Shri Vile Parle Kelavani Mandal's

Dwarkadas J. Sanghvi College of Engineering

(Autonomous College Affiliated to the University of Mumbai)

Course Structure and Syllabus

of

Third Year Engineering

in

Computer Engineering

Prepared by:- Board of Studies in Computer Engineering

Recommended by:- Academic Council of D. J. Sanghvi College of Engineering

Approved by:- Governing Body of D. J. Sanghvi College of Engineering

Revision: 2 (2022)

With effect from the Academic Year: 2024-2025

Scheme for Third Year B.Tech. Program in Computer Engineering : Semester V (Autonomous)
(Academic Year 2024-2025)

Semester V

Sr	Course Code	Course	Teaching Scheme				Semester End Examination (A)						Continuous Assessment (B)			Aggregate (A+B)	Credits earned	
			Theory (hrs.)	Practical (hrs.)	Tutorial (hrs.)	Credits	Duration (Hrs)	Theory	Oral	Pract	Oral & Pract	End Sem Exam Total	Theory	Termwork	CA Total			
1	DJS22CEC501	Data Warehousing and Mining	3	--	--	3	2	65	--	--	--	65	35	--	35	100	3	4
	DJS22CEL501	Data Warehousing and Mining Laboratory	--	2	--	1	2	--	25	--	--	25	--	25	25	50	1	
2	DJS22CEC502	Computer Network	3	--	--	3	2	65	--	--	--	65	35	--	35	100	3	4
	DJS22CEL502	Computer Network Laboratory	--	2	--	1	2	--	--	--	25	25	--	25	25	50	1	
3	DJS22CEC503	Artificial Intelligence	3	--	--	3	2	65	--	--	--	65	35	--	35	100	3	4
	DJS22CEL503	Artificial Intelligence Laboratory	--	2	--	1	2	--	25	--	--	25	--	25	25	50	1	
4	DJS22CEC504	Formal Language and Automata Theory	3	--	--	3	--	65	--	--	--	65	35	--	35	100	3	3
5@	DJS22CEC5011	Advanced Algorithms	3	--	--	3	2	65	--	--	--	65	35	--	35	100	3	4
	DJS22CEL5011	Advanced Algorithms Laboratory	--	2	--	1	2	--	25	--	--	25	--	25	25	50	1	
	DJS22CEC5012	Advanced Operating System	3	--	--	3	2	65	--	--	--	65	35	--	35	100	3	
	DJS22CEL5012	Advanced Operating System Laboratory	--	2	--	1	2	--	25	--	--	25	--	25	25	50	1	
	DJS22CEC5013	Advanced Database Management System	3	--	--	3	2	65	--	--	--	65	35	--	35	100	3	
	DJS22CEL5013	Advanced Database Management System Laboratory	--	2	--	1	2	--	25	--	--	25	--	25	25	50	1	
	DJS22CEC5014	Computer Graphics	3	--	--	3	2	65	--	--	--	65	35	--	35	100	3	
	DJS22CEL5014	Computer Graphics Laboratory	--	2	--	1	2	--	25	--	--	25	--	25	25	50	1	
6#	DJS22IHL	Professional and Business Communication Laboratory	--	4	--	2	--	--	--	--	--	--	--	50	50	50	2	2
7	DJS22ILLL1	Innovative Product Development-III	--	2	--	1	--	--	25	--	--	25	--	25	25	50	1	1
		Total	**15**	**14**	**0**	**22**	**16**	**325**	**100**	**0**	**25**	**450**	**175**	**175**	**350**	**800**	**22**	**22**

@ Any 1 elective course

2 hrs. of theory (class wise) and 2 hrs of activity based laboratory (batch wise)

Prepared by:
Name and Signatures (with date)

Checked By
Name and Signatures (with date)

HoD
Department of Computer Engineering

Vice-Principal

Principal

Scheme for Third Year B.Tech. Program in Computer Engineering : Semester VI (Autonomous)
(Academic Year 2024-2025)

Semester VI

Sr	Course Code	Course	Teaching Scheme				Semester End Examination (A)						Continuous Assessment (B)			Aggregate (A+B)	Credits earned	
			Theory (hrs.)	Practical (hrs.)	Tutorial (hrs.)	Credits	Duration	Theory	Oral	Pract	Oral & Pract	End Sem Exam Total	Theory	Termwork	CA Total			
1	DJS22CEC601	Software Engineering and Project Management	3	--	--	3	2	65	--	--	--	65	35	--	35	100	3	4
	DJS22CEL601	Software Engineering and Project Management Laboratory	--	2	--	1	2	--	25	--	--	25	--	25	25	50	1	
2	DJS22CEC602	Machine Learning	3	--	--	3	2	65	--	--	--	65	35	--	35	100	3	4
	DJS22CEL602	Machine Learning Laboratory	--	2	--	1	2	--	25	--	--	25	--	25	25	50	1	
3	DJS22CEC603	Information Security	3	--	--	3	2	65	--	--	--	65	35	--	35	100	3	4
	DJS22CEL603	Information Security Laboratory	--	2	--	1	2	--	25	--	--	25	--	25	25	50	1	
4@	DJS22CEC6011	Advanced Network Design	3	--	--	3	2	65	--	--	--	65	35	--	35	100	3	4
	DJS22CEL6011	Advanced Network Design Laboratory	--	2	--	1	2	--	25	--	--	25	--	25	25	50	1	
	DJS22CEC6012	High Performance Computing	3	--	--	3	2	65	--	--	--	65	35	--	35	100	3	
	DJS22CEL6012	High Performance Computing Laboratory	--	2	--	1	2	--	25	--	--	25	--	25	25	50	1	
	DJS22CEC6013	Business Analytics	3	--	--	3	2	65	--	--	--	65	35	--	35	100	3	
	DJS22CEL6013	Business Analytics Laboratory	--	2	--	1	2	--	25	--	--	25	--	25	25	50	1	
	DJS22CEC6014	Compiler Design	3	--	--	3	2	65	--	--	--	65	35	--	35	100	3	
	DJS22CEL6014	Compiler Design Laboratory	--	2	--	1	2	--	25	--	--	25	--	25	25	50	1	
	DJS22CEC6015	Virtual Reality	3	--	--	3	2	65	--	--	--	65	35	--	35	100	3	
	DJS22CEL6015	Virtual Reality Laboratory	--	2	--	1	2	--	25	--	--	25	--	25	25	50	1	
5	DJS22CEL604	Devops Laboratory	--	4	--	2	2	--	--	--	50	50	--	50	50	100	2	2
6	DJS22ILLL2	Innovative Product Development - IV	--	2	--	1	2	--	25	--	--	25	--	25	25	50	1	1
		Total	**12**	**14**	**0**	**19**	**20**	**260**	**125**	**0**	**50**	**435**	**140**	**175**	**315**	**750**	**19**	**19**

@ Any 1 Elective Course

Prepared by: **HoD**

Name and Signatures (with date) **Department of Computer Engineering** **Vice-Principal** **Principal**

Checked By

Continuous Assessment (A):

Course	Assessment Tools	Marks	Time (hrs.)
Theory	a. One Term test (based on 40 % syllabus)	20	1
	b. Second Term test (next 40 % syllabus) / presentation / assignment / course project / group discussion / any other.	15	1
	Total marks (a + b)	35	--
Audit course	Performance in the assignments / quiz / power point presentation / poster presentation / group project / any other tool.	--	As applicable
Laboratory	Performance in the laboratory and documentation.	As per the scheme	
Tutorial	Performance in each tutorial & / assignment.		

The final certification and acceptance of term work will be subject to satisfactory performance upon fulfilling minimum passing criteria in the term work / completion of audit course.

Semester End Assessment (B):

Course	Assessment Tools	Marks	Time (hrs.)
Theory	Written paper based on the entire syllabus.	65	2
Oral	Questions based on the entire syllabus.	25	As applicable
Practical	Performance of the practical assigned during the examination and the output / results obtained.	25	2
Oral & Practical	Project based courses - Performance of the practical assigned during the examination and the output / results obtained. Based on the practical performed during the examination and on the entire syllabus.	As per the scheme	2

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Program: Computer Engineering	T.Y B.Tech.	Semester: V
Course: Data Warehousing and Mining (DJS22CEC501)		
Course: Data Warehousing and Mining Laboratory (DJS22CEL501)		

Pre-requisite: Basic database concepts, Concepts of algorithm design and analysis

Course Objectives:
This course introduces data warehouse and data mining concepts.
1. To identify the need of and perform data modelling to provide strategic information for making business decisions.
2. To analyze data and identify and develop relevant mining models to discover knowledge from data in various applications.

Outcomes: On successful completion of course, learner will be able to:
1. Design data warehouse models using dimension-modeling techniques.
2. Analyse the data by applying Online Analytical Processing (OLAP) operations for strategic decisions.
3. Apply preprocessing techniques to the given raw data.
4. Apply appropriate data mining techniques on data sets to retrieve relevant information.

Data Warehousing and Mining (DJS22CEC501)		
Unit	**Description**	**Duration**
1	**Introduction to Data Warehouse and Dimensional modelling:** Introduction to Strategic Information, Need for Strategic Information, Features of Data Warehouse, Data warehouse versus Data Marts, Data warehouse versus Data Lake, Top-down versus Bottom-up approach. Data warehouse architecture, E-R modelling versus Dimensional Modelling, Information Package Diagram, STAR schema, STAR schema keys, Snowflake Schema, Fact Constellation Schema, Factless Fact tables, Update to the dimension tables, Aggregate fact tables.	8
2	**ETL Process and OLAP:** Major steps in ETL process, Data extraction: Techniques, Data transformation: Basic tasks, Major transformation types, Data Loading: Applying Data, OLTP Vs OLAP, OLAP definition, Dimensional Analysis, Hypercubes, OLAP operations: Drill down, Roll up, Slice, Dice and Rotation, OLAP models: MOLAP, ROLAP, HOLAP.	6
3	**Introduction to Data Mining, Data Exploration and Preprocessing:** Data Mining Task and Techniques, KDD process, Issues in Data Mining, Applications of Data Mining, Data Exploration: Types of Attributes, Statistical	6

	Description of Data, Data Visualization, Measuring data similarity and dissimilarity. Data Preprocessing: Major tasks in preprocessing, Data Cleaning: Missing values, Noisy data; Data Integration: Entity Identification Problem, Redundancy and Correlation Analysis, Tuple Duplication, Data Value Conflict Detection and Resolution; Data Reduction: Attribute subset selection, Histograms, Clustering and Sampling; Data Transformation & Data Discretization: Data Transformation by Normalization, Discretization by Binning, Discretization by Histogram Analysis	
4	**Classification and Clustering:** **Classification** Basic Concepts of classification, Decision Tree Induction, Attribute Selection Measures using Information Gain, Tree pruning Bayes Classification Methods: Bayes' Theorem, Naïve Bayesian Classification Model Evaluation: Metrics for Evaluating Classifier Performance, Holdout Method and Random Subsampling, Cross Validation, Bootstrap Improving Classification Accuracy: Ensemble classification, Bagging, Boosting and AdaBoost, Random Forests **Clustering:** Cluster Analysis and Requirements of Cluster Analysis Partitioning Methods: k-Means, k-Medoids Hierarchical Methods: Agglomerative, Divisive Evaluation of Clustering: Assessing Clustering Tendency, Determining Number of Clusters and Measuring cluster quality: Intrinsic and Extrinsic methods	8
5	**Mining Frequent Patterns and Association Rules:** Market Basket Analysis, Frequent Item sets, Closed Item sets, and Association Rule Frequent Item set Mining Methods: Apriori Algorithm, Association Rule Generation, FP growth	5
6	**Spatial and Web Mining:** Spatial Data, Spatial Vs. Classical Data Mining, Spatial	6

	Data Structures, Mining Spatial Association and Co-location Patterns, Spatial Clustering Techniques: CLARANS Extension **Web Mining**: Web Content Mining, Web Structure Mining, Web Usage mining, Applications of Web Mining	

Books Recommended:

1. Paulraj Ponniah, "Data Warehousing: Fundamentals for IT Professionals", 2nd Edition, Wiley India, 2013.
2. Theraja Reema, "Data Warehousing", 1st Edition, Oxford University Press, 2009.
3. Han, Kamber, "Data Mining Concepts and Techniques", 3rd Edition, Morgan Kaufmann, 2012.
4. P. N. Tan, M. Steinbach, Vipin Kumar, "Introduction to Data Mining", 2nd Edition, Pearson Education, 2018.
5. H. Dunham, "Data Mining: Introductory and Advanced Topics", 1st Edition, Pearson Education, 2006.

Suggested List of Experiments:

Data Warehousing and Mining Laboratory (DJS22CEL501)	
Sr. No.	**Suggested Practical**
1	To visualize the data for a data warehouse using the Business Intelligence tool.
2	Build Data Warehouse/Data Mart for a given problem statement i. Identifying the source tables and populating sample data ii. Making information package diagram iii. Design dimensional data model i.e. Star schema, Snowflake schema and Fact Constellation schema (if applicable)
3	Perform data Pre-processing task on your dataset
4	To perform various OLAP operations such as slice, dice, drilldown, rollup, pivot

5	Implementation of Classification algorithm i. Using Decision Tree ID3 ii. Naïve Bayes algorithm
6	Implementation of Clustering algorithm i. K-means ii. Hierarchical clustering (single/complete/average)
7	Implementation of Association Rule Mining algorithm i. Apriori algorithm ii. FP Tree algorithm
8	Demonstrate performing Classification, Clustering, Association algorithm on data sets using data mining tool (WEKA, R tool, XL Miner, etc.)
9	Implementation of page rank algorithm
10	Implementation of HITS algorithm.
11	Implementation of Spatial Clustering Algorithm- CLARANS Extensions.
12	Case study on recent data mining applications

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Program: Computer Engineering	T.Y B. Tech.	Semester: V
Course: Computer Network (DJS22CEC502)		
Course: Computer Network Laboratory (DJS22CEL502)		

Pre-requisite: None

Course Objectives:

1. To get familiar with contemporary issues and challenges of various protocol designs in layered architecture.
2. To assess the strengths and weaknesses of various routing algorithms.
3. To explore the issues and challenges of protocols design while delving into TCP/IP protocol suite.

Outcomes: On successful completion of course, learner will be able to:

1. Demonstrate the concepts of data communication at physical layer and compare ISO - OSI model & TCP/IP model.
2. Understand the fundamental concepts of the Data Link Layer and analyze different MAC protocols.
3. Design the network using IP addressing and subnetting / supernetting schemes.
4. Analyze various transport layer, application layer protocols.

Computer Network (DJS22CEC502)		
Unit	**Description**	**Duration**
1	**Introduction to Networking** Introduction to computer network, network applications, network software and hardware components (Interconnection networking devices), Network topology, protocol hierarchies, design issues for the layers, connection-oriented and connectionless services, **Reference models**: Layer details of OSI, TCP/IP models. **Introduction to 5G Networks**: Overview of 5G technology and its evolution from previous generations (3G, 4G), Core network architecture in 5G.	**05**
2	**Physical Layer** Introduction to the Digital Communication System, Guided Transmission Media: Twisted pair, Coaxial, Fiber optics, Unguided Media (Wireless Transmission): Radio Waves, Microwave, Bluetooth.	**04**
3	**Data Link Layer** DLL Design Issues (Services, Framing, Error Control, Flow Control), Error Detection and Correction (Hamming Code, Parity, CRC, Checksum), Elementary Data Link protocols: Stop and Wait, Sliding Window (Go Back N, Selective Repeat), HDLC	**08**

	Medium Access Control Sublayer: Channel Allocation problem, Multiple Access Protocol (Aloha, Carrier Sense Multiple Access (CSMA/CA, CSMA/CD)	
4	**Network layer** Network Layer design issues, Communication Primitives: Unicast, Multicast, Broadcast. IPv4 Addressing (classful and classless), Subnetting, Supernetting design problems, IPv4 Protocol, Network Address Translation (NAT), IPv6 **Routing algorithms**: Shortest Path (Dijkstra's), Link state routing, Distance Vector Routing **Routing Protocols:** ARP, RARP, ICMP, IGMP, RIP, OSPF **Congestion control algorithms**: Open loop congestion control, Closed loop congestion control, QoS parameters, Token & Leaky bucket algorithms.	**12**
5	**Transport Layer** The Transport Service: Transport service primitives, Berkeley Sockets, Connection management (Handshake), UDP, TCP, TCP state transition, TCP timers TCP Flow control (sliding Window), TCP Congestion Control: Slow Start	**06**
6	**Application Layer** DNS: Name Space, Resource Record and Types of Name Server. HTTP, SMTP, Telnet, FTP, DHCP	**04**
	Total	**39**

List of Laboratory Experiments: (At Least Ten)

Computer Network Laboratory (DJS22CEL502)	
Sr. No.	**Suggested Practical**
1	Execute and evaluate network administration commands and demonstrate their use in different network scenarios.
2	Installation & Configuration of Network Simulator (NS2) in Linux/Windows Environment.
3	Building of wired & wireless topology using NS2.
4	Write a program to implement A) Error Detection and Correction B) Framing
5	Implement Stop and Wait protocol in NS2.
6	Write a program to implement Sliding Window Protocols- Selective Repeat, Go Back N.
7	Write a program to find out class of a given IP address, subnet mask & first & last IP address of that block.
8	Write a program to implement any one Routing Protocol.
9	Write a program to implement Congestion Control algorithms.
10	Implement the socket programming for client server architecture.
11	Install and configure Network Management/ Monitoring Tools like Wireshark, Packet Tracer.
12	Analyze the traffic flow of different protocols using Network Management/ Monitoring Tools.

13	Perform File Transfer and Access using FTP.
14	Perform Remote login using Telnet server.
15	Perform network discovery using discovery tools (e.g. Nmap, mrtg)

Textbooks:

1. A.S. Tanenbaum, Computer Networks, 6th edition Pearson Education, 2020
2. B.A. Forouzan, Data Communications and Networking with TCP/IP Protocol Suite, 6th edition, TMH, 2022
3. James F. Kurose, Keith W. Ross, Computer Networking, A Top-Down Approach Featuring the Internet, 6th edition, Pearson, 2017

References:

1. Behrouz A. Forouzan, Firouz Mosharraf, Computer Networks: A Top-Down Approach, Mc Graw Hill, 2023
2. Dhanashree K. Toradmalle, Computer Networks and Network Design, Wiley, 2020

Online Resources:

1. https://www.netacad.com/courses/networking/networking-essentials
2. https://www.coursera.org/learn/computer-networking
3. https://nptel.ac.in/courses/106/105/106105081
4. https://www.edx.org/course/introduction-to-networking

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Program: Computer Engineering	**T.Y B. Tech.**	**Semester: V**
Course: Artificial Intelligence (DJS22CEC503)		
Course: Artificial Intelligence Laboratory (DJS22CEL503)		

Pre-requisite: Knowledge of 1. Programming Language 2. Algorithms

Objectives:

1. Provide the basic ideas and techniques underlying the design of intelligent systems.
2. Impart the knowledge of various search techniques for problem solving.
3. Learn knowledge representation, planning and provide the knowledge to deal with uncertain and incomplete information.

Outcomes: On completion of the course, learner will be able to:

1. Understand fundamentals of artificial intelligence systems.
2. Apply various AI approaches to knowledge intensive problem solving, reasoning, planning and uncertainty.
3. Develop the AI applications in real world scenarios.

Artificial Intelligence (DJS22CEC503)		
Unit	**Description**	**Duration**
1	**Introduction to Artificial Intelligence:** Introduction, History of Artificial Intelligence, Intelligent Systems: Categorization of Intelligent System, Components of AI Program, Foundations of AI **Agents and Environments:** Concept of rationality, Nature of environment, Structure of Agents, Types of Agents, PEAS representation for an Agent	**05**
2	**Problem Solving:** Problem Solving Agent, Formulating Problems, Example Problems. **Search Methods:** **Uninformed Search:** Breadth First Search (BFS), Depth First Search (DFS), Depth Limited Search, Depth First Iterative Deepening (DFID) **Informed Search:** Greedy Best First Search, A* Search, Memory bounded heuristic Search. **Local Search Algorithms and Optimization Problems:** Hill Climbing search, Simulated Annealing, Genetic algorithms, Ant Colony Optimization **Adversarial Search:** Game Playing, The Minimax algorithm, Alpha-Beta Pruning	**12**
3	**Knowledge Representation and Reasoning:** Knowledge based Agents, The Wumpus World, Propositional Logic, First Order Logic, Inference in FOL, Conjunctive Normal Form, Forward Chaining, Backward Chaining, Unification, Resolution, Logic Programming (PROLOG), Semantic networks	**07**

	Uncertain Knowledge and Reasoning: Representing knowledge in an uncertain domain, The semantics of Bayesian Belief Network, Inference in Belief Network	
4	**Planning:** The planning problem, Planning with state space search, Planning graphs, Partial order planning, Hierarchical planning,	**04**
5	**Learning:** Types of Learning, Inductive Learning **Artificial Neural Networks:** McCulloh Pitts Model, Perceptron, Feed Forward Network, Backpropagation Algorithm, Self-Organizing Map	**07**
6	**Expert System:** Introduction, Phases in building Expert Systems, ES Architecture, Case Study on MYCIN Rule based system **Advanced topic:** Responsible AI, Introduction to Generative AI	**04**
	Total	**39**

Suggested List of Experiments:

Artificial Intelligence Laboratory (DJS22CEL503)	
Sr. No.	**Suggested Practical**
1	Select a problem statement relevant to AI. i) Identify the problem ii) PEAS Description iii) Problem formulation
2	Identify and analyze Uninformed Search Algorithm to solve the problem. Implement BFS/DFS search algorithms to reach goal state.
3	Implement DFID search algorithms to reach goal state.
4	Identify and analyze Informed Search Algorithm to solve the problem. Implement A* search algorithm to reach goal state
5	Program to implement Local Search algorithm: Hill Climbing search
6	Program on Genetic Algorithm to solve an optimization problem in AI.
7	Program to implement learning: Perceptron Learning / Backpropagation Algorithm.
8	The laboratory will emphasize the use of PROLOG. (For example, Program to implement Family Tree in Prolog)
9	Implementation on any AI game: Wumpus world, Tic-tac-toe, 8-Queens Problem
10	Case study of AI Applications.

Any other experiment based on syllabus may be included, which would help the learner to understand topic/concept.

Books Recommended:

Text Books

1. Stuart J. Russell and Peter Norvig, "Artificial Intelligence A Modern Approach" 3rd Edition, Pearson Education 2010
2. George F Luger "Artificial Intelligence" 6th Edition, Pearson Education 2021
3. Deepak Khemani." A First Course in Artificial Intelligence", 6th reprint, McGraw Hill Education 2018.
4. Saroj Kaushik "Artificial Intelligence", 1st Edition, Cengage Learning 2010

Reference Books

1. AP Engelbrecht, "Computational Intelligence", 3rd Edition, Wiley–Blackwell 2021
2. Elaine Rich and Kevin Knight "Artificial Intelligence" 3rd Edition, McGraw Hill Education 2017
3. Ivan Bratko "PROLOG Programming for Artificial Intelligence", 4th edition, Addison-Wesley 2011
4. Hagan, Demuth, Beale, "Neural Network Design", 2nd edition, Martin Hagan 2014
5. Ronald J. Martin, "The age of Artificial intelligence", Independently published 2023

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Program: Computer Engineering	T.Y B. Tech.	Semester: V
Course: Formal languages and Automata Theory (DJS22CEC504)		

Pre-requisite: Knowledge of Discrete Structure, Some knowledge of programming languages, and computer architecture

Objectives:

To provide a theoretical foundation for the process of computation and to impart an understanding of the notions of automata, formal languages and computability.

Outcomes: On completion of the course, learner will be able to:

1. Acquire a fundamental understanding of the core concepts in automata theory and formal languages.
2. Design grammar and automata (recognizers) for different language classes.
3. Determine the decidability and intractability of computational problems

Formal languages and Automata Theory (DJS22CEC504)		
Unit	**Description**	**Duration**
1	**Fundamentals:** Strings, Alphabet, Language, Operations, Chomsky Hierarchy, Finite state machine, definitions, finite automaton model, Finite state machines, Acceptance of strings, and languages	**5**
2	**Regular Languages and Finite Automata:** DFA, NFA, NFA with epsilon moves, Equivalence of DFA and NFA- Conversion from NFA to DFA, Equivalence of NFA with epsilon and NFA without epsilon - Conversion from NFA with Epsilon to NFA without Epsilon, DFA minimization: DFA Minimization using Myhill Nerode Theorem, FA with output: Moore and Mealy machines,Regular Expressions: Equivalence of Regular Expressions and Finite automata (Arden's theorem), Closure Properties of Regular Languages, Pumping Lemma for Regular Languages.	**10**
3	**Context-free Languages** Regular Grammars, Context-free Grammars, Derivations - Leftmost, Rightmost, Parse Trees, Ambiguous Grammars, Simplification of CFG, Normal Forms – Chomsky Normal Form, Greibach Normal Form.	**5**
4	**Push Down Automata:** Model of a Pushdown Automata, PDA String Acceptance by Empty Stack and Acceptance by Final State, Equivalence of PDAs and Context-free Grammars, Closure Properties of Context-free Languages, Pumping Lemma for Context-free Languages	**7**
4	**Recursive and Recursively Enumerable Languages** Definition of Recursive and Recursively Enumerable Languages, Model of a Turing Machines, Computable Functions, Methods for Turing Machine Construction,	**8**

	Modifications of the Basic Turing Machine Model - Multiple Tape TM, Multiple Tracks TM, Non-deterministic TM, Universal Turing Machine.	
5	**Decidability and Undecidability:** NP complete and NP hard problem, Church's hypothesis, Halting Problem, Post correspondence problem, Rice's theorem	**4**
	Total	**39**

Books Recommended:

Text books:

1. John E. Hopcroft, Rajeev Motwani, Jeffrey D. Ullman, "Introduction to Automata Theory, Languages and Computation," Pearson Education, Third Edition, 2016.
2. Michael Sipser, "Theory of Computation," Cengage Learning, 2014.
3. J.C. Martin, "Introduction to Languages and the Theory of Computation," Fourth Edition, Tata McGraw-Hill (TMH), 2010.

Reference Books:

1. O.G. Kakde, "Theory of Computation," Laxmi Publications (LP), 2008
2. Krishnamurthy E.V., "Introductory Theory of Computer Science," East-West Press, 2009

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Program: Computer Engineering	T.Y B. Tech.	Semester: V
Course: Advanced Algorithms (DJS22CEC5011)		
Course: Advanced Algorithms Laboratory (DJS22CEL5011)		

Prerequisite:

1. Concepts of Data structures, Discrete mathematics and Analysis of Algorithm

Objectives: To provide conceptual and practical knowledge of Advance Algorithm

Outcomes: On completion of the course, learner will be able:

1. Analyze the chosen algorithm.
2. Choose appropriate data structure and algorithm for given problem statement.
3. Design the algorithm.

Advance Algorithm (DJS22CEC5011)		
Unit	**Description**	**Hours**
1	**Analysis of Algorithm Based on Time:** **Asymptotic notations:** Omega, Theta, Big-O, Small-o, small Omega and Tilde **Amortized Analysis:** Aggregate Method, Accounting Method, Potential Method Beyond worst-case analysis, Dynamic tables and its amortized analysis, RAM model analysis of algorithm	**5**
2	**Probabilistic and Randomized Algorithm:** Probabilistic approach to algorithm and Randomized Analysis, Indicator Random Variable (IRV), Randomized Quick Sort, Analysis of Hiring Problem, Las Vegas and Monte Carlo algorithm	**5**
3	**Advanced Data Structures:** **Balanced Search Trees:** Red-Black Tree, Randomized BST **Heap and Operations:** Binomial Tree, Binomial Heap, Treap **Spatial Data Structure:** KD Tree, R Tree, R* Tree **Probabilistic Data Structure:** LogLog and HyperLogLog, Count Min sketch, MinHash with Data mining context.	**11**
4	**Graph Based Algorithms:**	**6**

	Flow Network Introduction: Residual Network, Augmenting Path, Ford-Fulkerson Method, Edmonds-Karp Method, Push-Relable Algorithm, Relable to Front algorithm. **Bipartite Matching:** Maximum Bipartite Matching, Weighted Bipartite Matching.	
5	**Computational Geometry:** Line Segment Properties, Convex Hull Graham's scan algorithm, Conic Programming **Geometric Searching:** Point Location in polygon using Ray Crossing (Flipped Classroom: 2d Linear Programming with Prune and Search) **Online Algorithms:** Competitive Ratio, K-Server	**6**
6	**Algorithm Classes:** P, NP, NP Hardness and NP Completeness **Np Completeness Proofs:** Satisfiability (3 sat), Reducibility, TSP. **Approximation Algorithms:** Vertex Cover Problem, Travelling Sales Person problem **Network Approximation:** Randomized Rounding, Primal Dual algorithms **Randomized Classes:** RP, BPP, ZPP (Adleman's theorem)	**6**

Suggested List of Experiments:

Advance Algorithms Laboratory (DJS22CEL5011)	
Sr. No.	**Suggested Practical**
1	To perform Amortized Analysis
2	To implement Randomized Algorithms (Randomized Quick Sort)
3	To implement Randomized Algorithms (Hiring Problem)
4	To implement Advanced Data Structure (Red-black Tree Operations)
5	To implement Advanced Data Structure (Binomial Tree Operations)
6	To implement Advanced Data Structure (R Tree Operations)
7	To implement Advanced Data Structure (KD Tree Operations)
8	To implement Advanced Data Structure (MinHash implementation)

9	To implement Graph Based Algorithms (Ford Fulkerson Method)
10	To implement Graph Based Algorithms (Push Relable Method)
11	To implement Graph Based Algorithms (Maximum Bipartite Matching)
12	To implement Computational Geometry (Graham Scan Algorithm)
13	To implement Online Algorithms (K-Server algorithm)
14	To implement Approximation Algorithm (Approximate TSP implementation)

Any other practical covering the syllabus topics and subtopics can be conducted.

Books Recommended:

Text books:

1. Introduction to Algorithms by Thomas H Cormen, Charles E. Leiserson, Ronald L Rivest, Clifford Stein, Third Edition.
2. Design and analysis of algorithms by S. Sridhar
3. Horowitz, Sahani and Rajsekaran, ―Fundamentals of Computer Algorithms‖, Galgotia.
4. Harsh Bhasin, Algorithms Design and Analysis, Oxford, 2015.

Reference Books:

1. Rajeev Motwani, Prabhakar Raghavan, Randomized Algorithm, Cambridge University
2. S. K. Basu, Design Methods and Analysis of Algorithm, PHI
3. Vijay V. Vajirani, Approximation Algorithms, Springer.
4. Computational Complexity, Stanford University.

Prepared by Checked by Head of the Department Principal

Program: Computer Engineering	T.Y B. Tech.	Semester: V
Course: Advanced Operating System (DJS22CEC5012)		
Course: Advanced Operating System Lab (DJS22CEL5012)		

Pre-requisite: Operating System and Computer Organization.

Course Objectives:

1. To understand the difference between distributed, multiprocessor and virtualization concepts.
2. To explore Real time operating system concepts.
3. To explore mobile operating systems.

Outcomes: On successful completion of course, learner will be able to:

1. Understand different types of operating systems concepts to solve real life problems.
2. Analyze system performance by applying virtualization concepts.
3. Understand mobile operating systems concept.

Advanced Operating System (DJS22CEC5012)

Unit	Description	Duration
1	**Introduction:** Functions of operating systems, design approaches: layered, kernel based and virtual machine approach, need for advanced operating systems, types of advanced operating systems (NOS, DOS, Multiprocessor OS, Mobile OS, RTOS, Cloud OS).	04
2	**Distributed operating Systems:** Architecture of distributed operating systems, system architecture types, issues in distributed operating systems, inherent limitation of distribute systems. Distributed mutual exclusion: classification of mutual exclusion algorithms, Lamport's, token-based algorithm, Suzuki-Kasami's Broadcast algorithm, Raymond's Tree based algorithm Distributed deadlock detection, Distributed file systems.	09
3	**Real Time Operating Systems:** Basic Model of Real time systems, Characteristics, Applications of Real time systems, Real time task scheduling, Types of tasks and their characteristics. Task Scheduling, Clock driven Scheduling, Hybrid Schedulers, Event driven Scheduling, EDF Scheduling, Rate Monotonic Algorithm, handling resource sharing Resource Handling: Resource Sharing, Priority Inversion, PIP, PCP, HLP, Scheduling real time tasks in distributed systems.	09

4	**Multiprocessor Operating Systems:** Introduction, Basic multiprocessor system architectures, design issues, Threads Process synchronization: the test and set instruction, the swap instruction, implementation of the process waits. Processor scheduling: Issues, Co-scheduling, Smart scheduling, Affinity Based scheduling	**06**
5	**Virtualization:** Introduction to Virtualization, Types of Virtualizations, Bare Metal (XEN), Hosted (KVM) Virtualization, Para virtualization, Full virtualization, Emulation, Server Virtualization, Network Virtualization and Storage Virtualization.	**06**
6	**Mobile Operating System**: Mobile OS: Architecture, Android OS, iOS, Virtual OS, Cloud OS and their design issues, Application development using Android	**05**
	Total	**39**

Advanced Operating System Lab (DJS22CEL5012)	
Sr. No.	**Suggested Practical**
1	Implement concurrent client-server application.
2	Simulate Lamport's logical clock
3	Implement Ricart-Aggarwala Algorithm.
4	Demonstrate deadlock detection using Edge Chasing algorithm.
5	Demonstrate hosted virtualization using KVM.
6	Load a new operating system virtually on the client machine using the concept of bare metal virtualization by XEN.
7	Hello world, linking activities, passing data.
8	Create a simple list view with image and text.
9	Integrate a website inside an application, use of SQLite.
10	Application development using Android.

Books Recommended:

Textbooks:

1. Mukesh Singhal, Niranjan G. Shivaratri, "Advanced Concepts in Operating Systems", Tata McGraw-Hill Edition 2020
2. Andrew S. Tanenbaum and Maarten Van Steen,"Distributed Systems: Principles and Paradigms", 26 February 2016

Reference Books:

1. K. C. Wang, “embedded and Real Time Operating System”, Springer, January 2022.
2. Abraham Silberschatz, Peter B. Galvin, Greg Gagne, “Operating System Concepts”, 8th Edition by, 2017
3. Rajib Mall, “Real-Time Systems: Theory and Practice”, Pearson Education India, 2016
4. Cris Wolf and Eric M Halter,” Virtualization from Desktop to Enterprise”, Apress.
5. K.C. Wang, “Embedded and Real-Time Operating Systems Hardcover” 6 April 2017

Prepared by Checked by Head of the Department Principal

Program: Computer Engineering	T.Y B. Tech.	Semester: V
Course: Advanced Database Management System (DJS22CEC5013)		
Course: Advanced Database Management System Laboratory (DJS22CEL5013)		

Pre-requisite: Basic knowledge of Database Management System

Objectives:
1. To provide an overview of advancement in SQL and Database technology, distributed database systems and document-oriented database.
2. To impart knowledge of query processing and optimization.
3. To understand the usage of advanced data models for real life applications and secure them.

Outcomes: On completion of the course, learner will be able to:
1. Discuss new developments in database technology, implement advanced data models for real life applications and secure them.
2. Optimize query execution and design distributed database for better resource management.
3. Demonstrate the understanding of the concepts related to document-oriented databases.

Advance Database Management System (DJS22CEC5013)		
Unit	**Description**	**Duration**
1	**Advance Databases** Indexing and Hashing: Types of Single-Level Ordered Indexes; Multilevel Indexes; Dynamic Multilevel Indexes Using B-Trees and B+-Trees; New database applications and architectures: e.g., Data Warehousing; Multimedia database; NoSQL, Native XML databases (NXD), Graph database	**05**
2	**Query processing and Optimization** Query Processing: Overview, Measures of Query cost, Selection operation, Sorting, Join Operations, and other Operations, Evaluation of Expression Query Optimization: Translations of SQL Queries into relational algebra, Heuristic approach and cost-based optimization	**08**
3	**Distributed Databases** Introduction: Types of Distributed Database Systems, Distributed Database Architectures Distributed Database Design: Data Fragmentation, Replication and Allocation Techniques Distributed Query Processing (Semi join) Transaction Management, Concurrency Control (locking) and Recovery in Distributed Databases	**08**
	Document oriented database Object Oriented Database: Need of object-oriented database, Impedance matching problem between OO languages and Relational database, Case study db4O,	

4	Document Oriented Database: Need of Document Oriented database, difference between Document Oriented Database and Traditional database, Types of encoding XML, JSON, BSON, Representation XML, Json Objects. Case study on doc oriented based such a MongoDB.	**06**
5	**Advanced data models** Temporal data models: Aspects of valid time, Bitemporal time and bi-temporal time with examples of each. Spatial model: Types of spatial data models - Raster, Vector and Image. Graph Database: Introduction, Features, Data modeling with graph. MYSQL Postgres, Mobile databases	**06**
6	**Data Security** Introduction to Database Security Issues; Authentication and authorization, Database auditing, Discretionary Access Control Based on Granting and Revoking Privileges, Mandatory Access Control and Role-Based Access Control for Multilevel Security Introduction to Statistical Database Security	**06**
	Total	**39**

Suggested List of Experiments:

Advance Database Management System Laboratory (DJS22CEL5013)	
Sr. No.	**Title of Experiments**
1	Case study on Professional and Commercial Databases: Summary and Comparison
2	Simulate Query optimization by applying an SQL Query on any database
3	Implementation of Query monitor (QEP- Query Execution Plan, Query Statistics)
4	Perform Fragmentation (Range, List, Hash and Key) in DDBS design.
5	Implementation of Replication transparency in DDB
6	Implementation of two phase / three phases commit protocol.
7	Query execution on XML database
8	Data handing using JSON. (eg. Display user information from JSON file downloaded from Mobile)
9	Processing of Spatial and temporal data
10	Case study on Database security issues and measures taken to handle those issues. (Study and document a research paper / patent / product. If possible suggest an improvement.)

Books Recommended:

Textbooks:

1. Abraham Silberschatz, Henry F. Korth, Sudarshan, “Database System Concepts” 7th Edition, Mc Graw Hill, 2021.

2. Sveta Smirnova and Alkin Tezuysal, "My SQL Cookbook" 4th Edition, O'Reilly Publication, 2022.
3. Shannon Bradshaw, Eoin Brazil, "MongoDB: The Definitive Guide - Powerful and Scalable Data Storage", Third Edition, O'Reilly Publication, 2020
4. Christos Tjortjis, "Graph Databases Applications on Social Media Analytics and Smart Cities" 1st Edition, CRC Press, 2023

Reference Books:

1. Vinicius M. Grippa and Sergey Kuzmichev, "Learning MySQL" 2nd Edition, O'Reilly Publication, 2021.
2. Tamer OEzsu, Patrick V, "Principles of Distributed Database System", Springer Publication, 2020.

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Program: Computer Engineering	T.Y B. Tech.	Semester: V
Course: Computer Graphics (DJS22CEC5014)		
Course: Computer Graphics (DJS22CEL5014)		

Pre-requisite: None

Objectives:

- The objective of the course is to equip students with the fundamental knowledge of computer graphics and provide an understanding of how to scan convert the basic geometrical primitives, how to transform the shapes to fit them as per the picture definition.
- Provide an understanding of mapping from a world coordinate to device coordinates, clipping, solid modeling, rendering, and projections.

Outcomes: On completion of the course, learner will be able to:

- Explain the applications of computer Graphics. Apply and compare the algorithms for drawing 2D images also explain aliasing, anti-aliasing and half toning techniques.
- Analyze and apply clipping algorithms and transformation on 2D images.
- Explain basic shading, shadows, curves and surfaces and solve curve problems.

Computer Graphics (DJS22CEC5014)		
Unit	**Description**	**Duration**
1	**Introduction to Computer Graphics:** Overview of Computer Graphics, Computer Graphics Application and Software, Description of some graphics devices, Input Devices for Operator Interaction, Active and Passive Graphics Devices, Display Technologies, Storage Tube Graphics Displays, Calligraphic Refresh Graphics Displays, Raster Refresh (Raster-Scan) Graphics Displays, Cathode Ray Tube Basics, Colour CRT Raster Scan Basics, Video Basics, The Video Controller, Random Scan Display Processor, LCD displays.	**06**
2	**Scan conversion: lines, circles and Ellipses and Filling polygons** Scan Converting Lines, Mid-point criteria, Problems of Aliasing, Scan Converting Circles, Scan Converting Ellipses, Filling Polygons.	**08**
3	**Two-Dimensional Transformations:** Transformations and Matrices, Transformation Conventions, 2D Transformations, Homogeneous Coordinates and Matrix Representation of 2D Transformations, Translations and Homogeneous Coordinates, Rotation, Reflection, Scaling, Combined Transformation, Transformation of Points, Transformation of The Unit Square, Solid Body Transformations, Rotation About an Arbitrary Point, Reflection through	**07**

	an Arbitrary Line, A Geometric Interpretation of Homogeneous Coordinates. **Three-Dimensional Transformations**: Scaling,Shearing,Rotation,Reflection,Translation,Multiple Transformation, Rotation about an Arbitrary Axis in Space, Reflection through an Arbitrary Plane, Matrix Representation of 3D Transformations, Composition of 3D Transformations, Affine and Perspective Geometry, Perspective Transformations, Techniques for Generating Perspective Views, Vanishing Points, the Perspective Geometry and camera models, Orthographic Projections, Axonometric Projections, Oblique Projections	
4	**Two-Dimensional Viewing:** Introduction, Viewing Pipeline View Coordinate reference frame, Window to viewport transformation point clipping, Text Clipping, Line Clipping: Cohen Sutherland Algorithm, Liang Barsky algorithms, Polygon clipping: Sutherland Hodgeman polygon clipping and Weiler Atherton. Fractal Geometry: Fractal Dimension, Koch Curve. Piano Curve, Hilbert Curve.	**07**
5	**Visible-Surface Determination** Techniques for efficient Visible-Surface Algorithms, Categories of algorithms, Back face removal, The Z-buffer Algorithm, Scan-line method, Painter's algorithms (depth sorting), Area sub-division method, BSP trees, Visible-Surface Ray Tracing, comparison of the methods. **Illumination and Shading** Illumination and Shading Models for Polygons, Reflectance properties of surfaces, Ambient, Specular and Diffuse reflections, Atmospheric attenutation, Phong's model, Gouraud shading, some examples	**07**
6	**Graphics Programming using OPENGL** Why OpenGL, Features in OpenGL, OpenGL operations, Abstractions in OpenGL – GL, GLU & GLUT, 3D viewing pipeline, viewing matrix specifications, a few examples and demos of OpenGL programs	**04**
	Total	**39**

Computer Graphics Laboratory (DJS22CEL5014)	
Sr. No.	**Suggested Practical**
1	Implementation of Line Drawing algorithms: DDA, Bresenham's and using them generating line with different styles like dotted, dashed, centered and thick line.
2	Implementation of Circle generation algorithm: Midpoint and using it generating concentric circles.
3	Implementation of Area Filling Algorithm: Boundary Fill, Flood Fill and Scan line, Polygon Fill.

4	Curve Generation: Bezier for n control points, B Spline (Uniform), Fractal Generation (Koch Curve)
5	Program for performing Two Dimensional Transformations: Translation, Scaling, Rotation, Reflection, Shear by using a homogeneous Matrix representation, use of a function for matrix multiplication is desirable, to perform composite transformation
6	Implementation of Line Clipping Algorithm: Cohen Sutherland, Liang Barsky.
7	Implementation of Polygon Clipping Algorithm: Sutherland Hodgman.
8	Program to represent a 3D object using polygon surfaces and then perform 3D transformation.
9	Program to perform projection of a 3D object on Projection Plane: Parallel and Perspective.
10	Implement Illumination and shading apply on sphere using two light sources in OpenGL

A minimum of six experiments from the above suggested list or any other experiment based on syllabus will be included along with the mini project, which would help the learner to apply the concept learnt.

Books Recommended:

Textbooks:

1. Computer Graphics and Multimedia: Concepts, Algorithms and Implementation using C, Technical publications,2020.
2. William M. Newman, "Principles of Interactive Computer Graphics", 2001.
3. B.M. Havaldar ,"C Graphics and Projects", 2006.

Reference Books:

1.A. P. Godse, Dr. D. A. Godse, Computer Graphics and Multimedia, Concepts, Algorithms and Implementation using C, KDP Print US ,2020.
2. Donald Hearn and M. Pauline Baker, "Computer Graphics", Pearson Education,2011.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc20_cs90/preview
2. https://www.edx.org/learn/computer-graphics/the-university-of-california-san-diego-computer-graphics

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Program: Computer Engineering	T.Y B. Tech.	Semester: V
Course: Professional and Business Communication Laboratory (DJS22IHL)		

Pre-requisite:

Basic course in Effective Communication Skills

Objectives:

1. To inculcate a professional and ethical attitude at the workplace
2. To enhance communication and interpersonal skills
3. To develop effective employability skills
4. To hone written skills for technical documentation

Outcomes: On completion of the course, learner will be able to:

1. Prepare technical documents using appropriate style, format, and language
2. Use employability skills to optimize career opportunities
3. Employ storytelling techniques in corporate situations
4. Conduct effective meetings and document the process
5. Demonstrate interpersonal skills in professional and personal situations
6. Describe cultural differences, etiquettes, and the concept of professional ethics

Professional and Business Communication Laboratory (DJS22IHL)		
	Description	**Duration**
Unit 1: Technical Writing		
	Report Writing: Types of reports, Basic structure of a report, collection of data through questionnaires, survey analysis, language and style in reports **Business Proposal Writing:** Types of business proposals, format of proposal, language and style, presentation of proposal **Plagiarism:** Types of plagiarism, consequences of plagiarism	**06**
Unit 2: Employment Skills		
	Group Discussion: Purpose of a GD, types of GD, criteria for evaluating GD, Dos and Don'ts of GD **Resume Writing:** Types of resumes, structure, content and formatting of resume	**08**

	Interview Skills: Types and modes of interview, Preparation for interview, Dos and Don'ts of interview, frequently asked questions during interview **Presentation Skills:** Presentation strategies, overcoming stage fear, techniques to prepare effective PowerPoint presentation	
	Unit 3: Corporate Story Telling	**03**
	Basics of storytelling: Setting, characters, plot, crisis, climax, resolution, Benefits of storytelling **Types of stories:** Elevator pitch, product stories, event stories, stories in presentations, storytelling in SOP's and interviews, storytelling to manage conflict or to motivate **Storytelling techniques:** Narration using verbal and non-verbal communication, Analysis of storytelling strategies of corporate master storytellers	
	Unit 4: Meetings and Documentation	
	Planning and preparation for meetings: Planning layout of meetings, arranging logistics, defining roles and responsibilities **Strategies for conducting effective meetings:** Follow the agenda**,** record discussion, observe meeting decorum **Documentation:** Draft notice, agenda and minutes of meeting **Business meeting etiquettes: V**erbal and non-verbal aspects of etiquettes	**02**
	Unit 5: Introduction to Interpersonal Skills	
	Emotional Intelligence: Definition, difference between IQ and EQ, how to develop EQ **Leadership:** Types of leadership, leadership styles, case studies **Team Building:** Difference between group and team, importance of teamwork, strategies to be a good team player **Time Management:** Importance of time management, cultural views of time, 80/20 rule, time wasters, setting priorities and goals, **Conflict Management:** Types of conflicts, strategies to manage conflict, case studies	**05**
	Unit 6: Cross-cultural communication and Professional ethics	
	Communication across cultures: Understanding cultures and developing sensitivity towards cultural differences **Corporate etiquettes**: Telephone, dining, cubicle etiquette, etc. **Professional ethics:** Effective work habits, accountability, integrity and excellence	**02**

Professional and Business Communication Laboratory

Laboratory (conducted batch wise) will comprise of activities and assignments based on the syllabus)

Books Recommended:

1. Fred Luthans, *"Organizational Behavior",* McGraw Hill, edition

2. Lesiker and Petit, *"Report Writing for Business",* McGraw Hill, edition

3. Huckin and Olsen, *"Technical Writing and Professional Communication",* McGraw Hill

4. Wallace and Masters, *"Personal Development for Life and Work",* Thomson Learning, 12th edition

5. Heta Murphy, *"Effective Business Communication",* Mc Graw Hill, edition

6. Sharma R.C. and Krishna Mohan, *"Business Correspondence and Report Writing",* Tata McGraw-Hill Education

7. Ghosh, B. N., *"Managing Soft Skills for Personality Development",* Tata McGraw Hill. Lehman,

8. Bell, Smith, "Management Communication" Wiley India Edition, 3rd edition.

9. Dr. Alex, K.," Soft Skills", S Chand and Company

10. Subramaniam, R., "Professional Ethics" Oxford University Press.

11. Sandeep Das, "How Business Story Telling Works: Increase Your Influence and Impact" Penguin Random House India Pvt. Ltd.

Evaluation Scheme:

Laboratory: (Term work)

Term work shall consist of 6 assignments, Group Discussion and Power Point Presentation based on the business proposal.

The distribution of marks for term work shall be as follows:

Tutorials …… (25) Marks

Business Proposal…… (15) Marks

Group Discussion……. (10) Marks

TOTAL: ……... (50) Marks

The final certification and acceptance of term work will be subject to satisfactory performance of laboratory work and upon fulfilling minimum passing criteria in the term work.

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Program: Computer Engineering	T.Y B. Tech.	Semester: V
Course: Innovative Product Development-III (DJS22ILLL1)		

Objectives:

1. To acquaint the students with the process of identifying the need (considering a societal requirement) and ensuring that a solution is found out to address the same by designing and developing an innovative product.
2. To familiarize the students with the process of designing and developing a product, while they work as part of a team.
3. To acquaint the students with the process of applying basic engineering fundamentals, so as to attempt at the design and development of a successful value added product.
4. To inculcate the basic concepts of entrepreneurship and the process of self-learning and research required to conceptualise and create a successful product.

Outcome:

Learner will be able to:

1. Identify the requirement for a product based on societal/research needs.
2. Apply knowledge and skills required to solve a societal need by conceptualising a product, especially while working in a team.
3. Use standard norms of engineering concepts/practices in the design and development of an innovative product.
4. Draw proper inferences through theoretical/ experimental/simulations and analyse the impact of the proposed method of design and development of the product.
5. Develop interpersonal skills, while working as a member of the team or as the leader.
6. Demonstrate capabilities of self-learning as part of the team, leading to life-long learning, which could eventually prepare themselves to be successful entrepreneurs.
7. Demonstrate product/project management principles during the design and development work and also excel in written (Technical paper preparation) as well as oral communication.

Guidelines for the proposed product design and development:

- Students shall convert the solution designed in semester 3 and 4 into a working model, using various components drawn from their domain as well as related interdisciplinary areas.
- The working model is to be validated with proper justification and the report is to be compiled in a standard format and submitted to the department. Efforts are to be made by the students to try and publish the extended technical paper, either in the institute journal, “Techno Focus: Journal for Budding Engineers” or at a suitable publication, approved by the department research committee/ Head of the department.

- Faculty supervisor may provide inputs to students during the entire span of the activity, spread over 2 semesters, wherein the main focus shall be on self-learning.
- A record in the form of an activity log-book is to be prepared by each team, wherein the team can record weekly progress of work. The guide/supervisor should verify the recorded notes/comments and approve the same on a weekly basis.
- The focus should be on self-learning, capability to design and innovate new products as well as on developing the ability to address societal problems. Advancement of entrepreneurial capabilities and quality development of the students through the year long course should ensure that the design and development of a product of appropriate level and quality is carried out, spread over two semesters, i.e. during the semesters V and VI.

Guidelines for Assessment of the work:

- The review/ progress monitoring committee shall be constituted by the Head of the Department. The progress of design and development of the product is to be evaluated on a continuous basis, holding a minimum of two reviews in each semester.
- In the continuous assessment, focus shall also be on each individual student's contribution to the team activity, their understanding and involvement as well as responses to the questions being raised at all points in time.
- Oral examination should be conducted by Internal and External examiners. Students have to give presentation and demonstration on their working model
- The distribution of marks for term work shall be as follows:
    1. Marks awarded by the supervisor based on log-book : 10
    2. Marks awarded by review committee : 10
    3. Quality of the write-up : 05

The overall work done by the team shall be assessed based on the following criteria;

1. Quality of survey/ need identification of the product.
2. Clarity of Problem definition (design and development) based on need.
3. Innovativeness in the proposed design.
4. Feasibility of the proposed design and selection of the best solution.
5. Cost effectiveness of the product.
6. Societal impact of the product.
7. Functioning of the working model as per stated requirements.
8. Effective use of standard engineering norms.
9. Contribution of each individual as a member or the team leader.
10. Clarity on the write-up and the technical paper prepared.

- The semester reviews (V and VI) may be based on relevant points listed above, as applicable.

Guidelines for Assessment of Semester Reviews:

- The write-up should be prepared as per the guidelines given by the department.

- The design and the development of the product shall be assessed through a presentation and demonstration of the working model by the student team to a panel of Internal and External Examiners, preferably from industry or any research organisations having an experience of more than five years, approved by the Head of the Institution. The presence of the external examiner is desirable only for the 2nd presentation in semester VI. Students are compulsorily required to present the outline of the extended technical paper prepared by them during the final review in semester VI.

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Program: Computer Engineering	T.Y B.Tech.	Semester: VI
Course: Software Engineering and Project Management (DJS22CEC601)		
Course: Software Engineering and Project Management Laboratory (DJS22CEL601)		

Prerequisite:

1. Concepts of Object-Oriented Programming & Methodology
2. Knowledge of developing applications with front end & back end connectivity.

Objectives:

To provide an idea of using various process models in the software industry according to given scenario. To gain the knowledge of how Analysis, Design, Implementation, Testing and Management processes are conducted in a software project.

Outcomes: On completion of the course, learner will be able to:

1. Understand basic concepts of Software Engineering process and models.
2. Identify requirements, analyse, design and develop the software projects.
3. Create project plan and schedule and track the progress of the project using various software project management tools.
4. Apply testing principles on software projects.

Software Engineering and Project Management (DJS22CEC601)		
Unit	**Description**	**Hours**
1	**Introduction to Software Engineering and Process Models:** Nature of Software, Software Engineering, Software Process, CMM, Generic Process Model. **Prescriptive Process Models:** The Waterfall Model, V Model. **Incremental Process Model:** Incremental Model **Evolutionary Process Models:** Prototyping Paradigm, The Spiral Model **Concurrent Process Models:** Concurrent Process Model **Agile Methodology:** Agility Principals, Agile Process Models: Extreme Programming (XP), Adaptive Software Development (ASD), Dynamic Systems Development Method (DSDM), Scrum, Crystal, Feature Driven Development (FDD), Agile Modeling (AM), Kanban Model.	08

2	**Requirement Analysis:** Requirement Elicitation, Software Requirement Specification (SRS). **Requirement Models:** Scenario Based Models, Class Based Models, Behavioural Models and Flow Models.	07
3	**Design Engineering and Analysis:** Design Principles, Design Concepts, Effective Modular Design-Cohesion and Coupling. **Translating the requirement models into the design model.** **Designs** Architectural Design, Component Level Design, User Interface Design.	06
4	**Software Project Management:** **Project Management Concepts:** Management Spectrum, 3Ps **Process and Project Metrics:** Metrics in the Process and Project Domains, software measurement, metrics for software quality. **Software Project Estimation:** LOC, FP, Empirical Estimation Models COCOMO I COCOMO II, Specialized Estimation Techniques. **Software Project Scheduling:** Work Breakdown Structure, Network Diagram, Gantt Chart, PERT, CPM, Stakeholders and Communication plan, Introduction to Project Management Information System (PMIS).	08
5	**Software Risk Management:** Risk Identification, Risk Assessment, Risk Projection, Risk Refinement, RMMM Plan. **Software Configuration Management:** SCM, SCM Repositories, SCM Process, Change Control and Version Control.	05
6	**Software Testing Fundamentals:** Strategic Approach to Software Testing, Unit Testing, Integration Testing, Verification, Validation Testing, System Testing, Test Strategies for WebApps **Software Testing Techniques:** White Box Testing, Basis Path Testing, Control Structure Testing and Black Box Testing. TDD	05

Text books:

1. Roger Pressman, "Software Engineering: A Practitioner's Approach", McGraw-Hill Publications 7th Edition, 2010
2. Ian Sommerville, "Software Engineering", Pearson Education 9th Edition, 2017
3. Ugrasen Suman, "Software Engineering-Concepts and Practices", Cengage Learning, 2022

Reference Books:

1. Ali Behfrooz and Fredeick J. Hudson, "Software Engineering Fundamentals", Oxford University Press.
2. Pankaj Jalote, "An integrated approach to Software Engineering", Narosa, 2005
3. Jibitesh Mishra and Ashok Mohanty, "Software Engineering", Pearson, 2011
4. Rajib Mall, "Fundamentals of Software Engineering", Prentice Hall India, 2018

Suggested List of Experiments:

Software Engineering and Project Management Laboratory (DJS22CEL601)	
Sr. No.	**Suggested Practical**
1	Prepare detailed statement of problem for the selected / allotted mini project and identify suitable process model for the same with justification.
2	Develop Software Requirement Specification (SRS) document in IEEE format for the project.
3	Identify scenarios & develop UML Use case and Class Diagram for the project.
4	Draw DFD (upto 2 levels) and prepare Data Dictionary for the project.
5	Develop Activity / State Transition diagram for the project.
6	Develop Sequence and Collaboration diagram for the project.
7	Use project management tool to prepare schedule and estimation for the project.
8	Prepare RMMM plan for the project.
9	Change specification and make different versions using any SCM Tool.

10	Develop test cases for the project using testing techniques.

Any other practical covering the syllabus topics and subtopics can be conducted.

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Program: Computer Engineering	T.Y B.Tech.	Semester: VI
Course: Machine Learning (DJS22CEC602)		
Course: Machine Learning Laboratory (DJS22CEL602)		

Pre-requisite: Data Structures, Basic Probability and Statistics, Algorithms, Data Mining

Course Objectives:

1. To introduce students to the basic concepts and techniques of Machine Learning.
2. To become familiar with regression, classification and clustering tasks.
3. To become familiar with Dimensionality reduction Techniques.

Outcomes: On completion of the course, learner will be able to:

1. Gain knowledge about basic concepts of Machine Learning
2. Identify machine learning techniques suitable for a given problem
3. Apply various machine learning techniques.
4. Design application using machine learning techniques

Machine Learning (DJS22CEC602)		
Unit	**Description**	**Duration**
1	**Introduction to Machine Learning** Types of Machine Learning, Steps involved in developing a Machine Learning Application, Evaluating a Learning Algorithm: Deciding what to try next, Evaluating Hypothesis, Model Selection and Train/ Validation/ Test Sets, Bias Vs variance: Regularization and Bias/ Variance, Learning Curve, Error Analysis, Handling Skewed Data: Error Matrices for Skewed Classes, Tradeoff between Precision and recall, Issues in Machine Learning, Application of Machine Learning	06
2	**Learning with Regression and trees:** Learning with Regression: Simple Linear Regression, Multiple Linear Regression, Logistic Regression. Learning with Trees: Decision Trees, Constructing Decision Trees using Gini Index, Classification and Regression Trees (CART).	06
3	**Dimensionality Reduction:** Dimensionality Reduction Techniques: Principal components analysis (Eigen values, Eigen vectors, Orthogonality), Independent Component Analysis, Single value decomposition,	07

4	**Classification**: Classification using Bayesian Belief networks, Hidden Markov Models Support Vector Machine: Maximum Margin Linear Separators, Quadratic Programming solution to finding maximum margin separators, Kernels for learning non-linear functions. Classification using k Nearest Neighbour Algorithm	08
5	**Clustering:** Basics of clustering, Hard vs Soft Clustering, Density Based Clustering: DBSCAN, Expectation maximization (EM) for soft clustering, Semi-supervised learning with EM using labelled and unlabeled data, Radial Basis functions.	07
6	**Applications of Machine Learning** Recommender Systems, Machine Learning for Image Recognition, Sentiment Analysis, Machine Learning for video surveillance	05
	Total	39

Machine Learning Laboratory (DJS22CEL602)	
Sr. No.	**Suggested Practical**
1	To implement Linear Regression
2	To implement Logistic Regression
3	Implementing CART decision tree algorithm.
4	To implement Support Vector Machine.
5	To implement Bayesian Classification.
6	To implement PCA.
7	To implement K-Nearest Neighbour.
8	Implementing Radial basis functions.
9	Mini project based on any machine learning application.

A minimum of six experiments from the above suggested list or any other experiment based on syllabus will be included along with the mini project, which would help the learner to apply the concept learnt.

Books Recommended:
Text books:

1. Ethem Alpaydın, Introduction to Machine Learning, 4th Edition, The MIT Press 2020

2. Peter Harrington, "Machine Learning In Action", 1st Edition, Dreamtech Press 2012
3. Tom Mitchell , "Machine Learning", 1st Edition, McGraw Hill 2017
4. Andreas C, Müller and Sarah Guido, "Introduction to Machine Learning with Python: A Guide for Data Scientists", 1st Edition, O'reilly 2016
5. Kevin P. Murphy, "Machine Learning: A Probabilistic Perspective" MIT Press 2012

Reference Books:

1. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd Edition, 2019
2. Witten Ian H., Eibe Frank, Mark A. Hall, and Christopher J. Pal. "Data Mining: Practical machine learning tools and techniques", 1st Edition, Morgan Kaufmann, 2016.
3. Han, Kamber, "Data Mining Concepts and Techniques", 3rd Edition, Morgan Kaufmann, 2012.
4. Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar. Foundations of Machine Learning, The MIT Press, 2012
5. H. Dunham, "Data Mining: Introductory and Advanced Topics", 1st Edition, Pearson Education, 2006.

Prepared by Checked by Head of the Department Principal

Program: Computer Engineering	T.Y B.Tech.	Semester: VI
Course: Information Security (DJS22CEC603)		
Course: Information Security Laboratory (DJS22CEL603)		

Pre-requisite: Knowledge of Programming Basics and Computer Network.

Course Objectives:

1. To acquire fundamental knowledge of modular arithmetic and number theory to establish a foundational understanding of cybersecurity principles.
2. Grasp the concepts of symmetric and asymmetric cryptography, applying various techniques to address confidentiality and authentication requirements in information systems.
3. Apply digital signature and hashing algorithms effectively to achieve authentication and integrity in the design of secure applications, demonstrating practical competence in securing digital information.

Outcomes: On completion of the course, learner will be able to:

1. Understand system security goals and concepts, classical encryption techniques and acquire fundamental knowledge on the concepts of modular arithmetic and number theory.
2. Understand the concept of symmetric and asymmetric cryptography and apply the different techniques to solve confidentiality and authentication.
3. Apply different digital signature and hashing algorithms to achieve authentication and integrity to design secure applications.
4. Understand network security basics, analyze different attacks on networks and systems, understand vulnerability and apply preventive measures.

Information Security (DJS22CEC603)		
Unit	**Description**	**Duration**
1	**Introduction and Number Theory:** Services, Mechanisms and attacks-the OSI security architecture-Network security model classical Encryption techniques (Symmetric cipher models, substitution techniques, transposition Techniques), Number theory Groups, Rings, Fields-Modular arithmetic Euclid's algorithm-Finite fields-Polynomial Arithmetic –Prime numbers-Fermat's and Euler's theorem, Chinese Remainder theorem.	08
2	**Symmetric Cryptography:**	06

	Block cipher principles block cipher modes of operation, Simplified Data Encryption Standard (DES), DES, Double DES, Triple DES, Simplified Advanced Encryption Standard (S-AES).	
3	**Asymmetric Cryptography:** Symmetric vs. Asymmetric Cryptography, Principles of public key cryptosystems, and Essential Number Theory for Public-Key Algorithm: Euler's Phi Function. The RSA algorithm, Key management, Diffie Hellman Key exchange, **Case Study:** Elliptic curve arithmetic, Elliptic curve cryptography.	06
4	**Integrity, Authentication and Digital Certificates:** Cryptographic hash functions, Properties of secure hash function, MD5, SHA-1, MAC, HMAC, CMAC. User Authentication and Entity Authentication, One-way and mutual authentication schemes, Needham Schroeder Authentication protocol, Kerberos Authentication protocol. RSA Signature Schemes, Elgamal Digital Signatures, Digital Signature Algorithm. Digital Certificate: X.509, PKI.	08
5	**Network Security:** Network security basics: Packet Sniffing, ARP spoofing, port scanning, IP spoofing, TCP syn flood, DNS Spoofing. Denial of Service: Classic DOS attacks, Source Address spoofing, ICMP flood, SYN flood, UDP flood, Distributed Denial of Service, Defenses against Denial-of-Service Attacks. Internet Security Protocols: SSL, IPSEC, Secure Email: PGP, Firewalls, IDS and types, Honey pots.	07
6	**Software Security Software Vulnerabilities:** Buffer Overflow, Salami Attack, Format string, cross-site scripting, SQL injection, Malware: Viruses, Worms, Trojans, Logic Bomb, Bots, Rootkits. **Case Study:** Introduction to Secured Software Development Life Cycle.	04
	Total	39

Information Security Laboratory (DJS22CEL603)	
Sr. No.	**Suggested Practical**
1	Design and Implement Caesar cipher cryptographic algorithm by considering letter [A..Z] and digits [0..9]. Apply Brute Force Attack to reveal secret.
2	Design and Implement Encryption and Decryption algorithm using Simple Columnar Transposition cipher technique. Study how dictionary attack can be applied on it.
3	Design and Implement your "own" cipher combining "Substitution" and "Transposition" techniques.

4	Implement RSA Cryptosystem using RSA Algorithm / Implement Elliptical Curve Digital Signature Algorithm (ECDSA).
5	Demonstrate the data integrity using various cryptographic algorithms viz. MD-5, SHA-1 using VLAB, IIT Bombay.
6	Implement registration webpage asking for information along with the password (Strong enough). Store the password in database in encrypted form after adding few salt characters in the password. Verify the strength of password and perform analyses using various attack.
7	Study the use of network reconnaissance tools like WHOIS, dig, traceroute, nslookup to gather information about networks and domain registrars.
8	Study of packet sniffer tools wireshark, : Download and install wireshark and capture icmp, tcp, and http packets in promiscuous mode. Explore how the packets can be traced based on different filters.
9	Implementation of Network Intrusion Detection System using SNORT and IPTABLE
10	Implement DOS Attack using HPing, Hping3 and other tools.
11	Implement Buffer Overflow Attack using Ollydbg, Splint, Cppcheck.

Any other experiment based on syllabus may be included, which would help the learner to understand topic/concept.

Books Recommended:
Textbooks:

1. William Stallings, “Cryptography and Network Security: Principles and Practice”, 7thEdition, Pearson Education, 2017.
2. Behrouz A. Forouzan, “Cryptography & Network Security”, Tata Mc Graw Hill, 2007

Reference Books:

1. Bruce Schneier, “Applied Cryptography: Protocols, Algorithms and Source Code in C”, Wiley, 2007.
2. Charles Pfleeger, Shari Lawrence Pfleeger & Jonathan Margulies, “Security in Computing”, 5th Edition, Prentice Hall, 2018.
3. Michael Howard, Steve Lipner, “The Secured Development Life Cycle”, Microsoft Press, 2006.

Prepared by Checked by Head of the Department Principal

Program: Computer Engineering	T.Y B.Tech.	Semester: VI
Course: Advanced Network Design (DJS22CEC6011)		
Course: Advanced Network Design Laboratory (DJS22CEL6011)		

Pre-requisite: Data Structures, Computer Networks, Operating Systems

Course Objectives:

1. To develop a comprehensive understanding of advanced network design principles and their strategic implications.
2. To acquire proficiency in the practical implementation of network designs, including physical infrastructure, configurations, and lifecycle management.
3. To apply analytical skills to assess network data traffic, security threats, and performance metrics for informed decision-making.

Outcomes: On completion of the course, learner will be able to:

1. Analyze the need for advanced networks and standards in various scenarios, evaluating specific design requirements for topology, cabling, and physical component placement.
2. Develop frameworks and standards for the implementation of network designs, incorporating best practices in configuration management. Also apply human factor concepts to enhance usability and troubleshoot network issues
3. Integrate IPv6 in network design, design and implement security systems, and analyze real-world examples of advanced network design. Also compare performance metrics in Internet routing and VoIP

Advanced Network Design (DJS22CEC6011)		
Unit	**Description**	**Duration**
1	**Introduction to Advanced Network Design:** 1.1 Overview of Advanced Network Design Principles: Definition of advanced network design, Importance of strategic network planning 1.2 Review of Basic Networking Concepts: OSI Model revisited, TCP/IP fundamentals, Network addressing and subnetting 1.3 Emerging Trends in Networking: Software-Defined Networking (SDN), Network Function Virtualization (NFV), Internet of Things (IoT) in networking	05
2	**Physical Network Design and Infrastructure:** 2.1 Physical Network Design: Topology design considerations, Cabling and physical component placement, Redundancy and fault tolerance in physical design 2.2 Advanced Router Configuration: In-depth configuration of routers, Routing protocols (EIGRP, OSPF, BGP), Router optimization and scalability	09

3	**Configuring and Managing the Network Infrastructure:** 3.1 Network Configuration Best Practices: Implementation of network designs, Configuration management and version control 3.2 Network Lifecycle Management: Maintenance and troubleshooting strategies, Network monitoring and performance optimization	06
4	**Analyzing Network Data Traffic:** 4.1 Traffic Analysis Fundamentals: Packet capture and analysis tools, Understanding network protocols 4.2 Quality of Service (QoS) Implementation, QoS requirements and strategies, Traffic classification and shaping	06
5	**Network Security and IPv6:** 5.1 Threats and Vulnerabilities in Networks: Common network security threats, Vulnerability assessment and risk analysis 5.2 Firewall and Intrusion Detection/Prevention Systems, Designing and placing firewalls strategically, Intrusion detection and prevention strategies 5.3 Virtual Private Networks (VPNs) and IPv6: Implementing VPNs for security, Integration of IPv6 in network design	06
6	**Internet Routing and VOIP:** 6.1 Internet Routing with BGP: BGP essentials and best practices, Internet routing considerations 6.2 Voice over IP (VoIP) Basics: Introduction to VoIP technologies, Design considerations for VoIP in networks 6.3 Case Studies and Best Practices: Examining real-world examples of advanced network design, best practices for implementing advanced network solutions	07
	Total	39

Advanced Network Design Laboratory (DJS22CEL6011)

Sr. No.	Suggested Practical
1	Implement advanced network design principles through case study analysis.
2	Design a physical network layout using simulation tools like Cisco Packet Tracer or GNS3.
3	Configure routers for EIGRP, OSPF, and BGP, optimizing routing tables.
4	Set up a network infrastructure adhering to industry best practices.
5	Develop troubleshooting skills and perform routine maintenance tasks.
6	Analyze network traffic using tools like Wireshark.
7	Implement Quality of Service (QoS) strategies for network traffic.
8	Simulate and analyze common network security threats using tools like Metasploit.
9	Design and implement effective firewall and intrusion detection/prevention systems.

10	Configure and deploy Virtual Private Networks (VPNs) for secure communication

A minimum of six to eight experiments from the above suggested list or any other experiment based on syllabus will be included along with the mini project, which would help the learner to apply the concept learnt.

Books Recommended:

Text Books:

1. Olivier Bonaventure, "Computer Networking: Principles, Protocols and Practice," No Starch Press,2013.
2. Kevin Dooley, "Designing Large Scale LANs," O'Reilly Media,2011.
3. Mani Subramanian, "Network Management: Principles and Practice," Addison-Wesley,2000.
4. Ilya Grigorik, "High-Performance Browser Networking," O'Reilly Media,2013.
5. William Stallings, "Network Security Essentials," Pearson,2016.
6. William A. Flanagan, "VoIP and Unified Communications: Internet Telephony and the Future Voice Network," Wiley,2012.

Reference books:

1. Laura Chappell, "Wireshark Network Analysis," Protocol Analysis Institute,2012.
2. Silvia Hagen, "IPv6 Essentials," O'Reilly Media,2006.
3. Iljitsch Van Beijnum, "BGP: Building Reliable Networks with the Border Gateway Protocol," O'Reilly Media,2002.
4. Tim Szigeti, "End-to-End QoS Network Design," Cisco Press,2004.
5. Jeffrey S. Beasley and Piyasat Nilkaew, "A Practical Guide to Advanced Networking," Pearson, 2017.
6. Gary A. Donahue, "Network Warrior," O'Reilly Media,2011.

Prepared by Checked by Head of the Department Principal

Program: Computer Engineering	**T.Y B.Tech.**	**Semester: VI**
Course: High Performance Computing (DJS22CEC6012)		
Course: High Performance Computing Laboratory (DJS22CEL6012)		

Pre-requisite: Computer Organization and Architecture or equivalent

Course Objectives:

1. To design, develop and analyze parallel programs on high performance computing resources using parallel programming.
2. Learn to design parallel programs on high performance computing

Outcomes: On completion of the course, learner will be able to:

1. Describe parallel processing approaches and different parallel processing platforms involved in achieving High Performance Computing.
2. Discuss different design issues in parallel programming
3. Develop efficient and high-performance parallel programming
4. Understand parallel programming using message passing paradigm using open-source APIs.

High Performance Computing (DJS22CEC602)		
Unit	**Description**	**Duration**
1	**Introduction to Parallel Computing**: Motivating Parallelism, Scope of Parallel Computing, Levels of parallelism (instruction, transaction, task, thread, memory, function) Classification Models: Architectural Schemes (Flynn‘s, Shore‘s, Feng‘s, Handler‘s) and Memory access (Shared Memory, Distributed Memory, Hybrid Distributed Shared Memory) Parallel Architectures: Pipeline Architecture, Array Processor, Multiprocessor Architecture.	06
2	**Pipeline Processing:** Introduction, Pipeline Performance, Arithmetic Pipelines, Pipeline instruction processing, Pipeline stage design, Hazards, Dynamic instruction scheduling	06
3	**Parallel Programming Platforms:** Parallel Programming Platform Implicit Parallelism: Trends in Microprocessor & Architectures, Limitations of Memory System Performance, Dichotomy of Parallel Computing Platforms, Physical Organization of Parallel Platforms, Communication Costs in Parallel Machines	08

4	**Parallel Algorithm Design** Principles of Parallel Algorithm Design: Preliminaries, Decomposition Techniques, Characteristics of Tasks and Interactions, Mapping Techniques for Load Balancing, Methods for Containing Interaction Overheads. Parallel Algorithm Models, Basic Communication operations: Broadcast and Reduction Communication types.	07
5	**Performance Measures** Speedup, Efficiency and Scalability, abstract performance metrics (work, critical paths), Amdahl‟s Law, Gustafson‟s Law, Weak vs. Strong Scaling, Performance Bottlenecks, Data Races and Determinism, Data Race Avoidance. Cluster Setup & its Advantages, Performance Models & Simulations; Networking Protocols & I/O, Messaging Systems, Process Scheduling, Load Sharing and Balancing; Distributed Shared Memory, Parallel I/O.	06
6	**HPC Programming: P**rogramming Using the Message-Passing Paradigm: Principles of Message Passing Programming, The Building Blocks: Send and Receive Operations MPI: the Message Passing Interface, Topology and Embedding, Overlapping Communication with Computation, Collective Communication and Computation Operations, Introduction to OpenMP	06
	Total	39

High Performance Computing Lab (DJS22CEC602)	
Sr. No.	**Suggested Practical**
1	Execution of Simple Hello world program on MPI platform.
2	a. Program to send data and receive data to/from processors using MPI b. Program illustrating Broadcast of data using MPI.
3	Implement a parallel program to demonstrate the cube of N number within a set range.
4	Implement various Sorting Algorithm
5	Implement a program to demonstrate balancing of workload on MPI platform
6	Using directives of MPI/OpenMP implement parallel programming for calculator application (add, sub, multiplication, and division)
7	Evaluate performance enhancement of HPC for any of the following: One-Dimensional Matrix-Vector Multiplication/ Single-Source Shortest-Path/ Sample Sort/Two-Dimensional MatrixVector Multiplication.
8	Case Study: OpenMP
9	Mini Project

A minimum of six experiments from the above suggested list or any other experiment based on syllabus will be included along with the mini project, which would help the learner to apply the concept learnt.

Text Books:

1. AnanthGrama, Anshul Gupta, George Karypis, Vipin Kumar , ―Introduction to Parallel Computing‖, Pearson Education, Second Edition, 2007.
2. M. R. Bhujade, ―Parallel Computing‖, 2nd edition, New Age International Publishers, 2009.
3. Kai Hwang, Naresh Jotwani, ―Advanced Computer Architecture: Parallelism, Scalability, Programmability‖, McGraw Hill, Third Edition, 2017.
4. Georg Hager, Gerhard Wellein, ―Introduction to High Performance Computing for Scientists and Engineers", Chapman & Hall / CRC Computational Science series, 2011.

Reference Books:

1. Michael J. Quinn, ―Parallel Programming in C with MPI and OpenMP‖, McGraw-Hill International Editions, Computer Science Series, 2008.
2. Kai Hwang, Zhiwei Xu, ―Scalable Parallel Computing: Technology, Architecture, Programming‖, McGraw Hill, 1998.
3. Laurence T. Yang, MinyiGuo, ―High- Performance Computing: Paradigm and Infrastructure‖ Wiley, 2006.

Prepared by Checked by Head of the Department Principal

Program: Computer Engineering	T.Y B.Tech.	Semester: VI
Course: Business Analytics (DJS22CEC6013)		
Course: Business Analytics Laboratory (DJS22CEL6013)		

Pre-requisite: Basic statistics and Database

Course Objectives: Students will try to:

1. To acquire skills, practices and techniques used in converting data into information and knowledge that aids in business decision making.
2. To apply statistical learning including quantitative, qualitative analysis techniques.
3. To apply analysis and visualization to aid decision making in varied business scenarios.

Outcomes: Students will be able to

1. Comprehend analytics, its types and techniques.
2. Apply Base SAS programming to diverse dataset for analysis.
3. Apply visual analytics for data analysis and report design.
4. Formulate business objectives, data selection/collection, preparation and design for various business applications.

Business Analytics (DJS22CEC6013)		
Unit	**Description**	**Duration**
1	**Introduction to Analytics:** Analytics, Types of Analytics, Techniques for Analytics, Use Cases in Descriptive Analytics, Predictive Analytics, Presciptive Analytics, Role of Statistics, Datamining, Machine Learning in Analytics, Formulation of Business Problem.	07
2	**Introduction to Base SAS, Visual Analytics :** **SAS Program :** Introduction to SAS program, Submitting a SAS program – SAS Studio, SAS Enterprise Guide, SAS Windowing environment, SAS program syntax, Getting Stated with SAS Visual Analytics: Exploring SAS VA concepts, Using Home page, Administrating the Environment and Managing Data: Exploring Data Builder, Exploring Administrator.	07

3	**Reading SAS Dataset, Generating Statistical Reports:** **Accessing Data: Examining** SAS Data sets, Accessing SAS Libraries **Producing Detail Reports:** Subsetting Report data, Sorting and Grouping Report data, Enhancing Reports **Formatting Data Values:** Using SAS Formats, User defined Formats Reading SAS Dataset. Importing data into SAS from various sources. Generating Statistical Reports for the imported data into SAS. Interpretation of the Statistical Reports.	07
4	**Using the Explorer in Visual Analytics:** Selecting Data and defining Data Item properties. Creating Visualisations, Enhancing Visualisations with Analytics Interacting with Visualizations and Explorations	06
5	**Designing Reports** Creating a Simple Report. Creating Data Items and Working with Graphs Working with Filters and Report sections. Working with other objects. Applying Graph level display rules in Reports.	06
6	**Viewing SAS VA Reports and Case Study** Creating Analysis and Reports. Text Analytics. Case Study – Applying to different Business Scenarios.	06
	TOTAL	39

Suggested List of Experiments:

Business Analytics Laboratory (DJS22CEL6013)	
Sr. No.	**Title of the Experiment**
1.	Importing data in SAS from Excel and CSV file.
2.	Creating summary statistical data.
3.	Exporting results to Excel and PDF.
4.	Manipulating data with functions.
5.	Using data with formats like charts and graphs.
6.	Creating data by applying filters and performing data analysis on it.
7.	Working with graph level display rules.

8.	Analyzing a Text data source.

A minimum of six experiments from the above suggested list or any other experiment based on syllabus will be included along with the mini project, which would help the learner to apply the concept learnt.

Books Recommended:

1. Efraim Turban, Ramesh Sharda, Dursun Delen, "Business Intelligence and Analytics ", Pearson,2019.
2. SAS programming 1 – Essentials.
3. SAS Visual Analytics – Fast Track.
4. SAS Support

Reference Books:

1. R.N Prasad, Seema Acharya: Fundamentals of Business Analytics, Wiley 2nd Edition,2019.
2. U. Dinesh Kumar: Business Analytics: The Science of Data-Driven Decision Making, Wiley, 2nd Edition,2021.
3. Regi Mathew: Business Analytics for Decision Making, Pearson 1st Edition,2020.

Prepared by Checked by Head of the Department Principal

Program: Computer Engineering	T.Y B.Tech.	Semester: VI
Course: Compiler Design (DJS22CEC6014)		
Course: Compiler Design Laboratory (DJS22CEL6014)		

Pre-requisite: Knowledge of Data Structures and Algorithms, Theory of Computation

Course Objectives:
1. To initiate an understanding of compilers in general and in brief about phases of compiler.
2. To provide a theoretical framework for optimizing the code.
3. To familiarize and encourage the students to use various compiler construction tools.

Outcomes: On completion of the course, learner will be able to:

1. Understand the basics of compilation steps.
2. Apply different parsing algorithms.
3. Ability to apply the knowledge of lex tool & yacc tool to develop a scanner & parser.
4. Implement code generation and apply code optimization techniques.

Compiler Design (DJS22CEC6014)		
Unit	**Description**	**Duration**
1	**Introduction to compilers:** Compilers – Analysis of the source program – Phases of a compiler – Cousins of the Compiler – Grouping of Phases – Compiler construction tools – Lexical Analysis – Role of Lexical Analyzer – Input Buffering – Specification of Tokens.	7
2	**Syntax Analysis:** Role of the parser Top Down parsing – Recursive Descent Parsing – Predictive Parsing – Bottom-up parsing – Shift Reduce Parsing – Operator Precedent Parsing – LR Parsers – SLR Parser – Canonical LR Parser – LALR Parser.	8
3	**Syntax-Directed Translation** Syntax-Directed Translation: Syntax-Directed Definitions, Evaluation Orders for SDD's, Applications of Syntax-Directed Translation, Syntax-Directed Translation Schemes, Implementing L-Attributed SDD's. **Intermediate-Code Generation:** Variants of Syntax Trees, Three-Address Code, Types and Declarations, Type Checking, Control Flow, Switch-Statements, Intermediate Code for Procedures.	8
4	**Code Optimization**	6

	Introduction– Principal Sources of Optimization – Optimization of basic Blocks – DAG representation of Basic Blocks - Introduction to Global Data Flow Analysis	
5	**Runtime Environments**: Source Language issues – Storage Organization – Storage Allocation strategies – Access to non-local names – Parameter Passing, Error detection and recovery.	5
6	**Code generation:** Issues in the design of Code Generator, Basic Blocks and Flow graphs, Code generation algorithm, DAG representation of Basic Block.	5
	Total	39

Compiler Design Laboratory (DJS22CEL6014)	
Sr. No.	**Suggested Tutorials**
1	Develop a lexical analyzer to recognize a few patterns in c (ex. Identifiers, constants, comments, operators etc.)
2	Implementation of lexical analyzer using lex tool.
3	Derive First and Follow of a variable.
4	Design LL (1) Parser.
5	Implementation of Intermediate code generation. 1. Assignment statement 2. Boolean statement 3. Loop
6	Implementation of code generator algorithm
7	Implementation of code optimization techniques (constant folding etc.)
8	Case study: LLVM

Books Recommended:

Textbook:
1. A. V. Aho, R. Shethi, Monica Lam, J.D. Ulman: Compilers Principles, Techniques and Tools, Pearson Education, Second Edition.
Reference books:
1. Lex & yacc, 2nd Edition by John R. Levine, Tony Mason & Doug Brown O 'Reilly
2. Compiler construction: principles and practices, Kenneth C.Louden , CENGAGE Learning

Prepared by Checked by Head of the Department Principal

Program: Computer Engineering	T.Y B. Tech.	Semester: VI
Course: Virtual Reality (DJS22CEC6015)		
Course: Virtual Reality Laboratory (DJS22CEL6015)		

Pre-requisite: Computer Graphics

Objectives:

- The objective of the course is to equip students with the fundamental knowledge of Virtual Reality
- Acquire practical knowledge of 3D user interface input hardware, including tracking devices, 3D mice, and specialized input devices, and learn how to choose the most suitable input devices for various 3D interface applications.
- Gain proficiency in VR programming using VRML and Java 3D, enabling the creation of interactive and engaging virtual environments.

Outcomes: On completion of the course, learner will be able to:

- To make students know the basic concept and understand the framework of virtual reality
- To understand principles and multidisciplinary features of virtual reality and apply it in developing applications.
- To know the technology for multimodal user interaction and perception VR, particularly the visual, audial and haptic interface and behaviour.
- To understand an introduction to the AR system framework and apply AR tools in software development.

Virtual Reality (DJS22CEC6015)		
Unit	**Description**	**Duration**
1	**Introduction to VR:** Important factors in VR system, Types of VR System, advantages of VR, modelling techniques in VR. **3D USER INTERFACE INPUT HARDWARE:** Input device characteristics, Desktop input devices, Tracking Devices, 3D Mice, Special Purpose Input Devices, Direct Human Input, Home - Brewed Input Devices, Choosing Input Devices for 3D Interfaces.	**08**
2	**Computing Architecture for Virtual Reality:** Graphical rendering pipeline: OPENGL pipeline, Haptic, PC graphics architecture and accelerator SGI reality architecture, The Sun Blade 1000 architecture	**04**

3	**Software Technologies:** Database - World Space, World Coordinate, World Environment, Objects - Geometry, Position / Orientation, Hierarchy, Bounding Volume, Scripts and other attributes, VR Environment - VR Database, Tessellated Data, LODs, Cullers and Occluders, Lights and Cameras, Scripts, Interaction - Simple, Feedback, Graphical User Interface, Control Panel, 2D Controls, Hardware Controls, Room / Stage / Area Descriptions, World Authoring and Playback, VR toolkits, Available software in the market	**07**
4	**3d Interaction Techniques:** 3D Manipulation tasks, Manipulation Techniques and Input Devices, Interaction Techniques for 3D Manipulation, Design Guidelines - 3D Travel Tasks, Travel Techniques, Design Guidelines - Theoretical Foundations of Wayfinding, User Centred Wayfinding Support, Environment Centred Wayfinding Support, Evaluating Wayfinding Aids, Design Guidelines - System Control, Classification, Graphical Menus, Voice Commands, Gestural Commands, Tools, Multimodal System Control Techniques, Design Guidelines, Case Study: Mixing System Control Methods, Symbolic Input Tasks, symbolic Input Techniques, Design Guidelines, Beyond Text and Number entry	**08**
5	**Designing And Developing 3d User Interfaces:** Strategies for Designing and Developing Guidelines and Evaluation. Virtual reality programming using VRML and Java 3D VIRTUAL REALITY APPLICATIONS: Engineering, Architecture, Education, Medicine, Entertainment, Science, Training.	**08**
6	**Augmented and Mixed Reality** Taxonomy, technology and features of augmented reality, difference between AR and VR, Challenges with AR, AR systems and functionality, Augmented reality methods, visualization techniques for augmented reality, wireless displays in educational augmented reality applications, mobile projection interfaces, marker-less tracking for augmented reality, enhancing interactivity in AR environments, evaluating AR systems.	**04**
	Total	**39**

Virtual Reality Laboratory (DJS22CEL6015)

Students are supposed to complete any one mini project related to Virtual Reality (max group of 3 students).

Books Recommended:
Textbooks:

1.R. K Maurya, "Computer Graphics with Virtual Reality", Wiley India,2011.

2. Doug A Bowman, Ernest Kuijff, Joseph J LaViola, Jr and Ivan Poupyrev, "3D User Interfaces, Theory and Practice", Addison Wesley, USA, 2005.
3. Christopher D. Watkins, Stephen R. Marenka ,"Virtual Reality Excursions with Programs in C" Elsevier Science, 2014.

Reference Books:

1. Alan B Craig, William R Sherman and Jeffrey D Will, "Developing Virtual Reality Applications: Foundations of Effective Design", Morgan Kaufmann, 2009.
2. Gerard Jounghyun Kim, "Designing Virtual Systems: The Structured Approach", 2005.
3. Oliver Bimber and Ramesh Raskar, "Spatial Augmented Reality: Meging Real and Virtual Worlds", 2005.
4. William R Sherman and Alan B Craig, "Understanding Virtual Reality: Interface, Application and Design (The Morgan Kaufmann Series in Computer Graphics)". Morgan Kaufmann Publishers, San Francisco, CA, 2002
5. Alan B. Craig, Understanding Augmented Reality, Concepts and Applications, Morgan Kaufmann, 2013.

Online Resources:

1. https://archive.nptel.ac.in/courses/106/106/106106138
2. https://www.coursera.org/specializations/virtual-reality
3. https://www.edx.org/certificates/professional-certificate/ucsandiegox-virtual-reality-app-development

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Program: Computer Engineering	**T.Y B.Tech.**	**Semester: VI**
Course: DevOps Laboratory (DJS22CEL604)		

Pre-requisite:

1. Knowledge of Linux Operating system, installation and configuration of services and command line basics.
2. Software Development Life cycle.

Course Objectives:

1. To understand the fundamentals of DevOps engineering.
2. To be proficient with DevOps terminologies, concepts, benefits, and deployment options to meet real world software development requirements.

Outcomes: On completion of the course, learner will be able to:

1. Interpret and apply various principles, phases and activities of Agile methodology and DevOps principles to meet software development requirements.
2. Understand and implement DevOps principles for CI/CD.
3. Apply testing process for application development and configuration management tools.

Devops Laboratory (DJS22CEL604)		
Unit	**Description**	**Duration**
1	**Introduction to DevOps:** Phases of Software Lifecycle, Minimum Viable Product (MVP) & Cross-functional Teams, Lean, ITIL, Agile development methodologies, DevOps as a prominent culture to achieve agility in the software development process, DevOps Stakeholders, Goals, DevOps and Agile, DevOps Tools.	06
2	**Version Control:** Introduction, Overview of Version Control Systems, Role of Version Control System, Types of Control Systems and their Supporting Tools, Importance of version control in CICD pipeline.	06
3	**Continuous Integration:** Introduction to Jenkins (With Master –Slave Architecture), Choosing a launch method, Administering Jenkins slaves, Labels, groups and load balancing. Creating Views and Jobs in Jenkins: The Jenkins user interface, Jobs in Jenkins, Creating Views, Managing Views and Jobs in Jenkins: Managing Views in Jenkins, Navigating a job's project page, Job Execution, The Job Execution Configuration Panel, The Status Panel, Console Panel.	08
4	**Continuous Deployment:** Overview of Docker, Benefits of Docker Workflow, Process Simplification, Architecture, Docker Containers, Docker Workflow, Anatomy of Dockerfile, Building an Image, Running an Image, Custom base Images, Storing Images.	05

5	**Continuous Testing:** Introducing WebDriver and WebElements, Selenium Testing Tools, Differences between Selenium 2 and Selenium 3, Setting up a project in Eclipse with Maven and TestNG using Java, WebElements, Locating WebElements using WebDriver, Interacting with WebElements, Different Available WebDrivers, Using Java 8 Features with Selenium. Introducing Java 8 Stream API, Using Stream API with Selenium WebDriver.	08
6	**Continuous Management:** The Parts of an Infrastructure System, Infrastructure Platforms, Infrastructure Resources, Compute Resources, Storage Resources, Network Resources. **Puppet:** Puppet Architecture, The Puppet Server, setting up the Puppet Agent, Performance Optimizations, **Ansible:** Ansible Architecture, Ansible and Infrastructure Management, Local Infrastructure Development: Ansible and Vagrant. Introduction to open-source tools for data gathering and management, AWS	06
	Total	39

Devops Laboratory (DJS22CEL604)	
Sr. No.	**Suggested Experiments**
1	To understand Version Control System / Source Code Management, install git and create a GitHub account.
2	To Perform various GIT operations on local and Remote repositories using GIT Cheat-Sheet.
3	To understand Continuous Integration, install and configure Jenkins with Maven/Ant/Gradle to setup a build Job.
4	To Build the pipeline of jobs using Maven / Gradle / Ant in Jenkins, create a pipeline script to Test and deploy an application over the tomcat server.
5	To understand Jenkins Master-Slave Architecture and scale your Jenkins standalone implementation by implementing slave nodes.
6	To Setup and Run Selenium Tests in Jenkins Using Maven.
7	To understand Docker Architecture and Container Life Cycle, install Docker and execute docker commands to manage images and interact with containers.
8	To learn Dockerfile instructions, build an image for a sample web application using Dockerfile.
9	To install and Configure Pull based Software Configuration Management and provisioning tools using Puppet. /Ansible.
10	To learn Software Configuration Management and provisioning using Puppet Blocks (Manifest, Modules, Classes, Function).
11	To provision a LAMP/MEAN Stack using Puppet Manifest.

Any other experiment based on syllabus may be included, which would help the learner to understand topic/concept.

Books Recommended:

Textbook:

1. Karl Matthias & Sean P. Kane, “Docker: Up and Running”, 3 rd Edition, O'Reilly Publication, 2022.
2. Craig Berg, “DevOps For Beginners: A Complete Guide To DevOps Best Practices” 2020.
3. Mikael Krief, “Learning DevOps: A comprehensive guide to accelerating DevOps culture adoption with Terraform, Azure DevOps, Kubernetes, and Jenkins”, Packt Publication, 2nd Edition, 2022.
4. Gene Kim, Jez Humble, et.el, “The DevOps Handbook: How to Create World-Class Agility, Reliability, & Security in Technology Organizations”, IT Revolution Press; 2nd edition 2021.
5. Mark Reed, “DevOps: The Ultimate Beginners Guide to Learn DevOps Step-By-Step", LLC Publication, 2020.
6. Deepak Gaikwad, Viral Thakkar, “DevOps Tools from Practitioner's Viewpoint”, Wiley,2019.

Reference books:

1. Mark S. Merkow, “Practical Security for Agile and DevOps”, CRC Press Taylor & Francis, 2022.
2. Emily Freeman, “DevOps for Dummies”, 3rd Edition, Wiley Publication,2019.
3. Martin Alfke , Felix Frank, “Puppet 5 Essentials", 3rd Edition, O'Reilly Publication,2017.

Prepared by Checked by Head of the Department Principal

Program: Computer Engineering	T.Y B. Tech.	Semester: VI
Course: Innovative Product Development-IV (DJS22ILLL2)		

Objectives:

1. To acquaint the students with the process of identifying the need (considering a societal requirement) and ensuring that a solution is found out to address the same by designing and developing an innovative product.
2. To familiarize the students with the process of designing and developing a product, while they work as part of a team.
3. To acquaint the students with the process of applying basic engineering fundamentals, so as to attempt at the design and development of a successful value added product.
4. To inculcate the basic concepts of entrepreneurship and the process of self-learning and research required to conceptualise and create a successful product.

Outcome:

Learner will be able to:

1. Identify the requirement for a product based on societal/research needs.
2. Apply knowledge and skills required to solve a societal need by conceptualising a product, especially while working in a team.
3. Use standard norms of engineering concepts/practices in the design and development of an innovative product.
4. Draw proper inferences through theoretical/ experimental/simulations and analyse the impact of the proposed method of design and development of the product.
5. Develop interpersonal skills, while working as a member of the team or as the leader.
6. Demonstrate capabilities of self-learning as part of the team, leading to life-long learning, which could eventually prepare themselves to be successful entrepreneurs.
7. Demonstrate product/project management principles during the design and development work and also excel in written (Technical paper preparation) as well as oral communication.

Guidelines for the proposed product design and development:

- Students shall convert the solution designed in semester 3 and 4 into a working model, using various components drawn from their domain as well as related interdisciplinary areas.
- The working model is to be validated with proper justification and the report is to be compiled in a standard format and submitted to the department. Efforts are to be made by the students to try and publish the extended technical paper, either in the institute journal, “Techno Focus: Journal for Budding Engineers” or at a suitable publication, approved by the department research committee/ Head of the department.

- Faculty supervisor may provide inputs to students during the entire span of the activity, spread over 2 semesters, wherein the main focus shall be on self-learning.
- A record in the form of an activity log-book is to be prepared by each team, wherein the team can record weekly progress of work. The guide/supervisor should verify the recorded notes/comments and approve the same on a weekly basis.
- The focus should be on self-learning, capability to design and innovate new products as well as on developing the ability to address societal problems. Advancement of entrepreneurial capabilities and quality development of the students through the year long course should ensure that the design and development of a product of appropriate level and quality is carried out, spread over two semesters, i.e. during the semesters V and VI.

Guidelines for Assessment of the work:

- The review/ progress monitoring committee shall be constituted by the Head of the Department. The progress of design and development of the product is to be evaluated on a continuous basis, holding a minimum of two reviews in each semester.
- In the continuous assessment, focus shall also be on each individual student's contribution to the team activity, their understanding and involvement as well as responses to the questions being raised at all points in time.
- Oral examination should be conducted by Internal and External examiners. Students have to give presentation and demonstration on their working model
- The distribution of marks for term work shall be as follows:
    1. Marks awarded by the supervisor based on log-book : 10
    2. Marks awarded by review committee : 10
    3. Quality of the write-up : 05

The overall work done by the team shall be assessed based on the following criteria;

1. Quality of survey/ need identification of the product.
2. Clarity of Problem definition (design and development) based on need.
3. Innovativeness in the proposed design.
4. Feasibility of the proposed design and selection of the best solution.
5. Cost effectiveness of the product.
6. Societal impact of the product.
7. Functioning of the working model as per stated requirements.
8. Effective use of standard engineering norms.
9. Contribution of each individual as a member or the team leader.
10. Clarity on the write-up and the technical paper prepared.

- The semester reviews (V and VI) may be based on relevant points listed above, as applicable.

Guidelines for Assessment of Semester Reviews:

- The write-up should be prepared as per the guidelines given by the department.

- The design and the development of the product shall be assessed through a presentation and demonstration of the working model by the student team to a panel of Internal and External Examiners, preferably from industry or any research organisations having an experience of more than five years, approved by the Head of the Institution. The presence of the external examiner is desirable only for the 2nd presentation in semester VI. Students are compulsorily required to present the outline of the extended technical paper prepared by them during the final review in semester VI.

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