Shri Vile Parle Kelavani Mandal's

Dwarkadas J. Sanghvi College of Engineering

(Autonomous College Affiliated to the University of Mumbai)

Scheme and Detailed syllabus (DJS22)

Third Year B.Tech

in

Computer Science and Engineering (Data Science)

(Semester V)

Shri Vile Parle Kelavani Mandal's
DWARKADAS J. SANGHVI COLLEGE OF ENGINEERING
(Autonomous College Affiliated to the University of Mumbai)
NAAC Accredited with "A" Grade (CGPA : 3.18)

Course Structure for Third year Undergraduate Program in Computer Science and Engineering (Data Science) : Semester V (Autonomous)

(Academic Year 2024-25)

Sr	Course Code	Course	Teaching Scheme				Continuous Assessment (A)					Semester End Examination (B)						Aggregate (A+B)	Credits earned	
			Theory (hrs.)	Practical (hrs.)	Tutorial (hrs.)	Credits	Term Test 1 (TT1)	Term Test 2 (TT2)	Avg (TT1 & TT2)	Term Work Total	CA Total	Duration	Theory	Oral	Pract	Oral & Pract	SEE Total			
1	DJS22DSC501	Machine Learning - II (Deep Learning)	3	--	--	3	20	15	35	--	35	2	65	--	--	--	65	100	3	**4**
	DJS22DSL501	Machine Learning - II Laboratory	--	2	--	1	--	--	--	25	25	2	--	--	--	25	25	50	1	
2	DJS22DSC502	Intelligent Systems	3	--	--	3	20	15	35	--	35	2	65	--	--	--	65	100	3	**4**
	DJS22DSL502	Intelligent Systems Laboratory	--	2	--	1	--	--	--	25	25	--	--	--	--	--	--	25	1	
3	DJS22DSC503	Image Processing and Computer Vision - I	3	--	--	3	20	15	35	--	35	2	65	--	--	--	65	100	3	**4**
	DJS22DSL503	Image Processing and Computer Vision - I Laboratory	--	2	--	1	--	--	--	25	25	2	--	--	--	25	25	50	1	
4	DJS22DSL504	Big Data Engineering Laboratory	2	2	--	3	--	--	--	50	50	2	--	--	--	50	50	100	3	**3**
5@	DJS22DSC5011	Distributed Computing	3	--	--	3	20	15	35	--	35	2	65	--	--	--	65	100	3	**4**
	DJS22DSL5011	Distributed Computing Laboratory	--	2	--	1	--	--	--	25	25	--	--	--	--	--	--	25	1	
	DJS22DSC5012	Time Series Analysis	3	--	--	3	20	15	35	--	35	2	65	--	--	--	65	100	3	
	DJS22DSL5012	Time Series Analysis Laboratory	--	2	--	1	--	--	--	25	25	--	--	--	--	--	--	25	1	
	DJS22DSC5013	Digital System Design	3	--	--	3	20	15	35	--	35	2	65	--	--	--	65	100	3	
	DJS22DSL5013	Digital System Design Laboratory	--	2	--	1	--	--	--	25	25	--	--	--	--	--	--	25	1	
	DJS22DSC5014	Probabilistic Graph Models	3	--	--	3	20	15	35	25	60	2	65	--	--	--	65	125	3	
	DJS22DSL5014	Probabilistic Graph Models Laboratory	--	2	--	1	--	--	--	25	25	--	--	--	--	--	--	25	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	2	--	25	--	--	25	50	1	**1**
		Total	**23**	**22**	**0**	**34**	**140**	**105**	**245**	**325**	**570**	**22**	**455**	**25**	**0**	**100**	**580**	**1150**	**34**	**22**

@ Any 1 Elective Course

* 2 hrs Theory (Class wise) and 2 hrs. Tutorial (Batch wise)

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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 / qui / power point presentation / poster presentation / group project / any other tool.	--	As applicable
Laboratory	Performance in the laboratory and documentation.	25	
Tutorial	Performance in each tutorial & / assignment.	25	
Laboratory &Tutorial	Performance in the laboratory and tutorial.	50	

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 / * Computer based	Written paper based on the entire syllabus.	65	2
	* Computer based assessment in the college premises.		
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: B.Tech in Computer Science and Engineering (Data Science)	T.Y. B.Tech	Semester: V
Course: Machine Learning - II (Deep Learning) (DJS22DSC501)		
Course: Machine Learning - II Laboratory (DJS22DSL501)		

Pre-requisite: Linear Algebra, Calculus, Probability, Statistics and Machine Learning Basics.

Course Objectives:

1. To introduce students with the fundamental concepts of artificial neural network and different learning algorithms: supervised and unsupervised neural networks.
2. Develop in-depth understanding of the key techniques in designing Deep Network.
3. To expose Deep Network based methods to solve real world complex problems.

Outcomes: Students will be able to

1. Analyze different neural network architectures and their learning algorithms.
2. Implement deep network training and design concepts.
3. Build solution using appropriate neural network models.

Machine Learning - II (Deep Learning) (DJS22DSC501)		
Unit	**Description**	**Duration**
1	**Introduction to Artificial Neural Learning:** Fundamental concepts of biological Neural Networks, NN Architectures, Important terminologies of ANN: Activation functions (Sigmoid, ReLu, Leaky ReLu, Tanh, Softmax), weights, bias, threshold, learning rate, McCulloch Pitts Neuron: Theory and Architecture.	**05**
2	**Supervised Learning Networks:** Perceptron: Representational power of Perceptron, The Perceptron Training Rule, Delta Rule; Multilayer Networks: Representational Power of Feedforward Networks; Backpropagation Algorithm: Convergence and local minima, Hypothesis space search and Inductive Bias, Generalization, overfitting and stopping criteria. **Optimization for Training Deep Models:** Challenges in Neural Network Optimization, Basic Algorithms, Parameter Initialization Strategies. Optimizers: Gradient Descent (Stochastic, Mini-Batch, Batch), SGD with Momentum, Nesterov Accelerated GD, Adagrad, Adadelta, RMSProp, Adam, Regularization for Deep Learning: Parameter Norm Penalties, Dataset Augmentation, Noise Robustness, Early Stooping, Sparse Representation, Dropout.	**08**
3	**Convolutional Networks:** The Convolution Operation, sparse interactions, parameter sharing, Pooling, Convolution and Pooling as an Infinity Strong Prior, Variants of Basic Convolution Function, Efficient Convolution Algorithms (AlexNet, LeNet-5, VGG, DenseNet, InceptionNet, ResNet).	**06**
4	**Sequence Modelling:** Recurrent Neural Networks (RNN), Bidirectional RNNs, Deep recurrent Networks, Recursive Neural Networks, The challenges of Long-Term Dependencies, Echo State Networks, Leaky Units, The Long Short-Term Memory (LSTM).	**06**
5	**Unsupervised Learning Networks:** Kohonen Self-Organizing Feature Maps – architecture, training algorithm, Kohonen Self-Organizing Motor Map.	**08**

	Autoencoders: Sparse Autoencoder, Undercomplete Autoencoders, Regularized Autoencoders, Denoising Autoencoders, Applications of Autoencoders. Linear Factor Methods such as Probabilistic PCA and Factor Analysis, Independent Component Analysis.	
6	**Transfer Learning:** Fundamental of Transfer Learning, Pre-trained Model Approach, Freezing, Fine-tuning. Transfer Learning Strategies: Inductive Learning, Inductive Transfer, Transductive Transfer Learning, Unsupervised Transfer Learning; Types of Deep Transfer Learning: Domain Adaptation, Domain Confusion, One-shot Learning, Zero-shot Learning, Multitask Learning; Types of Transferable Components: Instance transfer, Feature-representation transfer, Parameter transfer, Relational-knowledge transfer; Transfer Learning Challenges: Negative Transfer, Transfer Bounds; Applications: Transfer learning for NLP/ Audio/ Speech/ Computer Vision.	**07**
	Total	**39**

Machine Learning - II Laboratory (DJS22DSL501)	
Exp.	**Suggested Experiments**
1	Implement Boolean gates using perceptron.
2	Implement backpropagation algorithm from scratch.
3	Monitoring and evaluating deep learning models using Tensorflow and Keras.
4	Evaluate and analyze Prediction performance using appropriate optimizers for deep learning models.
5	Implement Sentiment analysis on text dataset to evaluate customer reviews.
6	Building CNN models for image categorization.
7	Document classification using RNN models.
8	Outlier detection in time series dataset using RNN.
9	Anomaly detection using Self-Organizing Network.
10	Compare the performance of PCA and Autoencoders on a given dataset.
11	Transfer Learning with Pre-trained CNN model as a Feature Extractor for Image Classification with a Data Availability Constraint.

Books Recommended:

Text Books:

1. Simon Haykin, "Neural Networks and Learning Machines", Pearson Prentice Hall, 3rd Edition, 2010.
2. S. N. Sivanandam and S. N. Deepa, "Introduction to Soft Computing", Wiley India Publications, 3rd Edition, 2018.

Reference Books:

1. François Chollet, "Deep Learning with Python", Manning Publication, 2017.
2. Josh Patterson, Adam Gibson, "Deep Learning: A Practitioner's Approach", O'Reilly Publication, 2017.
3. Andrew W. Trask, Grokking, "Deep Learning", Manning Publication, 2019.
4. John D. Kelleher, "Deep Learning", MIT Press Essential Knowledge series, 2019.

Web Links:

1. Learning Rule: http://vlabs.iitb.ac.in/vlabs-dev/labs/machine_learning/labs/explist.php
2. ANN Virtual Lab: http://cse22-iiith.vlabs.ac.in/List%20of%20experiments.html
3. Deep Learning: https://vlab.spit.ac.in/ai/#/experiments
4. NPTEL Course: Deep Learning Part 1: https://onlinecourses.nptel.ac.in/noc19_cs85/preview

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Program: B.Tech in Computer Science and Engineering (Data Science)	T.Y. B.Tech	Semester: V
Course: Intelligent Systems (DJS22DSC502)		
Course: Intelligent Systems Laboratory (DJS22DSL502)		

Pre-requisite: Basic Mathematics and Data Structures

Course 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 and provide the knowledge to deal with uncertain and incomplete information.
4. Impart the knowledge of Intelligent planning.

Outcomes: Students will be able to:

1. Apply appropriate search-based method for a given problem.
2. Analyze various IS approaches to knowledge - problem solving, reasoning, and intelligent planning.
3. Apply the knowledge of reasoning and intelligent planning to solve a problem.

Intelligent Systems (DJS22DSC502)		
Unit	**Description**	**Duration**
1	**Fundamentals:** Introduction to Intelligence Systems, Evolution, Categorization of Intelligent System, Applications. **Problem solving:** Solving problem by Searching: Problem Solving Agent, Formulating Problems. State Space Search: Uninformed search, Breadth First Search (BFS), Depth First Search (DFS), Depth, Depth First Iterative Deepening (DFID). Heuristic Search: Best first Search, Hill Climbing, Variations of Hill Climbing, Solution Space, and Travelling Salesman Problem.	**08**
2	**Optimizations:** Population Based Methods: Simulated annealing, Local beam search, Genetic algorithm. Finding Optimal Paths: Branch and Bound, A*, Admissibility and monotonicity properties of A*. **Game Playing:** Game Theory, Board games and game tree, The minimax algorithm, Alpha-Beta Pruning.	**09**
3	**Knowledge and Reasoning in Logic:** Logic, Soundness and Completeness, Propositional Logic, First Order Logic, forward chaining, Backward chaining and Refutation. Uncertain Knowledge and Reasoning: Fuzzy sets, Fuzzy Logic, Fuzzy Logic Controller.	**06**
4	**Logic Foundation for Ontologies:** Knowledge Modelling, Definition, and importance of ontologies in AI, Components of ontologies: classes, properties, individuals, Ontology development methodologies (e.g. Protégé), Ontology languages (e.g. OWL, RDF), Ontology reasoning and inference,	**05**

	Applications of ontologies in AI (e.g. semantic web, knowledge management.	
5	**Ontology Modelling:** Advanced ontology modelling constructs (e.g. restrictions, class axioms), Ontology alignment, merging and versioning, Ontology-based data access and integration, Probabilistic and fuzzy ontologies, Rule-based reasoning with ontologies (e.g. SWRL), Scalable ontology reasoning techniques, Real-world ontology case studies and industry applications.	**06**
6	**Planning**: Domain independent planning, Forward and Backward search, Goal Stack Planning, Plan Space Planning, Means Ends Analysis, Graphplan, algorithm AO*.	**05**
	Total	**39**

Intelligent Systems Laboratory (DJS22DSL502)	
Exp.	**Suggested Experiments**
1	Implement domain specific function for different problems.
2	Identify and analyze uninformed search Algorithm to solve the problem. Implement BFS/DFS/DFID search algorithms to reach goal state.
3	Program to implement Local Search algorithm: Hill climbing search.
4	Program on any natures inspired algorithm to solve a optimization problem in AI.
5	Implement A* search algorithm to reach goal state.
6	Implement minimax algorithm for a two-player game.
7	Implement Fuzzy operations for given input values.
8	Design a fuzzy logic controller for a given problem.
9	Develop a knowledge base using OWL.
10	Develop a Rule based System using SWRL on Protégé software.

Books Recommended:

Text Books:

1. Deepak Khemani.” A First Course in Artificial Intelligence”, McGraw Hill Education (India), 2013.
2. Dean Allemang, James Hendler “Semantic Web for the Working Ontologist”, Elsevier 1st Edition, 2008.

Reference Books:

1. Saroj Kaushik “Artificial Intelligence”, First Edition, Cengage Learning, 2011.
2. Ivan Bratko “PROLOG Programming for Artificial Intelligence”, Fourth Edition, Pearson Education, 2011.
3. Elaine Rich and Kevin Knight “Artificial Intelligence” Third Edition, Tata McGraw-Hill, 2008.
4. Davis E.Goldberg, “Genetic Algorithms: Search, Optimization and Machine Learning”, Addison Wesley, N.Y.
5. Patrick Henry Winston, “Artificial Intelligence”, Addison-Wesley, Third Edition.
6. N.P.Padhy, “Artificial Intelligence and Intelligent Systems”, Oxford University Press, 2005.
7. John Yen and Reza Langari, "Fuzzy Logic: Intelligence, Control, and Information", Pearson, 2002.

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Program: B.Tech in Computer Science and Engineering (Data Science)	T.Y. B.Tech	Semester: V
Course: Image Processing and Computer Vision - I (DJS22DSC503)		
Course: Image Processing and Computer Vision - I Laboratory (DJS22DSL503)		

Pre-requisite: Basic co-ordinate geometry, matrix algebra, linear algebra and random process.

Course Objectives: To teach various feature engineering and preprocessing techniques on image and video data types.

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

1. Identify the need of different image and video pre-processing.
2. Apply different image and video corrections.
3. Compare different image and video processing methods.

Image Processing and Computer Vision - I (DJS22DSC503)		
Unit	**Description**	**Duration**
1	**Digital Image Fundamentals:** Steps in Digital Image Processing, Components, Image Sampling and Quantization, Neighborhood of pixels.	**04**
2	**Image Enhancement** (point processing): Image Negative, Thresholding, Gray-level slicing with and without background, power law and log transform, Contrast Stretching, Histogram equalization. **Image Enhancement in Spatial Domain** (Neighbourhood processing): Low Pass and High Pass filtering for image enhancement, High Boost Filtering, Basics of Spatial Filtering, Generating Spatial Filter Masks–Smoothing and Sharpening Spatial Filtering. **Image Transforms:** 1-D DFT, 2-D Discrete Fourier Transform and Its Inverse, Some Properties of 2D DFT, Walsh -Hadamard, Discrete Cosine Transform, Haar Transform, Slant Transform. **Image Enhancement in Frequency Domain:** The Basics of Filtering in the Frequency Domain, Smoothing and Sharpening frequency domain filters.	**11**
3	**Morphology:** Erosion and Dilation, Opening and Closing, The Hit or-Miss Transformation. Restoration: Noise models – Mean Filters – Order Statistics – Adaptive filters -Adaptive mean filter, Adaptive Gaussian Filter. **Corner and Interest Point detection:** The Harris Interest Point Operator: Corner Signals and shifts for various geometric configuration, Performance with crossing point and Junctions, Different forms of Harris Operator, Local Invariant Feature Detectors and Descriptors: Harris scale and Affine- Invariant Detectors and Descriptors.	**08**

4	**Point, Line, and Edge Detection:** Detection of Isolated Points, Line detection, edge models, basic and advance edge detection (Kirsch Compass Kernels), Edge linking and boundary detection, Canny's edge detection algorithm. **Thresholding:** Foundation, Role of illumination, Basic Global thresholding, Otsu's method Region Based segmentation: Region Growing, Region Splitting and merging, Relationships between pixels, Hough transform. **Region Identification:** Chain code, simple geometric border representation (Topological and region based descriptor). Fourier Transform of boundaries, Boundary description using segment sequences.	**08**
5	**Motion:** Optical Flow, Interpretation of Optical Fields, Using focus of expansion to avoid collision, Time to adjacency analysis, Basic difficulties with optical flow models, Stero from Motion.	**08**
	Total	**39**

Image Processing and Computer Vision - I Laboratory (DJS22DSL503)	
Sr. No	**Title of the Experiments**
1	To perform basic Image Processing, Geometric, Arithmetic and Logical operations on Images.
2	To perform Spatial Domain Image Enhancement using different Point Processing Techniques like Image Negative Transformation, Thresholding, Gray Level Slicing with without background.
3	To perform Spatial Domain Image Enhancement using different Neighborhood Processing Techniques.
4	To perform Histogram equalization.
5	To perform frequency domain Image Enhancement techniques.
6	To perform region-based segmentation.
7	To perform morphological operations on Image.
8	To perform edge detection using basic and advanced techniques.
9	To perform Image restoration using various filters.
10	To extract the key frames from a video.
11	To perform background subtraction in a video.
12	To perform motion analysis using Lucas-Kanade optical flow estimation Algorithm.

Books Recommended:

Textbooks:

1. Rafel C. Gonzalez and Richard E. Woods, "Digital Image Processing", Pearson Education Asia, 4th Edition, 2018.
2. Sanjit Mitra, "Digital Signal Processing: A Computer Based Approach", Tata McGraw Hill, 4th Edition, 2013.

Reference Books:

1. S. Salivahanan, A. Vallavaraj, C. Gnanapriya, "Digital Signal Processing", Tata McGraw Hill Publication 4th Edition, 2019.
2. E. R. Davies, "Computer and Machine Vision: Theory, Algorithms", Academic Press, 4th

Edition, 2012.
3. S. Jayaraman, E. Esakkirajan and T. Veerkumar, “Digital Image Processing”, Tata McGraw Hill Education Private Ltd, 1st Edition, 2017.
4. Anil K. Jain, “Fundamentals and Digital Image Processing”, Pearson Education, 1st Edition, 2015.
5. John G. Proakis, Dimitris and G. Manolakis, “Digital Signal Processing: Principles, Algorithms, and Applications”, Pearson Education, 4th Edition, 2014.

A. Anand Kumar, “Digital Signal Processing”, Prentice Hall, 2nd Edition, 2015.

6. S. Sridhar, “Digital Image Processing”, Oxford University Press, 2nd Edition, 2016.

Web Links:

1. NPTEL Digital Image Processing, By Prof. Prabir Kumar Biswas, IIT Kharagpur: https://nptel.ac.in/courses/117/105/117105135/

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Program: B.Tech in Computer Science and Engineering (Data Science)	T.Y. B.Tech	Semester: V
Course: Big Data Engineering Laboratory (DJS22DSL504)		

Pre-requisite: Foundations of Data Analysis, Database Management System, Python Laboratory, Java and Scala Laboratory.

Objectives: The objective of this lab is to provide the basic framework of handling and processing big data.

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

1. Relate to the need of different types of data preprocessing tools/methods.
2. Use appropriate tool/method for a specific Data Engineering task.

Sr. No	Suggested List	No of Hours
1	Hadoop Ecosystem • Understanding inputs and outputs of Map Reduce Concept of Hadoop. • The Map Tasks, grouping by Key, The Reduce Tasks, Combiners, Details of Map Reduce Execution. • HDFS file system - Command line. • Overview of resource management – YARN.	**04**
2	Infrastructure Implementation • Introduction to Kubernetes and Docker. • Setting up applications on Kubernetes and Docker. • Creating Docker images and deploying them.	**04**
3	Messaging Service • Differentiate between different types of connections: Point-to-point, Broadcast/Multicast and Multi point. • Real time messaging using AMPS. • Pub / Sub models. • Allows subscribers to apply filters on server level.	**02**
4	Messaging Service • Need of scalability and concurrency in the messaging services. • Real time messaging, ensuring scalability and concurrency using Kafka. • Pub / Sub models. • Allows subscribers to apply filters on client side.	**02**
5	Data Processing • Need of advance methods for data processing of Big Data • Introduce SPARK. • Real time and Batch processing of high volume of data. • Write scripts using Java/ Python/Scala. • Processing high volume records in-memory.	**08**

	• Integration with Hive, HDFS, Kafka, event hub and other messaging and storage system.	
6	Data Warehouse • Need of advance methods for data warehousing for storing Big data. • Introduce HIVE. • Storage of data on HDFS for high volume data. • Perform Analytical queries using Map Reduce.	**02**
7	No SQL Data Store • Difference between SQL and NoSQL data stores. • Types of NoSQL Data stores. • Introduce HBase. • Demonstration of Dynamic Scaling.	**02**
8	No SQL Data Store • NoSQL Databases for different use cases. • DynamoDB - Serverless AWS service for storing data in bytes. • MongoDB - Data Storage as documents (Binary JSON -BSon). • Pipeline, query aggregation, complex querying, transaction.	**04**
9	ETL Task • Introduce AWS Glue for ETL. • Data Integration service from multiple sources. • Keeping track of schema in form of catalogue. • Data query via Amazon Athena, Amazon EMR, and Amazon Redshift Spectrum.	**04**
10	Data Retrieval • Introduction to Open-Source Indexing Engine Elastic Search for transactional data. • Data querying, aggregation, visualization, log extraction and analytics.	**04**
11	Cold Data Retrieval AWS S3, Athena and Redshift • Introduction of AWS S3, Athena and RedShift. • Storing / Extracting data in S3 in different forms (csv, parquet, text). • Querying the data via Athena / Redshift.	**04**

Books Recommended:

Textbooks:

1. Joe Reis and Matt Housley, “Fundamentals of Data Engineering: Plan and Build Robust Data Systems”, O’Reilley, 1st Edition, 2022.
2. Stevan N Brunton and J Nathan Kutz, “Data-Driven Science and Engineering: Machine Learning, Dynamical Systems, and Control”, Cambridge University Press, 1st Edition, 2019.
3. Tom White, "Hadoop: The Definitive Guide", O'Reilley, 3rd Edition, 2012.
4. Eric Sammer, "Hadoop Operations", Reilly, 1st Edition, 2012.
5. Pramod J Sadalge and Martin Fowler, “NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence”, Addison-Wesley Professional publications, 1st Edition, 2012.

Reference Books:

1. Paul Zikopoulos, Chris Eaton, Dirk DeRoos, Tom Deutsch, George Lapis, "Understanding Big Data: Analytics for Enterprise Class Hadoop and streaming Data", The McGraw-Hill Companies, 1st Edition, 2017.
2. Gaurav Vaish, "Getting Started with NoSQL", Packt Publishing, 1st Edition, 2013.
3. Manoj Kukreja, "Data Engineering with Apache Spark, Delta Lake, and Lakehouse", Packt Publishing, 1st Edition, 2021.
4. Scott Haines, "Modern Data Engineering with Apache Spark: A Hands-On Guide for Building Mission-Critical Streaming Applications", Apress Publications, 1st Edition, 2022.

WebLinks:

1. Real-time Bigdata Messaging Services: Built for realtime: Big data messaging with Apache Kafka, Part 1 | InfoWorld
2. Understanding Big data Processing: Understanding Big Data Processing: 2022's Ultimate Guide - Learn | Hevo (hevodata.com)
3. Serverless Databases: What Is Serverless? An Overview | Knowledge Base | Dashbird
4. Kubernet Vs Docker: Kubernetes vs. Docker: Why Not Both? | IBM

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DEPARTMENT ELECTIVES

Program: B.Tech in Computer Science and Engineering (Data Science)	T.Y. B.Tech	Semester: V
Course: Distributed Computing (DJS22DSC5011)		
Course: Distributed Computing Laboratory (DJS22DSL5011)		

Pre-requisite: Operating Systems

Course objectives: The objective of this course is to introduce the fundamentals of distributed computing that includes system architecture, programming model, design, and implementation and performance analysis of these systems.

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

1. Demonstrate Interprocess Communication and Synchronization in a Distributed System.
2. Apply appropriate Resource, Process management, File and Memory technique in a given Distributed Environment for efficient processing.
3. Apply suitable methods to improve data availability in a system.

Distributed Computing (DJS22DSC5011)		
Unit	**Description**	**Duration**
1	**Introduction:** Distributed Computing Models, Issues in Designing Distributed Systems, Network communication: LAN and WAN technologies, Protocols for Network Systems, Asynchronous Transfer Mode.	**04**
2	**Communication:** Interprocess Communication: Message Passing, Group Communication, API for Internet Protocols; Remote Communication: Middleware, Remote Procedural Call (RPC) Basics, RPC Implementation, RPC Communication, Exception Handling and Security, RPC in Heterogeneous environment, Failure Handling, RPC Optimization.	**07**
3	**Synchronization:** Clock Synchronization, Logical Clocks, Global State, Mutual Exclusion: Centralized, Decentralized, Distributed and Token Ring Algorithms, Election Algorithms: Ring and Bully election algorithms, Deadlocks in Distributed Systems.	**06**
4	**Resource and Process Management:** Desirable features of a global scheduling algorithm, Task Assignment Approach, Load Balancing Approach, Load Sharing Approach, Functions of Distributed Process Management, Desirable features of a process migration mechanism, Process migrations and Threads.	**06**
5.	**Consistency, Replication and Fault Tolerance:** Introduction to Replication and Consistency, Data-Centric (Continuous Consistency, Consistent Ordering of Operation) and Client-Centric (Eventual Consistency, Monotonic Read, Monotonic Write, Read your Writes, Writes follow Reads); Consistency Models, Replica Management; Fault Tolerance: Introduction, Process resilience, Reliable client-server and group communication, Recovery.	**08**
6.	**Distributed Shared Memory (DSM) and Distributed File System (DFS):** DSM Architecture, Types of DSM, Advantages of DSM, Design Issues in DSM systems, Issues in Implementing DSM systems; Introduction to DFS, DFS Designs, DFS Implementation, File Caching and Replication in DFS.	**08**
	Total	**39**

Distributed Computing Laboratory (DJS22DSL5011)	
Exp.	**Suggested Experiments**
1	Implement Client/server using RPC/RMI.
2	Implementation of multi tread application.
3	Implement Inter-process communication.
4	Implement Group Communication.
5	Implement Load Balancing Algorithm.
6	Implement Election Algorithm.
7	Implement Clock Synchronization algorithms.
8	Implement Mutual Exclusion Algorithm.
9	Implement Deadlock management in Distributed systems.
10	Implement Distributed File System.

Books Recommended:

Text Books:

1. Andrew S. Tanenbaum and Maarten Van Steen, ―Distributed Systems: Principles and Paradigms, 2nd edition,Pearson Education, 2017.
2. Sunita Mahajan and Seema Shah, "Distributed Computing", Oxford University Press, 2013.

Reference Books:

1. S. Tanenbaum and M. V. Steen, "Distributed Systems: Principles and Paradigms", Second Edition, PrenticeHall, 2006.
2. M. L. Liu, ―Distributed Computing Principles and Applications‖, Pearson Addison Wesley, 2019.
3. George Coulouris, Jean Dollimore, Tim Kindberg, "Distributed Systems: Concepts and Design", 5th Edition,Pearson Education, 2011.

Web Links:

1. NPTEL Course: Distributed Computing Systems: https://nptel.ac.in/courses/106106107
2. NPTEL Course: Distributed Systems: https://nptel.ac.in/courses/106106168

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Program: B.Tech in Computer Science and Engineering (Data Science)	T.Y. B.Tech	Semester: V
Course: Time Series Analysis (DJS22DSC5012)		
Course: Time Series Analysis Laboratory (DJS22DSL5012)		

Pre-requisite: Probability, Statistics and Linear Models.

Objectives: Learn basic analysis of time series data; concepts in time series regression; auto-regressive and model averaging models; learn basic concepts of spectral analysis and space-time models.

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

1. Interpret a correlogram and a sample spectrum.
2. Apply appropriate model for a time series dataset.
3. Compute forecasts for a variety of linear and non-linear methods and models.

Time Series Analysis (DJS22DSC5012)		
Unit	**Description**	**Duration**
1	**Introduction:** Formal definition of a time series, Interpolation vs Extrapolation, Components of time series, Models of Time Series Analysis, Types of forecasting methods, Types of Time Series, Types of time series patterns, different types of data, simple descriptive techniques, Trends in time series (Parametric trends, differencing, non-parametric methods, noise), measurement of trends, seasonality, seasonal indices, stochastic processes, correlogram. **Stationary Time Series:** the sample mean and its standard error, Stationary processes (weak and strict), statistical inference of time series.	**08**
2	**Linear Time Series:** Motivation, Autocorrelation function (ACF) and Partial Autocorrelation function (PACF) plot, Linear time series and MA models, theoretical properties of time series with a MA (1) and MA (2) model, The AR model, simulating from an autoregressive process, The ARMA model, The ARIMA model, Unit roots with $\|\phi\|$, backshift and lag operator, integrated and non-invertible processes, SARIMA model, Box – Jenkins Model Selection.	**08**
3	**Prediction:** Using prediction in estimating, forecasting for autoregressive processes (1), forecasting for AR(p), forecasting for general time series using infinite past, forecasting for ARIMA model, Ψ-weight representation of ARIMA model, One-step ahead predictors based on the finite past: Levinson -Durbin algorithm, Kalman filter.	**06**
4	**Models with Trend:** Removing trend, Unit Root (Augmented Dickey Fuller Test) and Regression Residuals, The Monte Carlo Method, Multi-equation Time Series Models: Intervention Analysis, Estimating the Intervention Effect, ADLs and Transfer Functions, Introduction to VAR Analysis.	**06**

5	**Multivariate Time Series: Background:** Sequences and Functions, Convolution using Fourier transform, Methods for Estimating the Spectral Density, Smoothing Method (Nonparametric Estimation of the Spectral Density); Multivariate time series regression: Conditional independence, Partial correlation and coherency between time series.	**06**
6	**Non Linear Time series:** The ARCH model: Feature of an ARCH, interpretation of ARCH model, The GARCH model: Existence of stationary solution of a GARCH(1,1) and Bilinear models.	**05**
	Total	**39**

Time Series Analysis Laboratory (DJS22DSL5012)	
Exp.	**Suggested Experiments**
1	Trends: (1) Detecting trends using Hodrick -Prescott Filter. (2) Detrending a Time Series (Pandas, SciPy Signal, HP filter).
2	Seasonality: (1) Multiple Box Plots. (2) Autocorrelation Plot. (3) Deseasoning of Time-Series Data. (4) Seasonal Decomposition (Additive and Multiplicative). (5) Detecting Cyclic Variations.
3	Data Wrangling and Preparation for Time Series Data.
4	Smoothing Methods (Simple exponential, Double exponential, Triple exponential).
5	Making Data Stationary using Augmented Dicky Fuller Test.
6	Autoregressive Moving Average Model.
7	ARIMA Model.
8	VAR Model.
9	ARCH and GARCH Models.
10	Mini Project.

Books Recommended:

Text Books

1. Walter Enders," Applied Econometric Time Series," Fourth Edition, Wiley, 2014.
2. B. V. Vishwas and Ashish Patel, "Hands-on Time Series Analysis with Python," First Edition, Apress, 2020

Reference Books

1. Chris Chatfield, "Time- Series Forecasting," First Edition, Chapman & Hall/CRC, 2001.
2. Douglas C. Montgomery, Cheryl L. Jennings and Nurat Kulahci, "Introduction to Time Series Analysis and Forecasting," Second Edition, Wiley, 2015.
3. Aileen Nielsen, "Practical Time Series Analysis," O'Reilly, 2019.
4. James D Hamilton, "Time Series Analysis," Princeton University Press, 1994.
5. Robert H. Shumway and David S. Stoffer, "Time Series Analysis and Its Applications," Springer, 2000.

Web Links:

1. A course on Time Series Analysis.
   https://web.stat.tamu.edu/~suhasini/teaching673/time_series.pdf
2. A comprehensive guide to Time Series Analysis.
   https://www.analyticsvidhya.com/blog/2021/10/a-comprehensive-guide-to-time-series-analysis/
3. The Complete Guide to Time Series Analysis and Forecasting.
   https://towardsdatascience.com/the-complete-guide-to-time-series-analysis-and-forecasting-70d476bfe775

Prepared by Checked by Head of the Department Principal

Program: B.Tech in Computer Science and Engineering (Data Science)	T.Y. B.Tech	Semester: V
Course: Digital System Design (DJS22DSC5013)		
Course: Digital System Design Laboratory (DJS22DSL5013)		

Pre-requisite: Basic Electrical & Electronics Engineering

Objectives:

1. To introduce different digital codes and their conversions.
2. To introduce methods for minimizing logical expressions.
3. To outline the formal procedure to design combinational logic circuits.
4. To introduce flip flops and outline the formal procedure to sequential circuits.
5. To illustrate concept of programmable devices

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

1. Explain different digital codes and their conversions.
2. Minimize logic expressions using various reduction techniques.
3. Analyze and design combinational logic circuits.
4. Design flip-flops using logic gates and use them to realize different sequential circuits.
5. Classify different programmable logic devices.

Digital System Design (DJS22DSC5013)		
Unit	**Description**	**Duration**
1	Digital codes and binary arithmetic: Signed Binary number representation: Sign Magnitude, 1's complement, 2's complement representation and binary arithmetic's. Codes: Binary, BCD, XS-3, Gray code, ASCII, EBCDIC, Parity, Hamming, conversions.	**12**
2	Minimization techniques and Logic gates: Logic Gates: AND, OR, NOT, NAND, NOR, Exclusive–OR and Exclusive–NOR, Implementations of Logic Functions using universal gates. Boolean postulates and laws – De-Morgan's Theorem, Boolean expression - Minterm – Maxterm - Sum of Products (SOP) – Product of Sums (POS), Minimization of Boolean expressions —– Karnaugh map Minimization – Quine - Mc Cluskey method of minimization, don't care conditions.	**08**
3	Design of Combinational Logic: Introduction to combinational logic, Code converter: BCD, Excess-3, Gray code, Binary Code, Half- Adder, Full Adder, Half Subtractor, Full Subtractor, Binary Adder, BCD adder, Look ahead carry generator, Multiplexers- MUX tree, Encoder, De-multiplexer & Decoders, Implementation of SOP and POS using Multiplexer & De-multiplexer/Decoder.	**04**
4	Sequential Logic Design: Introduction to sequential logic, Flip- flop: SR, JK, D, T; Preset & Clear, Truth Tables and Excitation tables, Conversion, Shift Registers: SISO, SIPO, PISO, PIPO, Bi-directional, Counters: Asynchronous counter, Synchronous counter, ring counters, Johnson Counter, Modulus of the counter. State Machines: Basic design steps- State diagram, State table, State reduction, State assignment, Mealy and Moore machines representation,	**09**

	Sequence detector.	
5	Programmable Logic Devices: Programmable logic devices: Architecture of PROM, PAL, PLA, designing combinational circuits using PLDs. General Architecture of FPGA and CPLD, introduction to Hardware Description Language.	**06**
	Total	**39**

Digital System Design Laboratory (DJS22DSL5013)	
Exp.	**Name of Experiment**
1	Implement 8:3 octal to binary code converter using encoder IC 74148.
2	Verify different logic gates (introduce logic families CMOS and TTL and electrical and switching parameters).
3	Simplification of Boolean functions.
4	Verify Universal gates NAND and NOR and design EXOR and EXNOR gates using Universal gates.
5	Implement Half adder, Full adder, Half subtractor and Full subtractor circuits.
6	To study and implement 4-bit magnitude comparator using IC 7485 and verify its truth table.
7	Implement BCD adder using 4-bit binary adder IC-7483.
8	Flip flops conversion JK to D, JK to T and D to T FF.
9	Implement logic equations using Multiplexer.
10	Design synchronous MOD N counter using IC-7490.
11	Verify encoder and decoder operations.
12	Implement 1:8 De-multiplexer using IC 74138.
13	Implement the functions using 8:1 Multiplexer with the help of IC 74151.
14	Implement digital circuits to perform binary to gray and gray to binary operations.
15	Verify different counter operations.
16	Verify the functions of Universal Shift Register IC 74194: Parallel loading, Right shift, Left shift
17	Implement any two above experiments using HDL.

Books Recommended:

Text books:

1. John F. Wakerly, “Digital Design Principles and Practices”, Pearson Education, Fifth Edition, 2018.
2. R. P. Jain, “Modern Digital Electronics”, Tata McGraw Hill 4th Edition, 2010.
3. M. Morris Mano, “Digital Logic and computer Design”, PHI 4th Edition 2010.

Reference Books:

1. Thomas L. Floyd, “Digital Fundamentals”, Pearson Prentice Hall, Eleventh Global Edition, 2015.
2. Mandal, “Digital Electronics Principles and Applications”, McGraw Hill Education, First Edition, 2010.
3. Ronald J. Tocci, Neal Widmer, “Digital Systems Principles and Applications”, Twelfth Edition, PHI (2017)
4. Donald P Leach, Albert Paul Malvino, “Digital Principles and Applications”, Tata McGraw Hill, Eighth edition, 2015.

5. Balabanian, Carlson, “Digital Logic Design Principles”, Wiley Publication 3rd Edition, 2000.
6. Holdsworth and R. C. Woods, “Digital Logic Design”, 4thEdition, Newnes, 2002.
7. William I. Fletcher, “An Engineering Approach to Digital Design”, Tenth Edition, PHI, 2015.

Web Links:

1. Digital Electronic Circuits Lab: http://vlabs.iitkgp.ac.in/dec/#
2. Virtual Lab: https://cse15-iiith.vlabs.ac.in/List%20of%20experiments.html
3. NPTEL Course: Digital System Design: https://nptel.ac.in/courses/108106177

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Program: B.Tech in Computer Science and Engineering (Data Science)	T.Y. B.Tech	Semester: V
Course: Probabilistic Graph Models (DJS22DSC5014)		
Course: Probabilistic Graph Models Laboratory (DJS22DSL5014)		

Pre-requisite: Machine learning, Probability

Course Objectives: The objective of this course intends to model problems using graphical models; design inference algorithms; and learn the structure of the graphical model from data.

Outcomes: Students will be able to

1. Explain the basic fundamentals of probabilistic graphical models.
2. Illustrate various principles of representation methods, learning and inference algorithms.
3. Integrate theoretical knowledge of graphical models to solve problems.

Probabilistic Graph Models (DJS22DSC5014)		
Unit	**Description**	**Duration**
1	**Fundamentals:** Overview and Motivation of Probabilistic Graphical Models, Structured Probabilistic Models, Marginal and Joint Distributions, Independence and Conditional Independence, Factors. **Bayesian networks (Representation):** Semantics and Factorization, Reasoning Patterns, Flow of Probabilistic Influence, Conditional Independence, Independence in Bayesian Networks, Naïve Bayes, Applications.	**05**
2	**Temporal Models of Bayesian Network (Representation):** Overview of Temporal Models, Dynamic Bayesian Networks (DBN), Hidden Markov Model (HMM), Plate Models. **Structured CPDs (Representation):** Overview of Structured CPDs, Tree-Structured CPDs, Independence of Casual Influence, Continuous Variable, Applications.	**07**
3	**Markov networks (Representation):** Pairwise Markov Networks, General Gibbs Distribution, Conditional Random Fields, Independencies in Markov Networks, I-maps and perfect maps.	**06**
4	**Exact inference (Inference):** Conditional Probability Queries, MAP Inference, Analysis of Complexity, Sum- and Max-product algorithms, Variable elimination, Belief propagation (message passing) on trees, Clique tree.	**06**
5	**Inference and sampling methods (Inference):** Simple Sampling, MCMC method, Gibbs sampling Algorithm, Importance sampling, Particle filtering.	**06**
6	**Parameter Estimation (Learning):** Learning Overview, Maximum Likelihood Estimation for Bayesian Networks, Bayesian Estimation, Bayesian Prediction, Bayesian Estimation for Bayesian Networks. Maximum Likelihood for Log-Linear Models, Maximum Likelihood for MRFs and CRFs. **Structure Learning:** Overview, Likelihood Scores, BIC and Asymptotic Consistency, Bayesian Scores, Learning Tree Structured Networks, Learning General Graphs: Heuristic Search.	**09**
	Total	**39**

Probabilistic Graph Models Laboratory (DJS22DSL5014)	
Exp.	**Suggested Experiments**
1	Implement Discrete Bayesian Networks.
2	Implementation of Alarm Bayesian Network.
3	Implementation of Linear Gaussian Bayesian Networks (GBNs).
4	Implementation of Monty Hall Problem using Bayesian Network.
5	Implementation of Exact inference in Bayesian Networks.
6	Implementation of Inference in Discrete Bayesian Network.
7	Implementation of Causal Inference.
8	Implement Approximate Inference using MCMC.
9	Implementation of Parameter Learning in Discrete Bayesian Networks.
10	Mini Project.

Books Recommended:

Text Books

1. Koller, D. and Friedman, N. (2009). Probabilistic Graphical Models: Principles and Techniques. MIT Press.

Reference Books

1. Jensen, F. V. and Nielsen, T. D. (2002). Bayesian Networks and Decision Graphs. Information Science and Statistics. Springer, 2nd edition.
2. Marloes Maathuis, Mathias Drton, Steffen Lauritzen, Martin Wainwright, Handbook of Graphical Models, Routledge Taylor and Francis group, 2020
3. Kevin P. Murphy (2013) Machine Learning: A Probabilistic Perspective. 4th Printing. MIT Press.
4. Barber, D. (2011). Bayesian Reasoning and Machine Learning. Cambridge University Press, 1st edition.
5. Bishop, C. M. (2011). Pattern Recognition and Machine Learning (Information Science and Statistics). Springer, 2nd printing.
6. Wainwright, M. and Jordan, M. (2008). Graphical Models, Exponential Families, and Variational Inference. Foundations and Trends in Machine Learning, 1:1–305.

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Program: B.Tech in Computer Science and Engineering (Data Science)	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 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 (DJS22IHL2)		
	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 **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.	**08**
	Unit 3: Corporate Story Telling	
	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.	**03**

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.	**05**

Professional and Business Communication Laboratory

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

*The term work will be calculated based on Tutorials (25m), Business Proposal (15m) and Group Discussion (10m).

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.

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Program: B.Tech in Computer Science and Engineering (Data Science)	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 conceptualize 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 conceptualizing 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 analyze 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:

1. Students shall form a team of 3 to 4 students (max allowed: 5-6 in extraordinary cases, subject to the approval of the department review committee and the Head of the department).
2. Students should carry out a survey and identify the need, which shall be converted into conceptualization of a product, in consultation with the faculty supervisor/head of department/internal committee of faculty members.
3. Students in the team shall understand the effective need for product development and accordingly select the best possible design in consultation with the faculty supervisor.
4. Students shall convert the best design solution into a working model, using various components drawn from their domain as well as related interdisciplinary areas.
5. 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.
6. 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.
7. The design solution 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 a 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.

8. 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 4 semesters, i.e. during the semesters III to VI.

Guidelines for Assessment of the work:

1. 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.
2. 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.
3. Distribution of marks individually for the both reviews as well as for the first review during the subsequent semester shall be as given below:
    A. Marks awarded by the supervisor based on log-book : 20
    B. Marks awarded by review committee : 20
    C. Quality of the write-up : 10

Review/progress monitoring committee may consider the following points during the assessment.

In the semester V, the entire design proposal shall be ready, including components/system selection as well as the cost analysis. Two reviews will be conducted based on the presentation given by the student's team.

- First shall be for finalization of the product selected.
- Second shall be on finalization of the proposed design of the product.

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 V reviews 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 organizations 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 technical paper prepared by them during the final review in semester VI.

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