectory generation, Sensors in robotics: LiDAR,depth cameras, IMUs, Computer vision for robotics: feature detection, object tracking, AI-based perception: YOLO, Faster R-CNN for object detection, SLAM (Simultaneous Localization and Mapping), Introduction to deep learning in robotics (CNNs for perception), Reinforcement learning in robotics: OpenAI Gym, Stable-Baselines3, Policy learning for robotic control (PPO, DDPG), Case studies on AI-powered robots, Introduction to ROS2 & Gazebo, Creating and simulating robotic environments, Writing ROS nodes, topics, and services, Controlling robots in simulation (URDF, RViz, Gazebo plugins), Robotics in autonomous vehicles, industrial automation, and healthcare, AI-driven robotic manipulation (Dex-Net for grasping), Robot Manipulation and Grasping – Stability analysis, dexterous grasping, Humanoids & Soft Robotics – Bio-inspired designs and applications, Ethics & Safety in Robotics – AI safety, ethical concerns, Research Challenges & Trends – Future of robotics and AI integration.

Abstract Syllabus (Integrated Lab):

Implementation of robotic systems using Python APIs, Simulation-based robot programming and behavior control, Designing and modifying robot routines and motion sequences, Manipulation of robot joints and degrees of freedom, Programming robots for pick-and-place operations including moving objects, Robot control and automation using Python, Motion analysis and path validation, Robot walking simulation, Development of custom robot classes for movement tracking and execution, Implementation of PID control for path following, Forward and inverse kinematics implementation for robotic arms.

References:

1. Introduction to Autonomous Robots, Nikolaus Correll, Bradley Hayes, and Samuel Paivinen, CreateSpace Independent Publishing Platform, 1st Edition, 2017.

2. Modern Robotics: Mechanics, Planning, and Control, Kevin M. Lynch & Frank C. Park, Cambridge University Press, 1st Edition, 2017.

3. Robot Modeling and Control, Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, Wiley, 1st Edition, 2005.

4. Planning Algorithms, Steven M. LaValle, Cambridge University Press, 1st Edition, 2006.

5. Probabilistic Robotics, Sebastian Thrun, Wolfram Burgard, and Dieter Fox, MIT Press, 1st Edition, 2005.

6. Computer Vision: Algorithms and Applications, Richard Szeliski, Springer, 2nd Edition, 2022.

7. Deep Reinforcement Learning Hands-On, Maxim Lapan, Packt Publishing, 2nd Edition, 2020.

8. Reinforcement Learning: An Introduction, Richard S. Sutton and Andrew G. Barto, MIT Press, 2nd Edition, 2018.

9. Programming Robots with ROS, Morgan Quigley, Brian Gerkey, and William D. Smart, O'Reilly Media, 1st Edition, 2015.

10. Artificial Intelligence for Robotics, Francis X. Govers, Packt Publishing, 1st Edition, 2018.

CEO 3129 Robot Sensing and Vision [3 0 3 4]

Overview of sensors and their role in robotics, Types of sensors, Sensor characteristics, Vision-based sensors, Localization and challenges, Robot reactive paradigm, Sensing techniques for reactive robots, Navigation, Topological Planning and Metric Path Planning, Robot vision and its applications, Illumination and sensors, Camera sensors, Camera interface and video standards, Image acquisition and representation, Sampling and quantization, Image Segmentation, Region and boundary based approaches, Edge detection techniques, Object recognition, position recognition, shape and dimension check, Programming methodologies, Robot control language.

Abstract Syllabus (Integrated Lab):

Create various sensor based robotic applications. Design and implement sensing techniques in robotics. Create machine vision system to build robotic applications. To demonstrate image processing techniques to build robotic applications and visual algorithms for real time robotic applications.

References:

1. Roland Siegwart, Introduction to Autonomous Mobile Robotics, MIT Press.

2. Robin Murphy, Introduction to AI Robotics, MIT Press.

3. David Vernon, Machine vision –automated visual inspection and robot vision, Prentice Hall, 1991.

CEO 3130 Robot Operating System [3 0 3 4]

Introduction to Robot Operating Systems (ROS), ROS packages and ROS Respiratory. Python/C++ programming for ROS, Compilation ROS packages, Comparison between ROS1 Vs ROS2 versions. ROS Plug-ins Rviz (Visualization), Teleope package, ROS Serial and ROS Bridge packages. ROS Simulation using Gazebo, Building maps of the world, Autonomous Navigation using ROS. ROS MoveiT Package for Robot Manipulator, Degree of Freedom robotic ARM, Joint structures. ROS Hardware Interfacing, Arduino open source platform with ROS, Sensor interfacing with ROS, DC/Stepper Motor drive using ROS, and WiFi communication using ROS.ROS Algorithms Packages, ROS open source respiratory, Teleop keyboard, Map creation using Gmapping SLAM, Hector SLAM and Cartographer algorithms.

Abstract Syllabus (Integrated Lab):

Familiarization with Basic Linux commands and operations, ROS2 basics, Create ROS2 Workspace, Creation of ROS2 Nodes, Creation of Publisher and Subscriber nodes, and simulation of robot motion, with Turtlesim. ROS-based simulation, URDF-based representation of robot model, 3-axis manipulator design and control, Mobile robot design, Robot dynamic simulation, Gazebo and RViz, Introduction to Moveit2, Object detection with OpenCV and ROS2 using RGB and depth cameras.

Text Books:

1. Morgan Quigley, Brian Gerkey, William D. Smart, “Programming Robots with ROS”, O'Reilly Media, Inc., 2015.

2. Lentin Joseph, “Mastering ROS for Robotics Programming”, Third Edition, Packt Publishing, 2021.

Reference Books:

1. Joseph, Lentin, and Jonathan Cacace. Mastering ROS for Robotics Programming: Design, build, and simulate complex robots using the Robot Operating System. Packt Publishing Ltd, 2018.

2. Programming Robots with ROS’, M. Quigley, B. Gerkey, and W. D. Smart, Oreilly Publishers, 2015.

3. Koubâa, Anis, ed. Robot Operating System (ROS). Vol. 1. Cham: Springer, 2017.

4. ‘ROS Robotics by example’, Fairchild & Harman, PACKT Publishing, 2016

VI SEMESTER

CEO 3220 Deep Learning for Robotics [3 0 3 4]

Deep Networks Basics: Learning algorithms, Maximum likelihood estimation, Building machine learning algorithm, Neural Networks Multilayer Perceptron, Back-propagation algorithm and its variants Stochastic gradient decent, Curse of Dimensionality, Deep feed forward networks.Deep Learning Architectures: Machine Learning and Deep learning, Representation Learning, Width and Depth of Neural Networks, Activation Functions: RELU, LRELU ,ERELU, adam optimizer, adagrad optimizer Convolutional Neural Networks: Architectural Overview, Motivation, Layers, Filters, Parameter sharing, Regularization, Unsupervised Training of Neural Networks, Self Organizing maps, Restricted Boltzmann Machines, Auto Encoders: Auto Encoders: Under complete Auto encoder, Regularized Auto encoder, stochastic Encoders and Decoders, Contractive Encoders. Sequence Modelling-Recurrent And Recursive Nets: Recurrent Neural Networks, Bidirectional RNNs, Encoder – decoder sequence to sequence architectures – Long Short Term Memory Networks. Applications of Deep Learning :Computer Vision ,Popular CNN Architectures: ResNet, Alexnet –Applications.Speech Recognition - Natural language Processing, Case studies in classification, Regression and deep networks,Generative adversarial Networks. Introduction to Reinforcement Learning – Elements of Reinforcement Learning – Multi-armed Bandits – Finite Markov Decision Processes – Dynamic Programming – Monte Carlo Methods – Temporal-Difference Learning – n-step Bootstrapping - Planning and Learning with Tabular Methods. Robot Languages-Classifications, Structures- VAL- language commands motion control, hand control, program control, pick and place applications, palletizing applications using VAL, Robot welding application using VAL program-WAIT, SIGNAL and DELAY command for communications using simple applications. RAPID- language basic commands- Motion Instructions- Pick and place operation using Industrial robot- manual mode, automatic mode, subroutine command based programming. Movemaster command language- Introduction, syntax, simple problems. VAL-II programming-basic commands, applications- Simple problem using conditional Statements-Simple Pick and Place applications.

Abstract Syllabus (Integrated Lab)

Basic neuron models with activation functions and visualization; learning methods including error correction, memory-based approaches, and Hebbian Learning; perceptron-based logic gates and MLP for XOR; PCA using Hebbian learning; SOM and Hopfield networks; backpropagation for training networks; performance evaluation on datasets; and robotic arm control with pick-and-place, sensor-based detection, OpenCV-based object recognition, and automated sorting.

References

1. Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press, 2016

2. Neural Networks and Learning Machines by Simon Haykin ,

3. Michael A. Nielsen, Neural Networks and Deep Learning , Determination Press, 2015

4. David Forsyth and Jean Ponce," Computer Vision: a modern approach" – Year and PHI, 2015.

5. Josh Patterson, Adam Gibson "Deep Learning: A Practitioner's Approach", O'Reilly Media, 2017

6. 'Foundations of Statistical Natural Language Processing', Christopher Manning and Hinrich Schütze, MIT press, 1999

7. Anil K Jain, "Fundamentals of Digital Image Processing", Springer, Second Edition, 2016.

8. Richard Szeliski ,"Computer Vision: Algorithms and Applications" , Springer 2015

CEO 3221 Advanced Robotics Programming [3 0 3 4]

Advanced topics in robotics programming, focusing on motion planning, perception, control systems, and artificial intelligence applications. Robot Operating System (ROS), implement path planning algorithms such as A*, Dijkstra's, Perception techniques, including computer vision with OpenCV, sensor fusion with Kalman Filters, and SLAM (Simultaneous Localization and Mapping) using LiDAR and camera data. Exploration of machine learning and reinforcement learning approaches for robotic decision-making, multi-agent systems, and swarm intelligence. Discussion of Real-world applications, including autonomous vehicles, drones, and industrial robotics.

Abstract Syllabus (Integrated Lab):

Develop and simulate robotic systems using ROS2 and Gazebo, including robot modeling, kinematics, and motion planning. Implement forward and inverse kinematics for robotic arms using Denavit-Hartenberg (D-H) convention and numerical methods. Apply motion planning algorithms such as A*, RRT, and PRM for autonomous navigation and obstacle avoidance. Utilize perception techniques with LiDAR, cameras, and deep learning models for object detection, localization, and mapping. Implement AI-based control strategies including reinforcement learning and PID controllers for autonomous robotic applications.Design and simulate multi-robot coordination systems, integrating swarm intelligence and collaborative path-planning techniques.

References:

1. Robot Operating System (ROS) for Absolute Beginners by Lentin Joseph, Aleena Johny, publisher- Apress Berkeley, CA, February 2022

2. Mastering ROS2 and Python for Robotics : Develop Intelligent Autonomous Systems with Real-World Applications by Thompson Carter , Rafael Sanders , Miguel Farmer.

3. Programming Robots with ROS by Morgan Quigley -A Practical Introduction To The Robot Operating System, Brian Gerkey, and William D. Smart, Oreily publication , 2015

PROGRAM ELECTIVES

CEP 4401 INTERNET OF THINGS AND ITS APPLICATIONS [3 0 0 3]

Abstract Syllabus :
Introduction to IoT – Definition & Evolution, Physical and Logical Design, Functional Blocks, Machine-to-Machine (M2M) Communication, and Layered Architecture, Protocols and Standards – IEEE 802.15.4, LoRaWAN, ZigBee, NB-IoT, IPv6, 6LoWPAN, Constrained Networks, MQTT, CoAP, HTTP, AMQP, DDS, and OPC-UA, Hardware Platforms and Data Acquisition Techniques – Raspberry Pi, Arduino, ESP8266, Various Sensors, Real-Time data Processing and Management, Cloud Infrastructure for IoT, Edge Computing, Fog computing and Everything-as-a-Service (XaaS) Models, IoT Networking and Power Efficiency – LPWAN and BLE, IoT Applications – Smart Homes, Industrial Automation, Industry 4.0, Smart Agriculture, Healthcare, Smart Cities, Security, Wearable Devices, and Urban Development.

References:

1. Rajkumar Buyya, Amir Vahid Dastjerdi, *Internet of Things: Principles and Paradigms* Morgan Kaufmann, 2016
2. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton, Jerome Henry, *IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things*, Cisco Press, 2017
3. Olivier Hersent, David Boswarthick, Omar Elloumi, *The Internet of Things: Key Applications and Protocols*, Wiley, 2012
4. Arshdeep Bahga, Vijay Madisetti, *Internet of Things: A Hands-On Approach*, Universities Press, 2015
5. Rajkamal, *Internet of Things: Architecture, Design Principles and Application,* McGraw Hill Higher Education
6. Velte, Toby, Anthony Velte, *Cloud Computing and IoT: A Technology Perspective* McGraw Hill, 2019
7. *Industrial IoT (IIoT): Concepts, Methodologies, Tools, and Applications* – IGI Global
8. Mike Barlow, Cornelia Levy, *Smart Cities, Smart Future: Showcasing Tomorrow*, Bencheton
9. Zaigham Mahmood, *IoT in Healthcare and Ambient Assisted Living*
10. Benoît Hilt, Cuong Pham, *LPWAN Technologies for IoT and M2M Applications*, Elsevier, 2020
11. https://onlinecourses.nptel.ac.in/noc22_cs53/preview (Nptel Course)

CEP 4402 AUGMENTED AND VIRTUAL REALITY [3 0 0 3]

Abstract Syllabus:

Introduction of Virtual and Augmented reality: Definition, scope History of Early VR and Commercial VR Technologies, VR Industry Growth and Applications, The 3 I's of Virtual Reality (Immersion, Interaction, Imagination),Differences Between AR, VR, MR, and XR, AR/VR System Components and Interaction: Components of a VR System: Hardware & Software, AR Display Technologies: Optical See-Through & Video See-Through Displays, Multimodal Interfaces: Gesture, Haptic, and Auditory Interfaces, Perception Requirements and Characteristics in AR/VR, Input Devices: 3D Position Trackers, Navigation & Manipulation Interfaces, Output Devices: Graphics Displays, Sound Displays, Haptic Displays, Computer Vision and Tracking for Augmented Reality: Natural Feature Tracking: Marker-Based and Markerless AR, Simultaneous Localization and Mapping (SLAM) in AR, Optical and Sensor-Based Tracking, Outdoor Tracking Techniques in AR, Real-Time Rendering Pipeline for AR Applications, VR System Architectures and Modeling: Computing Architectures for VR: Workstation-Based and Distributed Systems, Parallel Processing for Real-Time VR Applications, Graphics pipeline - Overview and Transformations, Geometric and Kinematics Modeling for VR Environments, Physical and Behavioral Modeling in VR, The Rendering Pipeline in VR and Optimization Techniques, AR/VR Development and Applications: AR/VR Development Tools: Unity3D, Unreal Engine, Vuforia, ARKit, ARCore, Application Development Process: Scene Creation, Interactions, and Physics, Programming for AR/VR: Scripting in C# (Unity) and Blueprints (Unreal), Use Cases: Gaming, Healthcare, Education, Engineering, Retail, and Entertainment, Ethics and Challenges in AR/VR Development, Future Trends and Research in AR/VR: Cloud-Based and 5G-Enabled AR/VR Applications, AI and Machine Learning in AR/VR Experiences, AR/VR in the Metaverse and Social Media Integration, Haptic Feedback and Brain-Computer Interfaces (BCI), Research Challenges and Opportunities in AR/VR

References:

1. Dieter Schmalstieg & Tobias Hollerer, *Augmented Reality: Principles & Practice*, *(2e),* Addison-Wesley, 2023.
2. Steven M. LaValle, *Virtual Reality*, Cambridge University Press, 2021.
3. Jesse Glover & Jonathan Linowes, *Complete Virtual Reality and Augmented Reality Development with Unity*, Packt Publishing, 2021.
4. Grigore C. Burdea & Philippe Coiffet, *Virtual Reality Technology*, *(2e),* Wiley-IEEE Press, 2006.
5. Tony Parisi, *Learning Virtual Reality: Developing Immersive Experiences and Applications*, O'Reilly Media, 2015.
6. Steve Aukstakalnis, *Practical Augmented Reality: A Guide to Technologies and Human Factors*, Addison-Wesley, 2016.
7. **NPTEL Online Course:** *Virtual Reality and Augmented Reality* – https://nptel.ac.in/courses/106106138

CEP 4403 CONVERSATIONAL AI [3 0 0 3]

Abstract syllabus (theory):
Introduction to Conversational AI & NLP: Overview of Conversational AI and its applications, Basics of Natural Language Processing (NLP), History and evolution of chatbots and virtual assistants, Components of a Conversational AI system, Rule-based vs. ML-based vs. Hybrid chatbots. Conversational AI Architectures: Sequence-to-sequence models and their limitations, Attention Mechanism in Conversational AI, Transformer-based architectures for dialogue (BERT, GPT, T5), Dialogue Management Systems. Advanced NLP Techniques for Chatbots: Transfer Learning in NLP, Intent Recognition & Slot Filling, Dialogue Management Systems (Rule-based vs. ML-based), Enhancing Conversational AI: Speech-to-Text & Text-to-Speech Integration, Context Handling and Multi-Turn Dialogues, Custom NLU pipelines and integrating with APIs. Evaluation, Challenges, and Ethics: Evaluation Metrics for Conversational AI, Challenges in Conversational AI and Future Trends. End-to-end conversational AI Development, Deployment.

References:

1. Daniel Jurafsky & James H. Martin, *Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition with Language Models, (3e),* Pearson, 2024.
2. Andrew R. Freed, *Conversational AI:Chatbots that work*, Manning, 2021
3. Steven Bird, Ewan Klein and Edward Loper, *Natural Language Processing with Python, (1e)*, O'Reilly Media, 2009
4. Steven Bird, Ewan Klein, Edward Loper, *Natural Language Processing with Python – Analysing Text with natural language toolkit*, O'Reilly Media, 2009
5. Chris Manning, Hinrich Schutze, *Foundations of Statistical Natural Language Processing,* MIT Press, Cambridge, 1999.
6. NPTEL: Applied Natural Language Processing By Prof. Ramaseshan R | CMI

CEP 4404 FUNDAMENTALS OF iOS [3 0 0 3]

Abstract syllabus :
Swift Lessons: Installations, iCloud Service, Introduction to Swift and Playgrounds, Constants Variables and Data Types, Operators and Control Flow, Strings, Functions, Structures, Structures, Classes and Inheritance, Classes and Inheritance, Collections, Loops, Optionals, Type Casting and Inspection, Guard, Scope, Enumerations, Constants.
SDK Lessons: Documentation, Building, Running and Debugging an app, Interface Builder Basics, Strings, Introduction to UIKit, Displaying Data, Controls in Action, Auto Layout and Stack Views, Segues and Navigation Controllers, Tab Bar Controllers, View Controller Life Cycle, Building Simple Workflows
Guided Projects: Light, about me, Calculator, Apple pie, personality quiz.

References: *Develop in Swift Fundamentals, Xcode 13*, by Apple Corporation, USA

CEP 4405 iOS APPLICATION DEVELOPMENT [3 0 0 3]

Abstract syllabus :

Tables and Persistence: Protocols, App life Cycle, MVC, Scroll views, table views, intermediate table views, system view controllers, saving data, complex input screens.

Working with Web: Closures, Extensions, Practical Animations, working with HTTP, URL session, JSON and Concurrency

Advanced Data display: Swift generics, collection views, dynamic data, compositional layout, advanced layout

Guided projects: List, Restaurant, Habits.

References:

1. *Develop in Swift Data Collections, Xcode 13*, by Apple Corporation, USA.

CEP 4406 BLOCKCHAIN TECHNOLOGY [3 0 0 3]

Abstract syllabus:

Introduction to Blockchain: Definition, History and evolution of Blockchain, Features of Blockchain, Blockchain Architecture, Types of Blockchain, Potential of Blockchain and Myths, Decentralization in Practice and Decentralized Web. Cryptographic Primitives, Blockchain Data Structure and Consensus Mechanisms. Overview of Ethereum and its architecture, Ethereum Virtual Machine, Smart contracts and its development environment, Smart Contracts with Remix IDE, Overview of DApps, DApps development. Hyperledger and Permissioned Blockchain: Overview of Hyperledger frameworks, tools and building blocks, Hyperledger Fabric Model, Chaincode. Case Studies: Application of Blockchain in finance, healthcare, agriculture, IoT, supply chain, logistics, smart grid, smart cities, data management and e-governance.

References:

1. Kumar M V, Manoj, Annappa B, Thomas Likewin, Addya Sourav Kanti, and Niranjanamurthy M. *Blockchain Technology and Applications, (1e),* CRC Press, 2024.
2. S. Shukla, M. Brahmbhatt, P. Tiwari, *Blockchain Technology and Applications*, Wiley, 2020.
3. Bashir, Imran, *Mastering Blockchain: A Deep Dive into Distributed Ledgers, Consensus Protocols, Smart Contracts, DApps, Cryptocurrencies, Ethereum, and More(3e),* Packt Publishing, 2020.
4. Ritesh Modi, *Solidity Programming Essentials: A Beginner's Guide to Build Smart Contracts for Ethereum and Blockchain*, Packt Publishing, 2018.
5. S.Kulkarni, *Hands-On Blockchain with Hyperledger: Building Enterprise-Ready Applications*, Packt Publishing, 2020.
6. https://onlinecourses.nptel.ac.in/noc22_cs44/preview Blockchain Technology & Applications.

CEP 4407 WIRELESS TECHNOLOGIES [3 0 0 3]

Abstract syllabus:

Introduction to Wireless Networks: Evolution, Challenges, Introduction to Wireless Communication, Electromagnetic spectrum, Spectrum regulation, Wireless propagation, Modulation techniques, Multiple access for wireless systems, Cellular concept, Wireless services Ubiquitous Connectivity, Types of Wireless Networks, Analog Cellular Systems, AMPS, DAMPS, GSM, 3G Spectrum allocation, CDMA, WCDMA, 4G and Beyond, OFDM, Fixed Wireless Networks. IEEE 802.16, WLAN, applications, topology, requirements, Physical and MAC layers, IEEE 802.11a,b and g, Ad Hoc Networks: topology, Ad Hoc routing, VANETs, The 5G Internet, 5G Mobile Networks, SDL: IMS architecture, IMS Call Flow, services within IMS

References:

1. R Nicopolitidis et al, *Wireless networks*, Wiley, first, 2011
2. Jonathan Rodriguez, *Fundamentals of 5G Mobile Networks*, Wiley, 2015
3. Kaveh Pahlavan, Prashant Krishnamurthy, *Principles of Wireless Networks*, Prentice Hall, 2011
4. William Stallings ,*Wireless Communication and Networking*, PHI, 2014
5. https://archive.nptel.ac.in/courses/106/105/106105160/ Wireless Networks

CEP 4408 FOUNDATIONS OF QUANTUM COMPUTING [3 0 0 3]

Abstract syllabus:

Introduction to Quantum computation, Quantum bits, Single qubit operations, Postulates of quantum mechanics, Quantum Measurement, Bell states, EPR Paradox, No Cloning Theorem, Quantum Gates, Single qubit gates, Pauli Gates, Hadamard gate, Quantum Circuits, Multi-qubit gates, CNOT gate, Toffoli Gate, Fredkin Gate, Universal quantum gates, Quantum Key Distribution, Superdense coding and Quantum Teleportation, Quantum Parallelism and entanglement, The quantum Fourier transform (QFT), Walsh-Hadamard transformation, Quantum search algorithms, Grover's Search Algorithm, Deutsch Algorithm, Deutsch-Jozsa Algorithm, Bernstein-Vazirani Algorithm, Simon's Algorithm, Shor's Factorization algorithm, Quantum error correcting codes. Overview of Qiskit- IBM quantum computing open-source tool, SDL: Designing quantum circuits and implementing quantum algorithms using Qiskit.

References :

1. M. Nakahara and T Ohmi, *Quantum Computing From Linear algebra to Physical Realizations,* CRC press 2008.
2. Michael A Nielsen, and Isaac L. Chuang, *Quantum Computation & Quantum Information, (10e),* Cambridge University Press, 2011.

3. https://onlinecourses.nptel.ac.in/noc19_cy31/preview Quantum Computing

CEP 4409 REINFORCEMENT LEARNING [3 0 0 3]

Abstract syllabus (theory):

The Reinforcement Learning Problem: Reinforcement Learning, Elements, Limitations and Scope, Multi-arm Bandits, Finite Markov Decision Processes: The–Environment Interface, Goals and Rewards Returns, Unified Notation for Episodic and Continuing Tasks, The Markov Property, Decision Processes, Optimality, Dynamic Programming - Policy Evaluation, Improvement, Iteration, Asynchronous Dynamic Programming, Generalized Policy Iteration, Efficiency, Monte Carlo Methods and Temporal-Difference Learning: Monte Carlo Prediction, Estimation of Action Values, Control, Off-policy Prediction via Importance Sampling, Incremental Implementation, TD Prediction, Advantages, Optimality, TD Control, Q-Learning, Approximate Solution Methods On-policy Approximation, Value Prediction, Gradient-Descent Methods, Linear Methods, Introduction to Deep Reinforcement Learning, Actor-Critic Methods, Applications

References:

1. Sutton, R. S., & Barto, A. G., *Reinforcement Learning: An Introduction*, *(2e),* MIT Press, 2020
2. Stefano V. Albrecht, Filippos Christianos, Lukas Schfer, *Multi-Agent Reinforcement Learning: Foundations And Modern Approaches,* MIT Press, 2024
3. Warren B. Powell, *Reinforcement Learning and Stochastic Optimization: A Unified Framework for Sequential Decisions*, Wiley & Sons, 2022
4. Maxim Lapan, *Deep Reinforcement Learning Hands-On,* Packt, 2018
5. NPTEL: Reinforcement Learning, By Prof. Balaraman Ravindran | IIT Madras

CEP 4410 MOBILE APPLICATION DEVELOPMENT [3 0 0 3]

Abstract Syllabus:

Understanding Flutter and its features, Introduction to Dart programming language, Widgets and their properties, Building layouts with Flutter, Handling user input and gestures, Navigation stacks and routes, Passing data between screens, Implementing bottom navigation bars and drawer menus, Understanding state in Flutter, Managing state with setState, Using state management libraries like Bloc, Making HTTP requests in Flutter, Working with RESTful APIs, Storing data locally with shared preferences, Using SQLite for local database storage, Implementing data caching strategies, Introduction to Firebase services, Authentication with Firebase Auth, Working with Firestore for real-time database, Integrating Firebase Cloud Messaging for push notifications, Writing unit tests and widget tests, Debugging techniques and tools in Flutter, Performance profiling and optimization strategies, App distribution.

References:

1. R. Payne, *Flutter App Development: How to Write for iOS and Android at Once*, *(2e),* Razeware LLC, 2023.
2. raywenderlich Tutorial Team, M. Katz, K. D. Moore, and V. Ngo, *Flutter Apprentice Learn to Build Cross-Platform Apps*, *(3e),* Razeware LLC, 2022.
3. T. Bailey and A. Biessek, *Flutter for Beginners - Third Edition: Cross-Platform Mobile Development from Hello, World! to App Release with Flutter 3.10+ and Dart 3.x*, *(3e),* Packt Publishing, 2023.
4. M. L. Napoli, *Beginning Flutter: A Hands-On Guide to App Development*. Wiley, 2019
5. *Flutter Documentation*. [Online]. Available: https://docs.flutter.dev.

CEP 4411 FOUNDATIONS AND ETHICS OF GENERATIVE AI [3 0 0 3]

Abstract syllabus:
Introduction; Generative Modeling, Deep Learning, Variational Encoders, Generative Adversarial Networks, Autoregressive Models, Normalizing Flow Models, Energy-Based Models, Diffusion Models, Transformers, Music Generation, World Models, Multimodal Models, Ethical Issues in Generative AI. Ethical vs unethical use of Generative AI, professional and creative integrity while using AI to produce work. Complying with copyright laws, intellectual property. Effect of Data privacy on content generation. Transparency. Eliminating bias in outputs. Third-party fact-checking. Tangible benefits and risks of ethical GenAI use.

References:

1. David Foster, *Generative Deep Learning: Teaching Machines to Paint, Write, Compose and Play, (2e),* O'Reilly, 2023.
2. Jakub Langr, and Vladimir Bok, *GANs in Action: Deep Learning with Generative Adversarial Networks*, Manning, 2019
3. Joseph Babcock, and Raghav Bali, *Generative AI with Python and TensorFlow 2: Create images, text, and music with VAEs, GANs, LSTMs, Transformer models*, Packt, 2021.
4. Altaf Rehmani, *Generative AI for Everyone,* Bluerose Publishers Pvt. Ltd, 2024
5. Oliver Caelen and Marie-Alice Blete, *Developing Apps with GPT-4 and ChatGPT,* O'Reilly, 2023.
6. Generative AI and Large Language Models (8 weeks) By Naveen Kumar Bhansali | Indian Institute of Management Bangalore (IIMB). https://onlinecourses.swayam2.ac.in/imb24_mg116/preview
7. Introduction to Large Language Models (LLMs) (12 weeks) By Prof. Tanmoy Chakraborty, Prof. Soumen Chakraborti | IIT Delhi, IIT Bombay. https://onlinecourses.nptel.ac.in/noc25_cs45/preview

CEP 4412 PROMPT ENGINEERING [3 0 0 3]

Abstract syllabus:

Module-1: Introduction to Prompt Engineering and Its History, Principles of Prompt Design, Emotion and Tone Management in Prompt Design, User-Centered Design, Creative Thinking and Problem-Solving Techniques, Cultural and Linguistic Diversity in Prompt Design, Ethics and Responsibility in Prompt Engineering, Accessibility and Inclusivity in Prompt Design, Prompt Types and Custom Prompt Techniques: Open-Ended, Close-Ended, Instructional, and Contextual Prompts, Prompt Techniques: Zero-Shot, Few-Shot, Chain-of Thought, Tree of Thoughts Prompts and Fine-Tuning LLM Responses, Persuasion and Rhetorical Techniques in Prompt Engineering, Communication Strategies in Prompt Engineering, Feedback and Revision for Prompt Analysis, Evaluation and Development Suggestions on Prompts. Module-2: Contextual Understanding, Advanced Applications of Prompt Engineering for Understanding and Crafting Specialized Prompts for Industry Spesific Applications, Enhancing Learning through Effective Educational Prompts, Ensuring Compliance and Accuracy in Legal and Regulatory Prompts, Prompt Engineering Applications For Creating & Engaging Prompts for Media, Marketing, and Advertising, Understanding Psychological and Sociological Factors in Prompt Design, Algorithmic Thinking and Structural Design in Prompts, Data and Information Management in Prompt Design, Multimodal Prompts: Integrating Multiple Data Sources for Enhanced Interactions, Visual, Musical, and Auditory Prompts, Prompts for Risk and Crisis Management, Prompts for Global Communication and Collaboration, Evaluation and Testing Processes in Prompt Design, Preparation for Innovative Technologies and Trends in the Future of Prompt Design and Development.

References:

1. Zisan Cihangir ISIN, Hilal FIDAN, Tamer ISIN, Dr. Mustafa Kemal TOPCU, *Prompt Engineering 101*, Amazon.com, Inc, 2024
2. Nathan Hunter, *The Art of Prompt Engineering with ChatGPT A Hands-On Guide (Learn AI Tools the Fun Way!),* Amazon.com, Inc , 2023
3. James Phoenix and Mike Taylor, *Prompt Engineering for Generative AI,* O'Reilly Media Inc, 2024
4. Russel Grant, *PROMPT ENGINEERING AND CHATGPT*, Amazon.com, Inc, 2024
5. https://www.udemy.com/course/mastering-ai-powered-prompt-engineering-with-ai-models/?couponCode=NVDIN35 Prompt Engineering [Master Prompt Engineering In 2025 With New AI Models]
6. https://www.coursera.org/learn/prompt-engineering Prompt Engineering [Prompt Engineering for ChatGPT].

CEP 4413 PRODUCT MANAGEMENT [3 0 0 3]

Abstract syllabus:

Introduction to Product Management, Market Research and Customer Insights, Ideation and Concept Development, User-Centered Design and Usability Testing, Product Requirement definition, Roadmapping and Prioritization, Product Development and Agile Execution, Pricing Strategies and Revenue Models, Product Metrics and Success Measurement, Taking Product to

Market, Post-Launch Analysis and Iteration, Cross Functional Collaboration and Leadership, Ethics in Product Management, Product Strategy and Competitive Analysis, Product Marketing and Customer Acquisition, Product Lifecycle Management and Growth

References:

1. Karl T. Ulrich & Steven D. Eppinger, *Product Design and Development, (7e),* McGraw Hill, 2020.
2. Hans-Bernd Kittlaus, *Software Product Management: The ISPMA-Compliant Study Guide and Handbook, (2e),* Springer, 2022
3. David A. Aaker, *Strategic Market Management, (12e)*, Wiley, 2023
4. Alistair Croll & Benjamin Yoskovitz, *Lean Analytics: Use Data to Build a Better Startup Faster, (1e)*, O'Reilly Media, 2013.
5. Dan Olsen, *The Lean Product Playbook: How to Innovate with Minimum Viable Products and Rapid Customer Feedback, (1e),* Wiley 2015.
6. https://onlinecourses.swayam2.ac.in/imb19_mg01/preview New Product Development, Indian Institute of Management Bangalore

CEP 4414 ENTERPRISE DATA ARCHITECTURE [3 0 0 3]

Abstract syllabus:

Introduction to Enterprise Architecture:- Overview, core elements, Structure of enterprises, Introduction to Enterprise Data Architecture (EDA), Evolution of architecture, Monolithic systems – Mainframes. N-tier Architecture:- Introduction to N-tier architecture, Application Layer, Data Layer – Structured and Unstructured Data, Communication Layer, Hands-on N-tier architecture.. Service oriented architecture and Micro services:- Service oriented architecture, Web Services, Introduction to Microservices, Components of Microservices, Containers, Orchestration, Mesh, API Design, Data Handling, Architectural principles, Effectiveness of SoA. Data Models and Data governance: - Introduction to Data Models, Performance considerations, rendering, performance testing and monitoring, Disaster Recovery strategies, Fault Tolerance and Recovery, data-sharding, de-duplication in-memory computing, Scaling, Data governance, Security, privacy, value and risk, Repository and Support Tool. Architecture for Modern Technologies: - Hardware, Polycloud, Modern communication, Architecture for AI systems Enterprise Architectural frameworks: Zachman Framework and TOGAF

References :

1. Andy Graham, *The Enterprise Data Model: A framework for enterprise data architecture*, Koios Associates Ltd, *(2e),* 2012.
2. Charles D. Tupper, *Data Architecture: From Zen to Reality,* Morgan Kaufmann, 1 edition, 2011.
3. Scott A. Bernard , *An Introduction to Enterprise Architecture*, *(3e),* AuthorHouse,
4. https://www.opengroup.org/togaf, TOGAF, The Open Group

CEP 4415 OPTIMIZATION TECHNIQUES [3 0 0 3]

Abstract Syllabus:

Linear Programming: Problem Formulation, Linear Programming (LP) in standard form, Graphical Solution, Simplex Method, Big M Method. Transportation and Assignment Model: Transportation problem formulation, optimal solution, unbalanced transportation problem, degeneracy, Assignment problem, Hungarian Problem. Network Analysis: Graphs, Network and Flows, Minimum cost flow Models, Sources, Sinks Max Flow - Min Cut Theorem, CPM and PERT Networks. Inventory: Introduction, Single Item, Deterministic model, Purchase Inventory model with one price, break and multiple price breaks. Dynamic Programming: Introduction, Forward and backward recursions, Bellman's Principle of Optimality. Equipment Replacement Model, Allocation Problem, Inventory Models. Decision Theory: Decision under certainty: Analytic Hierarchy Process (AHP), decision under risk: decision trees, expected value criterion, Variations of the Expected value criterion, decision under uncertainty: Laplace, MinMax, Savage, Hurwicz method. Game Theory: Introduction, Minmax – Maxmin pure strategies, Optimal solution of two person zero sum games, solution of mixed strategy games, 2 x 2 games, 2 x n games, m x 2 games. Heuristics and approximation algorithms: approximation algorithms for Travelling Salesman Problem (TSP), Vertex cover problem.

References:

1. Taha H, *Operation Research: An Introduction*, *(10e),* McMillan, 2017.
2. Rardin, Ronald L., *Optimization in Operations Research*, Pearson Education (2005)
3. Ravindra K. Ahuja, Thomas L. Magnanti, James B. Orlin, *Network Flows: Theory, Algorithms, and Applications*, Pearson New International Edition, 2014.
4. Teofilo F. Gonzalez, *Handbook of Approximation Algorithms and Metaheuristics*, *(1e),* Chapman & Hall/CRC Computer and Information Science Series, , 2007.
5. S.S. Rao, *Engineering Optimization: Theory and Practice*, New Age International Pvt. Ltd., New Delhi, 2013.
6. NPTEL course: Optimization from fundamentals, By Prof. Ankur A. Kulkarni, https://onlinecourses.nptel.ac.in/noc21_me10/preview

CEP 4416 CYBER FORENSICS [3 0 0 3]

Abstract Syllabus:

Understanding the Digital Forensics Profession and Investigations: - An Overview of Digital Forensics, Preparing for Digital Investigations, Procedures for Private-Sector High-Tech Investigations. The Investigator's Office and Laboratory:- Understanding Forensics Lab Accreditation Requirements, Data Acquisition, Validating Data Acquisitions Processing Crime and Incident Scenes, Current digital forensics tools, Network Forensics and email investigation, Exploring the Role of E-mail in Investigations, Exploring the Roles of the Client and Server in E-mail, Investigating E-mail Crimes and Violations, Understanding E-mail Servers, Using Specialized E-mail Forensics Tools. Report Writing for High-Tech Investigations, Expert Testimony in Digital Investigations and ethics, Understanding the Importance of Reports, Guidelines for Writing Reports, Generating Report Findings with Forensics Software Tools,

Preparing for Testimony, Testifying in Court, Preparing for a Deposition or Hearing, Preparing Forensics Evidence for Testimony, Applying Ethics and Codes to Expert Witnesses.

References:

1. Bill Nelson, Amelia Phillips, *Guide to Computer Forensics and Investigations: Processing Digital Evidence*, *(5e),* CENGAGE Learning, 2015.
2. John R. Vacca, *Computer Forensics, Computer Crime Scene Investigation*, *(3e revised),* Jones and Bartlett Publishers, Inc., 2019.
3. Keith J. Jones, Richard Bejtiich, Curtis W. Rose, *Real Digital Forensics*, Addison Wesley Pearson Education, 2006.
4. NPTEL Course: Digital Forensics, By Dr. Jeetendra Pande, https://onlinecourses.swayam2.ac.in/nou22_cs05/preview

CEP 4417 DEEP LEARNING [3 0 0 3]

Abstract syllabus:

Introduction to Deep Learning: Motivation, History and Applications of Deep Learning, Machine Learning Vs. Deep Learning; **Fundamental of Neural Networks:** Artificial Neuron, Perceptron Model, Perceptron Learning, Multi-layer Network of Perceptrons, Artificial Neural Networks, Activation Functions, Loss functions, Gradient Descent, Backpropagation, Deep Neural Networks. **Optimization of Neural Networks:** Bias-variance trade-off, Underfitting and Overfitting, Regularization, Batch normalization, Weight initialization strategies, Learning rate schedulers, Optimizers. **Convolutional Neural Networks:** Convolution, Stride and Padding, Pooling, Properties of CNN, Classical CNN architectures for Image Classification. **Sequence Models:** RNN, LSTM, GRU, Encoder-Decoder architecture, Attention mechanism, Sequence models for Neural Machine Translation. **Representational Learning:** Stacked autoencoders, Denoising autoencoders, Sparse autoencoders, Contractive Autoencoders, Convolutional Autoencoders, Variational Autoencoders, Deep Generative Models, Introduction to Transformers

References:

1. Ian Goodfellow, Yoshua Bengio and Aaron Courville, *Deep Learning*, MIT Press 2016.
2. Charu C. Aggarwal*, Neural Networks and Deep Learning*, Springer 2018.
3. Eli Stevens, Luca Antiga, and Thomas Viehmann, *Deep Learning with PyTorch*, Manning, 2020
4. Josh Patterson, Adam Gibson, *Deep Learning: A Practitioner's Approach*, O'Reilly Media, 2017
5. https://onlinecourses.nptel.ac.in/noc24_cs114, Deep Learning by Prof. Sudarshan Iyengar, IIT Ropar
6. https://onlinecourses.nptel.ac.in/noc25_ee13, Computer Vision and Image Processing - Fundamentals And Applications by Prof. M. K. Bhuyan, IIT Guwahati

CEP 4418 MACHINE LEARNING TOOLS AND TECHNOLOGY [3 0 0 3]

Abstract syllabus:

Supervised Machine Learning: Algorithms and Applications- Introduction, Supervised Machine Learning, Linear and Logistic Regression, Support Vector Machines, Decision Tree, Machine Learning Applications in Daily Life. *Zonotic Diseases Detection Using Ensemble Machine Learning Algorithms*- Introduction, Bayes Optimal Classifier, Bootstrap Aggregating (Bagging), Bayesian Model Averaging (BMA), Bayesian Classifier Combination (BCC), Bucket of Models, Stacking, Efficiency Analysis. *Model Evaluation*-Introduction, Model Evaluation, Metric Used in Regression Model, Confusion Metrics, Correlation, Natural Language Processing (NLP), Additional Metrics, Summary of Metric Derived from Confusion Metric, Metric Usage, Pro and Cons of Metrics. *The Significance of Feature Selection Techniques in Machine Learning*- Introduction, Significance of Pre-Processing, Machine Learning System, Feature Extraction Methods, Feature Selection, Merits and Demerits of Feature Selection. *Detection of Diabetic Retinopathy Using Ensemble Learning Techniques*-Introduction, Related Work, Methodology, Data Pre-Processing, Feature Extraction, Learning, Proposed Models, Experimental Results and Analysis. *Machine Learning and Deep Learning for Medical Analysis—A Case Study on Heart Disease Data*-Introduction, Related Works, Data Pre-Processing, Feature Selection, ML Classifiers Techniques, Hyperparameter Tuning, Dataset Description, Experiments and Results. *Predictive Analysis on Online Television Videos Using Machine Learning Algorithms*- Introduction, Overview of Video Analytics, Machine Learning Algorithms, Proposed Framework, Feature Selection, Classification, Online Incremental Learning, Results and Discussion. *Application of Machine Learning Algorithms With Balancing Techniques for Credit Card Fraud Detection:A Comparative Analysis*-Introduction, Methods and Techniques, Results and Discussion. *Measuring Urban Sprawl Using Machine Learning*- Introduction, Literature Survey, Remotely Sensed Images, Feature Selection, Classification Using Machine Learning Algorithms, Results, Discussion and Conclusion.

References :

1. Pradeep Singh, *Fundamentals and Methods of Machine and Deep Learning-Algorithms, Tools and Applications*, *(2e),* Scrivener Publishing, WILEY, 2022
2. M. Gopal, *Applied Machine Learning,* McGraw Hill Education, 2018
3. Ethem Alpaydin, *Introduction to Machine Learning*, *(2e),* MIT Press. 2010
4. Peter Harrington, *Machine Learning in Action*, Manning Publications, 2012.
5. Andreas C. Müller & Sarah Guido, *Introduction to Machine Learning with Python,* O'Reilly Media Inc., 2017
6. Gopinath Rebala · Ajay Ravi, Sanjay Churiwala, *An Introduction, to Machine Learning*, Springer 2019.
7. Trevor Hastie, Robert Tibshirani, and Jerome Friedman, *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*, *(2e),* Springer, 2008.
8. https://nptel.ac.in/courses/106106202 MACHINE LEARNING TOOLS AND TECHNOLOGY [Machine Learning]

CEP 4419 WEB TECHNOLOGIES [3 0 0 3]

Abstract Syllabus :

Introduction to World Wide Web, Protocols and Programs, Application and Development Tools,Web Design, Introduction to HTML 5, Tags and simple HTML forms, Meta tags, Frames, Style Sheets: CSS formatting, Introduction to JavaScript, Client-Side Scripting, Advanced Scripting, JavaScript Objects, JavaScript ES6, DOM and Web browser environments, DHTML, Combining HTML and CSS, Ajax, HTTP/HTTPS, Restful APIs**,** XML and JSON, Server-Side Scripting with PHP**,** NoSQL, Introduction to MongoDB, CRUD Operations.

References:

1. DT Editorial Services, *HTML 5 Black Book*, *(2e),* DreamTech Press, 2016
2. Powell. Thomas A., *JavaScript: The Complete Reference*
3. Lemay. Laura, Rafe Colburn, Jennifer Kyrnin, *Mastering HTML, CSS & JavaScript Web*, BPB Publication, 2016
4. Vishvajeet. Sisodia, *Basic of Web Design, HTML, CSS3*, Centrum Press, 2014
5. Karl Seguin, *The Little MongoDB Book*
6. https://onlinecourses.swayam2.ac.in/nou25_cs09/preview Web Technology

CEP 4420 GAME THEORY AND APPLICATIONS [3 0 0 3]

Abstract syllabus :

Introduction to Game Theory, Strategic Interactions, Types of Games, Non-Cooperative Game Theory: Key Notions in Game Theory, Extensive-Form Games, Normal-Form Games, Dominant Strategy Equilibria, Pure Strategy Nash Equilibrium, Mixed Strategy Nash Equilibria, Utility Theory, Matrix Games, Bayesian Games, Cooperative Game Theory: Correlated Strategies and Correlated Equilibria, Two Person Bargaining Problem, Coalitional Games with Transferable Utility, Core of Coalition Games, Shapley Value and other Solution Concepts in Game Theory, Fundamentals of Mechanism Design, VCG Mechanisms, Introduction to Algorithmic Game Theory, Price of Anarchy, Applications in Computing.

References:

1. Y. Narahari, *Game Theory and Mechanism Design*, IISc Press and World Scientific, 2020.
2. Michael Maschler, Eilan Solan, and Schmuel Zamir, *Game Theory*, Cambridge University Press, *(2e),* 2020.
3. Dario Bauso, *Game Theory with Engineering Applications*, SIAM, Philadelphia, 2016.
4. Eva Tardos, Noam Nisan, Tim Roughgarden, and Vijay V. Vazirani, *Algorithmic Game Theory*, Cambridge University Press, 2007.
5. https://onlinecourses.nptel.ac.in/noc22_cs77/preview Introduction to Game Theory and Mechanism Design:

CEP 4421 EXPLAINABLE AI [3 0 0 3]

Abstract syllabus :

Introduction; Pre-model Interpretability and Explainability: EDA, Feature engineering; Model Visualization Techniques and Traditional Interpretable Algorithms: Model validation and evaluation, Classification model visualization, Traditional interpretable algorithms, Model Interpretability: Interpretable vs. explainable algorithms, Ensemble-based explainable machines, Rule-based techniques, Scoring system; Post-Hoc Interpretability and Explanations; Explainable Deep Learning: Visualizing Neural Networks, Interpretability of Transformer Models, Intrinsic, Perturbation, Gradient/Backpropagation; Fairness, Bias and Interpretability: Fairness Metrics, Bias Mitigation in AI Models; Explainability in Different Applications Domains

References:

1. Uday Kamath, and John Liu, *Explainable Artificial Intelligence: An Introduction to Interpretable Machine Learning*, Springer, 2021
2. Christoph Molnar, *Interpretable Machine Learning*, *(1e),* Shroff Publishers, 2024
3. Wojciech Samek, Grégoire Montavon, Andrea Vedaldi, Lars Kai Hansen, and Klaus-Robert Müller, *Explainable AI: Interpreting, Explaining and Visualizing Deep Learning*, Springer, 2019
4. Serg Masis, *Interpretable Machine Learning with Python*, Packt Publishing Ltd, 2021
5. https://www.coursera.org/specializations/explainable-artificial-intelligence-xai (XAI)
6. https://onlinecourses.nptel.ac.in/noc24_cs132/preview (Responsible and Safe AI Systems)

CEP 4422 USER INTERFACE ENGINEERING [3 0 0 3]

Abstract syllabus:

Goal-Directed Design : A Design Process for Digital Products, Understanding the Problem: Design Research, Modeling Users: Personas and Goals, Setting the Vision: Scenarios and Design Requirements, Designing the Product: Framework and Refinement, Making Well-Behaved Products: A Basis for Good Product Behavior, Digital Etiquette, Optimizing for Intermediates, Orchestration and Flow, Reducing Work and Eliminating Excise, Metaphors, Idioms, and Affordances, Preventing Errors and Informing Decisions, Designing for Different Needs, Interaction Details: Designing for Mobile and Other Devices, Designing for the Web, Design Details: Controls and Dialogs

References:

1. Alan Cooper, Robert Reimann, David Cronin, Christopher Noessel, *About Face: The Essentials of Interaction Design, (4e),* Wiley, 2014.

2. Yvonne Rogers, Helen Sharp, Jennifer Preece, *Interaction Design: Beyond Human-Computer Interaction*, *(6e),* Wiley, 2023.
3. Masaaki Kurosu (Editor), *Human-Computer Interaction. Design and User Experience Case Studies*, *(1e),* Springer, 2021
4. Don Norman, *The Design of Everyday Things, Revised Edition*, Basic Books, 2013.
5. Steve Krug, *Don't Make Me Think: A Common Sense Approach to Web and Mobile Usability*, *(3e),* New Riders, 2013.
6. William Lidwell, Kritina Holden, Jill Butler, Universal Principles of Design, *(2e),* Rockport Publishers, 2010.
7. https://onlinecourses.nptel.ac.in/noc23_ar24/preview Introduction To Interaction Design by IIT Roorkee

CEP 4423 SEMANTIC WEB [3 0 0 3]

Abstract Syllabus:

Semantic Web web technologies, a layered approach, RDF-data model, syntaxes, RDFS-adding semantics, RDF schema, RDF and RDF schema in RDFS, Axiomatic schematics for RDF and RDF schema, Direct inference system for RDF and RDFS, Querying Semantic Web – SPARQL, Ontology Languages- OWL2, Ontology Design and Management, Current Applications of the Semantic Web.

References:

1. Grigoris Antoniou, Paul Groth, Frank van Harmelen, Rinke Hoekstra, and Eric Yu, *A Semantic Web Primer*, *(3e),* MIT Press, 2012.
2. Peter Szeredi, Gergely Lukacsy, Tamas Benko, and Zsolt Nagy, *The Semantic Web Explained*, Cambridge University Press, 2014
3. Liyang Yu, *Introduction to the Semantic Web and Semantic Web Services*, CRC Press, 2019
4. Elisa F.Kendall, Deborah L.McGuinness, Ying Ding, and Paul Groth, *Ontology Engineering*, Morgan & Claypool Publishers, 2019
5. NPTEL course: Artificial Intelligence: Knowledge Representation and Reasoning, By Prof. Deepak Khemani, https://onlinecourses.nptel.ac.in/noc24_cs14/preview

CEP 4424 BIG DATA ANALYTICS [3 0 0 3]

Abstract Syllabus :

Overview of Big Data: Big Data Definition, Big Data Types, Analytics, Industry Examples of Big Data. Distributed and Parallel Computing for Big Data, Hadoop, Cloud Computing and Big Data, In-memory Computing Technology for Big Data, Big Data Stack, Virtualization and Big Data. Hadoop: Hadoop & Hadoop EcoSystem, Moving Data in and out of Hadoop, Inputs and outputs of MapReduce, Hadoop Architecture, HDFS, Common Hadoop Shell commands, NameNode, Secondary NameNode, and DataNode. Hadoop MapReduce paradigm, Map and

Reduce tasks, Job, Task trackers , Algorithms using map reduce, Examples of Map Reduce (Word count problem, Matrix-Vector Multiplication), YARN & Zookeeper, Hadoop Cluster Setup & Hadoop Configuration. Hive Architecture, Comparison with Traditional Database, HiveQL - Querying Data - Sorting and Aggregating, Map Reduce Scripts, Joins & Subqueries, HBase concepts, Advanced Usage, Schema Design & Indexing - PIG, Zookeeper. Spark: RDD's in Spark, Data Frames & Spark SQL, Spark Streaming, MongoDB, NoSQL

References:

1. Chris Eaton, Dirk Deroos et al., *Understanding Big data*, McGraw Hill, 2012.
2. Boris lublinsky, Kevin t. Smith, Alexey Yakubovich, *Professional Hadoop Solutions*, Wiley, ISBN: 9788126551071, 2015.
3. Tom White, *HADOOP: The definitive Guide*, O Reilly 2012.
4. Aven Jeffrey, *Data Analytics with Spark Using Python*, Big Data, *(1e),* Pearson, 2018.

NPTEL:

1. Prof. Rajiv Misra, IIT Patna, "Big Data Computing", https://onlinecourses.nptel.ac.in/noc20_cs92/preview
2. Prof. Sandeep Singh Rawat, Indira Gandhi National Open University, New Delhi, "Data Science and Big Data", https://onlinecourses.swayam2.ac.in/nou25_ma07/preview

CEP 4425 GRAPH DATABASE [3 0 0 3]

Abstract Syllabus:

Introduction to graph theory, Graph types, Graph data structures, Graph storage and models, Resource Description Framework (RDF), Labelled Property Graph (LPG), Traversal Algorithms (BFS, DFS), Shortest Path Algorithms (Dijkstra, Bellman-Ford), Minimum Spanning Tree (Kruskal, Prim), Community Detection (Louvain), Graph Pattern Matching, Graph databases, Overview of Popular Graph Databases (Neo4j, TigerGraph, Amazon Neptune), Advanced Graph Technology: TigerGraph, Architecture of TigerGraph , Data Modelling in TigerGraph , Data Query Using GSQL, Data/Graph Visualizations using TigerGraph Insights, Graph Algorithms in TigerGraph, Graph Neural Networks (GNNs), Applications of Graphs in AI/ML, Graph-Based Learning Algorithms Integration of Graphs with LLMs, Graph Embedding, Industry Use Cases of TigerGraph

References:

1. Lee, Nguyen, Chang, Graph-Powered Analytics and Machine Learning with TigerGraph, O'Reilly Media, Inc, 2023.
2. Gosnell, Broecheler, *The Practitioner's Guide to Graph Data: Applying Graph Thinking and Graph Technologies to Solve Complex Problems*, O'Reilly Media, Inc, 2020.
3. Negro, Eifrem, *Graph-Powered Machine Learning*, Manning,2021.
4. Robinson, Webber, EiFrem, *Graph Databases,* O'Reilly Media, Inc, 2013.
5. Ma, Tang, *Deep Learning on Graphs*, Cambridge University Press, 2021.