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ताळगांव पठार,
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(Accredited by NAAC with Grade A+)

GU/Acad –PG/BoS -NEP Engg. /2025-26/501 Date: 18.10.2025

CIRCULAR

Ref. No.: GU/Acad –PG/BoS -NEP Engg. /2024-25/783 dated 27.01.2025

In supersession to the above referred Circular, the Syllabus of Semester III & IV of the **Master of Engineering (Data Sciences)** Programme approved by the Standing Committee of the Academic Council in its meeting held on 24th & 25th July 2025 is attached. The Syllabus of Semester II approved earlier by the Academic Council in its meeting held on 06th December 2024 and syllabus of Semester I approved by the Academic Council in its meeting held on 22nd August 2024 is also attached.

The Dean, Faculty of Engineering and Principals of affiliated Colleges offering the **Master of Engineering (Data Sciences)** are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2025.10.18 11:15:48 +05'30'

(Ashwin V. Lawande)
Deputy Registrar – Academic

To,

1. The Dean, Faculty of Engineering, Goa University.
2. The Principals of affiliated Engineering Colleges.

Copy to,

1. The Director, Directorate of Technical Education, Govt. of Goa
2. The Chairperson, BoS in Computer Engineering.
3. The Controller of Examinations, Goa University.
4. The Assistant Registrar Examinations (Prof.), Goa University.
5. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

MASTER OF ENGINEERING (DATA SCIENCES)
RC 2024-25

TWO YEAR PROGRAMME STRUCTURE						
Semester I						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
Programme Specific Core (PSC) Courses						
1	DEN-500	Mathematical Foundation for Data Science	4	0	0	4
2	DEN-501	Python for Data Science and Analytics	3	0	0	3
3	DEN-502	Python for Data Science and Analytics Lab	0	0	1	1
4	DEN-503	Statistical Methods using R	3	0	0	3
5	DEN-504	Statistical Methods using R Lab	0	0	1	1
Programme Specific Elective (PSE) Courses						
6	DEN-531	Database Technologies for Data Science	3	1	0	4
OR						
7	DEN-532	Cloud Computing for Data Science	3	1	0	4
Research Specific Elective (RSE) Courses						
8	REC-561	Engineering Research & Publications	3	1	0	4
OR						
9	REC-562	Literature Review & Technical Writing for Engineers	3	1	0	4
		TOTAL	**16**	**2**	**2**	**20**
Semester II						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
Programme Specific Core (PSC) Courses						
1	DEN-505	Big Data Systems	3	0	0	3
2	DEN-506	Big Data Systems Lab	0	0	1	1
3	DEN-507	Digital Marketing Analytics	3	0	0	3
4	DEN-508	Digital Marketing Analytics Lab	0	0	1	1
5	DEN-509	Data Visualization and Modeling	3	0	0	3
6	DEN-510	Data Visualization and Modeling Lab	0	0	1	1
Programme Specific Elective (PSE) Courses						
7	DEN-533	Neural Networks	3	0	0	3
8	DEN-534	Neural Networks Lab	0	0	1	1
OR						
9	DEN-535	Business Intelligence	3	0	0	3
10	DEN-536	Business Intelligence Lab	0	0	1	1
Research Specific Elective (RSE) Courses						
11	REC-563	Statistics and Data Analysis for Engineering Research	2	0	0	2
12	REC-564	Statistics and Data Analysis Lab	0	0	2	2
OR						
13	REC-565	Statistical Techniques for Engineering Research	2	0	0	2
14	REC-566	Probability & Statistical Analysis Lab	0	0	2	2
		TOTAL	**14**	**0**	**6**	**20**

Semester III						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
Programme Specific Core (PSC) Courses						
1	DEN-600	Machine Learning for Data Sciences	**3**	**0**	**0**	**3**
2	DEN-601	Machine Learning for Data Sciences Lab	**0**	**0**	**1**	**1**
3	DEN-602	Deep Learning for Data Science	**3**	**0**	**0**	**2**
4	DEN-603	Deep Learning for Data Science Lab	**0**	**0**	**1**	**2**
Programme Specific Elective (PSE) Courses						
5	DEN-631	Information Retrieval	**3**	**0**	**0**	**3**
6	DEN-632	Information Retrieval Lab	**0**	**0**	**1**	**1**
OR						
7	DEN-633	Cyber Security and Threat Analysis	**3**	**0**	**0**	**3**
8	DEN-634	Cyber Security and Threat Analysis Lab	**0**	**0**	**1**	**1**
Research Specific Elective (RSE) Courses						
9	DEN-661	Web Mining	**2**	**0**	**0**	**2**
10	DEN-662	Web Mining Lab	**0**	**0**	**2**	**2**
OR						
11	DEN-663	Recommender Systems	**2**	**0**	**0**	**2**
12	DEN-664	Recommender Systems Lab	**0**	**0**	**2**	**2**
General Elective (GE) Courses						
13	GEC-681	Sustainability - Principles & Practices	**3**	**0**	**0**	**3**
14	GEC-682	Sustainability - Principles & Practices Lab	**0**	**0**	**1**	**1**
OR						
15	GEC-683	Project Management	**3**	**0**	**0**	**3**
16	GEC-684	Project Management Lab	**0**	**0**	**1**	**1**
		TOTAL	**14**	**0**	**6**	**20**
Semester IV						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
General Elective (GE) Courses						
1	GEC-685	Financial Management	**4**	**0**	**0**	**4**
OR						
2	GEC-686	Entrepreneurship	**4**	**0**	**0**	**4**
Dissertation/Internship						
3	**DEN-698**	Dissertation	**0**	**0**	**0**	**16**
OR						
4	**DEN-699**	Internship	**0**	**0**	**0**	**16**
		TOTAL	**4**	**0**	**0**	**20**

THREE YEAR PROGRAMME STRUCTURE						
Semester I						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
Programme Specific Core (PSC) Courses						
1	DEN-500	Mathematical Foundation for Data Science	**4**	**0**	**0**	**4**
Programme Specific Elective (PSE) Courses						
2	DEN-531	Database Technologies for Data Science	**3**	**1**	**0**	**4**
OR						
3	DEN-532	Cloud Computing for Data Science	**3**	**1**	**0**	**4**
Research Specific Elective (RSE) Courses						
4	REC-561	Engineering Research & Publications	**3**	**1**	**0**	**4**
OR						
5	REC-562	Literature Review & Technical Writing for Engineers	**3**	**1**	**0**	**4**
		TOTAL	**10**	**2**	**0**	**12**
Semester II						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
Programme Specific Core (PSC) Courses						
1	DEN-505	Big Data Systems	**3**	**0**	**0**	**3**
2	DEN-506	Big Data Systems Lab	**0**	**0**	**1**	**1**
Programme Specific Elective (PSE) Courses						
3	DEN-533	Neural Networks	**3**	**0**	**0**	**3**
4	DEN-534	Neural Networks Lab	**0**	**0**	**1**	**1**
OR						
5	DEN-535	Business Intelligence	**3**	**0**	**0**	**3**
6	DEN-536	Business Intelligence Lab	**0**	**0**	**1**	**1**
Research Specific Elective (RSE) Courses						
7	REC-563	Statistics and Data Analysis for Engineering Research	**2**	**0**	**0**	**2**
8	REC-564	Statistics and Data Analysis Lab	**0**	**0**	**2**	**2**
OR						
9	REC-565	Statistical Techniques for Engineering Research	**2**	**0**	**0**	**2**
10	REC-566	Probability & Statistical Analysis Lab	**0**	**0**	**2**	**2**
		TOTAL	**8**	**0**	**4**	**12**

Semester III						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
Programme Specific Core (PSC) Courses						
1	DEN-501	Python for Data Science and Analytics	**3**	**0**	**0**	**3**
2	DEN-502	Python for Data Science and Analytics Lab	**0**	**0**	**1**	**1**
3	DEN-503	Statistical Methods using R	**3**	**0**	**0**	**3**
4	DEN-504	Statistical Methods using R Lab	**0**	**0**	**1**	**1**
Programme Specific Elective (PSE) Courses						
5	DEN-631	Information Retrieval	**3**	**0**	**0**	**3**
6	DEN-632	Information Retrieval Lab	**0**	**0**	**1**	**1**
OR						
7	DEN-633	Cyber Security and Threat Analysis	**3**	**0**	**0**	**3**
8	DEN-634	Cyber Security and Threat Analysis Lab	**0**	**0**	**1**	**1**
		TOTAL	**9**	**0**	**3**	**12**
Semester IV						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
Programme Specific Core (PSC) Courses						
1	DEN-507	Digital Marketing Analytics	**3**	**0**	**0**	**3**
2	DEN-508	Digital Marketing Analytics Lab	**0**	**0**	**1**	**1**
3	DEN-509	Data Visualization and Modeling	**3**	**0**	**0**	**3**
4	DEN-510	Data Visualization and Modeling Lab	**0**	**0**	**1**	**1**
Generic Elective (GE) Courses						
5	GEC-681	Sustainability - Principles & Practices	**3**	**0**	**0**	**3**
6	GEC-682	Sustainability - Principles & Practices Lab	**0**	**0**	**1**	**1**
OR						
7	GEC-683	Project Management	**3**	**0**	**0**	**3**
8	GEC-684	Project Management Lab	**0**	**0**	**1**	**1**
		TOTAL	**9**	**0**	**3**	**12**

SEMESTER V						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
Programme Specific Core (PSC) Courses						
1	DEN-600	Machine Learning for Data Sciences	**3**	**0**	**0**	**3**
2	DEN-601	Machine Learning for Data Sciences Lab	**0**	**0**	**1**	**1**
3	DEN-602	Deep Learning for Data Science	**3**	**0**	**0**	**2**
4	DEN-603	Deep Learning for Data Science Lab	**0**	**0**	**1**	**2**
Research Specific Elective (PSE) Courses						
5	DEN-661	Web Mining	**2**	**0**	**0**	**2**
6	DEN-662	Web Mining Lab	**0**	**0**	**2**	**2**
OR						
7	DEN-663	Recommender Systems	**2**	**0**	**0**	**2**
8	DEN-664	Recommender Systems Lab	**0**	**0**	**2**	**2**
Semester VI						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
Generic Elective (GE) Courses						
1	GEC-685	Financial Management	**4**	**0**	**0**	**4**
OR						
2	GEC-686	Entrepreneurship	**4**	**0**	**0**	**4**
Dissertation/Internship						
3	**DEN-698**	Dissertation	**0**	**0**	**0**	**16**
OR						
4	**DEN-699**	Internship	**0**	**0**	**0**	**16**
		TOTAL	**4**	**0**	**0**	**20**

Semester I

Programme Specific Core (PSE) Courses

Name of the Programme : Master of Engineering (Data Sciences)
Course code : DEN-500
Title of the course : Mathematical Foundation for Data Science
Number of Credits : 4
Effective from AY : 2024-25

Pre- requisites for the Course:	Basic Understanding of Mathematics	
Course Objectives:	This course will enable students to: 1. Constructing the foundation of Data Science 2. Demonstrate the data pre-processing terms for improving the quality of dataset 3. Gaining hands-on experience with data sciences programming tools	
Units	**Contents**	**No of Hours**
Unit-1	Mathematical concepts for Data Science: Vectors and matrices, Arithmetic symbols, Graphs, Logarithms/exponents, Set theory, Linear algebra. Probability: Basic definitions, Probability, Bayesian versus Frequentist, Compound events, Conditional Probability, The rules of probability, collectively exhaustive events, Bayes theorem, Random variables.	**15**
Unit-2	Data Science: Benefits and uses, Facets of data, Data Science Process: Overview, defining research goals, Retrieving data, Data preparation, Exploratory Data analysis, build the model, presenting findings and building applications, Data Mining, Data Warehousing – Basic Statistical descriptions of Data.	**15**
Unit- 3	Data Pre-processing: Data cleaning, Data integration, Data Reduction, Data Transformation and Data Discretization, Feature Generation and Feature Selection, Feature Selection algorithms: Filters, Wrappers, Decision Trees, Random Forests	**15**
Unit- 4	Importing Matplotlib, Line plots, Scatter plots, visualizing errors, density and contour plots, Histograms, legends, colors, subplots, text and annotation customization, three-dimensional plotting, Geographic Data with Basemap, Visualization with Seaborn.	**15**
Pedagogy:	Inquiry Based Learning, Reflective, Integrative Learning	
References/ Readings:	**Text Books** 1. David Cielen, Arno D. B. Meysman, and Mohamed Ali, "Introducing Data Science", Manning Publications, 2016. 2. Cathy O'Neil, Rachel Schutt, Doing Data Science, Straight Talk from The Frontline. O'Reilly, 2013. 3. Data Mining: Concepts and Techniques", Third Edition, Jiawei Han, Micheline Kamber and Jian Pei, 2011. 4. Sinan Ozdemir, "Principles of Data Science: Learn the techniques and math you need to start making sense of your data", 1st edition, Packt	

	publishing, 2016. 5. Jake VanderPlas, "Python Data Science Handbook", O'Reilly, 2016. **Reference Books** 1. Big Data and Business Analytics, Jay Liebowitz, CRC press (2013) 2. Data mining methods,2nd edition, C. Rajan, Narosa (2016) 3. Mark Gardener, "Beginning R - The Statistical Programming Language", John Wiley & Sons, Inc.
Course Outcomes:	After going through this course, the students will be able to: CO 1. Illustrate the basic concepts of data science CO 2. Apply data visualization techniques in data science CO 3. Solve mathematical problems using various arithmetic and more challenging forms of math CO 4. Illustrate the obtaining and sampling data in statistics to quantify and visualize our data.

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Name of the Programme : Master of Engineering (Data Sciences)
Course code : DEN-501
Title of the course : Python for Data Science and Analytics
Number of Credits : 3
Effective from AY : 2024-25

Pre- requisites for the Course:	Basic programming skills	
Course Objectives:	This course will enable students to: 1. Student will be equipped with essential Python skills for data science and analytics 2. Student will be able to understand cleaning and preprocessing data, apply regression techniques, perform basic statistical analysis and visualization on data using python. 3. Course will enable student to analyze real-world datasets and make data-driven decisions.	
Units	**Contents:**	**No of Hours**
Unit-1	**Basics of Python:** Datatypes in Python, Operators, Input Output, Control Statements, **Functions in Python:** defining function, calling, returning results from a function, returning multiple values, types of arguments, anonymous functions or lambdas. **Classes, Objects and Methods.**	**12**
Unit-2	**NumPy Arrays:** Working with Arrays using NumPy, Creating Arrays with array(), line space , logs pace and arrange() function, Mathematical operations on NumPy Arrays, Indexing, Slicing, Working with Multidimensional arrays, Indexing and Slicing in Multidimensional arrays, Matrices in NumPy, Operations on Matrices: getting Diagonal elements, sorting the Matrix, Transpose, Addition and Multiplication. Random Numbers. **Modules, Packages and Libraries in Python**	**12**
Unit- 3	**Data Analysis Using Pandas:** Series and Data Frame, Viewing Data frame using loc() and iloc(), Operations on Data frames: knowing number of rows and columns, retrieval, display statistical information, sorting data, handling missing data, **Advance Data Analytics using Pandas:** Joining data frames, concatenation of tables, aggregate functions on Data Frames, Writing SQL equivalent Statements in Pandas.	**12**
Unit- 4	**Data Visualization using Matplotlib:** Bar Graph, Histogram, creating a pie chart, creating a line graph, creating scatter plot **Data Visualization using Seaborn:** Datasets, Distribution plot, Count plot, Box Plot, Scatter Plot, Joint Plot, Line Plot, Displaying Scatter Plot with Regression Line, Heat Map.	**09**
Pedagogy:	Inquiry Based Learning, Reflective, Integrative Learning	
References/ Readings:	**Text Books** 1. Dr. R.Nageswara Rao, "Machine Learning in Data Science using Python", Edition :June 2022 , Dreamtech Press,2022 **Reference Books**	

	1. Thomas Nield, “Essential Math for Data Science”, First Edition 2022, June 2022, O’Reilly Media Inc. 2. Dr. R. Nageshwara Rao, “Core Python Programming”, Third Edition, Reprint Edition 2022, Dreamtech Press,2022
Course Outcomes:	After going through this course, the students will be able to: CO 1. Develop a strong understanding of Python programming concepts CO 2. Examine and manipulate datasets effectively using Python libraries such as Pandas and NumPy, applying data transformation and analysis techniques. CO 3. Create informative data visualizations using Matplotlib and Seaborn. CO 4. Illustrate concepts like linear regression and multiple linear regressions.

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Name of the Programme : **Master of Engineering (Data Sciences)**
Course code : **DEN-502**
Title of the course : **Python for Data Science and Analytics Lab**
Number of Credits : **1**
Effective from AY : **2024-25**

Pre- requisites for the Course:	Basic Programming skills	
Course Objectives:	This course will enable students to: 1. Student will be equipped with essential Python skills for data science and analytics 2. Student will be able to understand cleaning and preprocessing data, apply regression techniques, perform basic statistical analysis and visualization on data using python. 3. Course will enable student to analyze real-world datasets and make data-driven decisions.	
Content:	**List of Programs /Experiments**	**No. of Hours**
	1. Python Program to demonstrate the use of datatypes, operators and Input output 2. Python Program to demonstrate the use of Functions 3. Python Program to demonstrate the use of datatypes, operators and Standard Input output 4. Python Program to demonstrate the use of Functions 5. Python program to demonstrate the use of NumPy arrays 6. Python Program to demonstrate the use of NumPy Matrices 7. Python Program to demonstrate use of Pandas for Data Analysis 8. Python Program to demonstrate the use of Matplotlib 9. Python Program to demonstrate the use of Seaborn 10. Python Program to Demonstrate EDA	**30**
Instructions	Minimum 8 experiments to be performed	
Course Outcomes:	After going through this course, the students will be able to: CO 1. Develop a comprehensive understanding of core Python programming concepts, including syntax, data types, and control structures. CO 2. Effectively examine and manipulate datasets using Python libraries such as Pandas and NumPy, applying data transformation and analysis techniques. CO 3. Create clear and informative data visualizations using libraries like Matplotlib and Seaborn to represent data insights. CO 4. Illustrate and explain the concepts of linear regression and multiple linear regression in the context of data modelling.	

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Name of the Programme : Master of Engineering (Data Sciences)
Course code : DEN-503
Title of the course : Statistical Methods using R
Number of Credits : 3
Effective from AY : 2024-25

Pre- requisites for the Course:	Basic knowledge of statistical methods used in analytics	
Course Objectives:	This course will enable students to: 1. To analyse the concept of statistical methods. 2. To equip the students to visualize and analyse the data using R 3. To communicate statistical results in correct manner. 4. To understand scientific inference from R	
Units	**Contents:**	**No of Hours**
Unit-1	**R AND RSTUDIO:** Getting started with R - installing R and R studio - getting help - installing and loading packages - simple arithmetic calculations - data structure – expressions - conditional statements – functions – loops - R–markdown - introduction to Statistics - probability and data with R.	**12**
Unit-2	**EXPLORATORY DATA ANALYSIS:** Visualizing numerical data - graphing systems available in R - descriptive Statistics - measures of central tendency and dispersion – correlation - transforming data - exploring categorical variables.	**12**
Unit- 3	**PROBABILITY AND PROBABILITY DISTRIBUTIONS:** Introduction - disjoint events - general addition rule – independence - probability examples - disjoint vs. Independent - conditional probability - probability trees - normal distribution - evaluating the normal distribution - working with the normal distribution - binomial distribution - normal approximation to binomial - working with the binomial distribution.	**12**
Unit- 4	**ESTIMATION:** Introduction to Inference - sampling from population - maximum likelihood estimator - least square estimator - confidence interval (CI) (for a mean) - accuracy vs. Precision - required sample size for mean, CI (for the mean) examples.	**09**
Pedagogy:	Inquiry Based Learning, Reflective, Integrative Learning	
References/ Readings:	**Text Books** 1. Grolemund G., Hands-on programming with R: write your own functions and simulations, O' Reilly Media Inc., 2014. 2. James G., Witten D., Hastie T., & Tibshirani R, An introduction to statistical learning: with Applications in R, Springer, 2013 **Reference Books** 1. Gupta S. C., & Kapoor V. K., Fundamental of Mathematical Statistics, Sultan Chand & Sons, 2018. 2. Peng R. D, Exploratory data analysis with R, Lulu.Com, 2012.	
Course Outcomes:	After going through this course, the students will be able to: CO 1. Develop a comprehensive understanding of R programming	

	language and proficiently use R Studio for data analysis CO 2. Create reports using R markdown CO 3. Analyse data for a given problem CO 4. Apply probability and statistics in real life problem.

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Name of the Programme : Master of Engineering (Data Sciences)
Course code : DEN-504
Title of the course : Statistical Methods using R Lab
Number of Credits : 1
Effective from AY : 2024-25

Pre- requisites for the Course:	Basic knowledge of statistical methods used in analytics	
Course Objectives:	This course will enable students to: 1. To analyse the concept of statistical methods. 2. To equip the students to visualize and analyse the data using R 3. To communicate statistical results in correct manner. 4. To understand scientific inference from R	
Content:	**List of Programs /Experiments**	**No. of Hours**
	1. R program to illustrate different data structures 2. Defining functions and making report in markdown 3. Loading dataset and visualizing data 4. Producing descriptive statistics measures 5. Computing probabilities in R 6. Functions for probability distributions in R 7. Finding ML estimates and least square estimates 8. Constructing confidence interval 9. Carrying out large sample tests in R 10. Some small samples tests: t-test, paired t-test in R	**30**
Instructions	Minimum 8 experiments to be performed	
Course Outcomes:	After going through this course, the students will be able to: CO 1. Demonstrate a comprehensive understanding of R programming concepts and effectively use R Studio CO 2. Create reports using R markdown CO 3. Analyse data for a given problem CO 4. Apply probability and statistics in real life problems	

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Programme Specific Elective (PSE) Courses

Name of the Programme : Master of Engineering (Data Sciences)
Course code : DEN-531
Title of the course : Database Technologies for Data Science
Number of Credits : 4
Effective from AY : 2024-25

Pre- requisites for the Course:	Fundamentals of Relational Database Systems and Query language	
Course Objectives:	This course will enable students to: 1. Understanding of the basic concepts and applications of database systems. 2. Understanding and use of data manipulation language to query, update, and manage database. 3. The ability to design and build a simple database system and demonstrate competence with the fundamental tasks involved in modeling, designing, and implementing a DBMS. 4. Familiarity with the basic issues of transaction processing and concurrency control.	
Units	**Contents:**	**No of Hours**
Unit-1	INTRODUCTION: Concept & Overview of DBMS, Data Models, Database Languages, Database Administrator, Database Users, Three Schema architecture of DBMS. Basic concepts, Design Issues, Mapping Constraints, Keys, Entity-Relationship Diagram, Weak Entity Sets, Extended E-R features	**15**
Unit-2	RELATIONAL MODEL AND DATABASE DESIGN SQL and Integrity Constraints, Concept of DDL, DML, DCL. Basic Structure, Set operations, Aggregate Functions, Null Values, Domain Constraints, Referential Integrity Constraints, assertions, views, Nested Subqueries, Functional Dependency, Different anomalies in designing a Database, Normalization: using functional dependencies, Boyce-Codd Normal Form, 4NF, 5NF.	**15**
Unit- 3	DATA WAREHOUSE: THE BUILDING BLOCKS Defining Features, Data Warehouses and Data Marts, Architectural Types, Overview of the Components, Metadata in the Data warehouse, Data Design and Data Preparation: Principles of Dimensional Modeling, Dimensional Modeling Advanced Topics From Requirements To Data Design, The Star Schema, Star Schema Keys, Advantages of the Star Schema.	**15**
Unit- 4	Star Schema: Examples, Dimensional Modeling: Advanced Topics, Updates to the Dimension Tables, Miscellaneous Dimensions, The Snowflake Schema, Aggregate Fact Tables, Families OoStars	**15**
Pedagogy:	Inquiry Based Learning, Reflective, Integrative Learning	
References/ Readings:	**Text Books** 1. Henry F. Korth and Silberschatz Abraham, Database System Concepts,	

	Mc.Graw Hill. 2. Thomas Cannolly and Carolyn Begg, Database Systems, A Practical Approach to Design, Implementation and Management", Third Edition, Pearson Education, 007. 3. The Data Warehouse Toolkit: The Complete Guide to Dimensional Modeling, 2nd John Wiley & Sons Inc., New York, USA, 2002. **Reference Books** 1. LiorRokach and OdedMaimon, Data Mining and Knowledge Discovery Handbook, Springer, 2nd edition, 2010. 2. Elmasri Ramez and Navathe Shamkant, Fundamentals of Database System, 7e
Course Outcomes:	After going through this course, the students will be able to: CO 1. Describe fundamental elements of relational database management systems and NoSQL. CO 2. Classify basic concept of relational data model, entity-relationship model, relational database design using normalization, relational algebra and SQL. CO 3. Discuss the basic issues of transaction processing and concurrency control techniques. CO 4. Evaluate query processing and query optimization.

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Name of the Programme : Master of Engineering (Data Sciences)
Course code : DEN-532
Title of the course : Cloud Computing for Data Science
Number of Credits : 4
Effective from AY : 2024-25

Pre- requisites for the Course:	Basic knowledge of Database, Networking and Operating System	
Course Objectives:	This course will enable students to: 1. Discuss the concepts, characteristics, delivery models and benefits of cloud computing. 2. Explore the key technical, organizational and compliance challenges of cloud computing. 3. Grasp the concepts of virtualization efficiently. 4. Explore the security issues that arise from cloud computing architectures intended for delivering cloud-based enterprise IT services.	
Contents:		**No of Hours**
Unit-1	**Introduction, Cloud Computing**, Cloud Computing delivery models and Defining Attributes. Ethical Issues and Cloud Vulnerabilities, Cloud Computing delivery models and services, Amazon Web Services, Google Clouds, Microsoft Windows Azure and Online Services, Cloud Storage Diversity and Vendor Lock In. Energy use and ecological impact of cloud computing, Major challenges faced by cloud computing.	**15**
Unit-2	**Cloud Applications:** Cloud Application Development and Architectural Styles, Workflow Patterns, Coordination Based on a State Machine Model – The Zookeeper, The MapReduce Programming Model. Clouds for Science and Engineering	**15**
Unit- 3	**Cloud Resource Virtualization:** Performance and Security Isolation in Computer Clouds, Virtual Machines, Full virtualization and Para virtualization, Hardware support for Virtualization. Case study: Xen – a Hypervisor based on Para virtualization. Optimization of network virtualization in Xen 2.0 The Darker Side of Virtualization	**15**
Unit- 4	**Cloud Resource Management and Scheduling:** Policies and mechanisms for resource management. Control Theory and Optimal Resource Management, Stability of two – level resource allocation architecture. Feedback control based on Dynamic Thresholds, Coordination of Autonomic Performance Managers. Scheduling Algorithms for Computer Clouds	**15**
Pedagogy:	Inquiry Based Learning, Reflective, Integrative Learning	
References/ Readings:	**Text Books** 1. Dan C. Marinesu, "Cloud Computing: Theory and Practice", 2013, Elsevier **Reference Books** 1. Rajkumar Buyya, James Broberg, Andrej Goscinki, "Computing Principles and Paradigms", 2014, Wiley. 2. John W. Rittinghouse, James F. Ransome, "Cloud Computing	

	Implementation", 2013, CRC Press
Course Outcomes:	After going through this course, the students will be able to: CO 1. Describe the fundamental concepts of cloud computing, including delivery models and services, with a clear understanding CO 2. Identify the challenges, architectural styles and workflows of cloud computing CO 3. Narrate cloud resource virtualization CO 4. Apply various cloud resource management and scheduling policies and techniques.

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Research Specific Elective (RSE) Courses

Name of the Programme : Master of Engineering (Data Sciences)
Course code : REC-561
Title of the course : Engineering Research & Publication
Number of credits : 4(3L+1T)
Effective from AY : 2024-25

Pre-requisites for the Course:	Knowledge of research requirements in real life	
Course Objectives:	The course will enable the students to 1. Understand the importance of literature review, defining the research objectives. 2. Explain qualitative and quantitative methods of data analyses and its importance. 3. Classify research publications, select appropriate journals based on research areas. 4. Practice ethics in publication and academic integrity	
Content:		**No of Hours**
Unit -1	**Overview of scientific research in engineering**, foundational and fundamental concepts like types of research and considerations for research in specific domains, motivation to do research, critical thinking, assumptions and hypotheses, basic and applied research, importance of formulation of broad research objectives	**11 + 4T**
Unit -2	**Purpose and Methodology of Literature Search and Review** of the scientific and engineering publications. Sources such as scholarly databases, public domain, open access, current literature, review articles, critical review and gap analysis, defining research objectives	**11 + 4T**
Unit -3	**Quantitative and qualitative Data –** importance of data in research, types of data, data collection techniques, Quantitative methods for analysis of data – statistical tools, mathematical modeling, simulation, experimental data, optimization methods; Qualitative data collection, preparing questioners, rating scale, conducting survey, validation of models.	**12 + 4T**
Unit- 4	**Preparation of Publications-** Elements of research publications, types of publications, writing for journal publications, basic requirements for publication, selection of journals, journal quality indicators, peer review, reply to comments and responses, publication ethics, references, citations, authorship, plagiarism, academic integrity	**11 + 3T**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning , Constructive learning and Collaborative learning	
References/ Readings:	1. Herman Tang, 'Engineering Research-Design, Methods and Publications', John Wiley and Sons, 2021, ISBN:9781119624486.	

	2. Michael Jay Katz, 'From Research to Manuscript', Springer Publication, 2009, ISBN:9781402094668. 3. Rob Dekkers, Lindsey Casey, Peter Langhorne, 'Making Literature Review Work', Springer Publications, 2022, ISBN:9783030900243 4. Meikang Qiu, Han Qiu, Yi Zeng, 'Research & Technical Writing for Science and Engineering', Taylor & Francis Publications, 2022, ISBN:9781003139058.
Course Outcomes:	CO 1. Understand the importance of literature review, defining the research objectives. CO 2. Explain qualitative and quantitative methods of data analyses and its importance. CO 3. Classify research publications, select appropriate journals based on research areas. CO 4. Practice ethics in publication and academic integrity

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Name of the Programme : Master of Engineering (Data Sciences)
Course code : REC-562
Title of the course : Literature Review & Technical Writing for Engineers
Number of credits : 4(3L + 1T)
Effective from AY : 2024-25

Pre-requisites for the Course:	Basics of Technical writing skills.	
Course Objectives:	The course will enable the students to 1. Understand the importance of literature review and writing a review paper. 2. Explain the method to be followed to write a review paper. 3. Classify data for qualitative and quantitative analysis 4. Demonstrate technical writing for conference.	
Content:		**No of Hours**
Unit -1	**Overview on Literature Review**, difference between objectives of literature review and research objectives; types of literature review, qualitative and quantitative reviews, search strategies, primary and secondary sources, database search strategies, field search, root search, complimentary search, meta-analysis	**12 + 4T**
Unit -2	**Database management of literature reviews**, bibliometric analysis, importance of writing a review paper, reply to comments and responses, publication ethics, references, citations, authorship, plagiarism, academic integrity; public domain, open access, current literature.	**11 + 4T**
Unit -3	**Technical writing on a specific research topic**, structure of the paper, abstract, introduction, experimental, simulation, analysis, discussion, inferences, title, acknowledgment, referencing, presentation of tables, figures, graphs, equations; comparison between technical writing for conference papers and journal paper	**11 + 4T**
Unit- 4	**Importance of data in research**, types of data, data collection techniques, Quantitative methods for analysis of data – statistical tools, mathematical modeling, simulation, experimental data, optimization methods; Qualitative data collection, preparing questioners, rating scale, conducting survey, validation of models.	**11 + 3T**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
References/ Readings:	1. Rob Dekkers, Lindsey Casey, Peter Langhorne, 'Making Literature Review Work – Multidisciplinary Guide to Systematic Approaches', Springer Publications, 2022, ISBN:9783030900243. 2. Michael Jay Katz, 'From Research to Manuscript', Springer Publication, 2009, ISBN:9781402094668. 3. Herman Tang, 'Engineering Research-Design, Methods and Publications', John Wiley and Sons, 2021, ISBN:9781119624486. 4. Meikang Qiu, Han Qiu, Yi Zeng, 'Research & Technical Writing for	

	Science and Engineering', Taylor & Francis Publications, 2022, ISBN:9781003139058.
Course Outcomes:	After taking this course, student will be able to: CO 1. Understand the importance of literature review and writing a review paper. CO 2. Explain the method to be followed to write a review paper. CO 3. Classify data for qualitative and quantitative analysis CO 4. Demonstrate technical writing for conference.

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SEMESTER II

Programme Specific Core (PSC) Courses

Name of the Programme : Master of Engineering (Data Sciences)
Course code : DEN-505
Title of the course : Big Data Systems
Number of Credits : 03 (3L)
Effective from AY : 2024-25

Pre- requisites for the Course:	Basic programming skills	
Course Objectives:	This course will enable students to: 1. Student will be equipped with essentials of Big Data Analytics. 2. Student will be able to understand the appropriate platforms and services for storing and processing Big Data. 3. Course will enable student to implement solutions for big data processing.	
Units	**Contents:**	**No of Hours**
Unit-1	Different Types of Data and Storage for Data: Structured Data (Relational Databases) , Semi-structured data (Object Stores), and Unstructured Data (File systems), What is Big Data: Characteristics of Big Data. Systems perspective - Processing: In-memory vs. (from) secondary storage vs. (over the) network	**12**
Unit-2	Parallel and Distributed Processing: Motivation (Size of data and complexity of processing); Storing data in parallel and distributed systems: Shared Memory vs. Message Passing; Strategies for data access: Partition, Replication, and Messaging.	**12**
Unit- 3	Memory Hierarchy in Distributed Systems: In-node vs. over the network latencies, Locality, Communication Cost. Distributed Systems: Motivation (size, scalability, cost-benefit), Client-Server vs. Peer-to-Peer models, Cluster Computing: Components and Architecture	**12**
Unit- 4	Big Data Lifecycle: Data Acquisition, Data Extraction –Validation and Cleaning, Data Loading, Data Transformation, Data Analysis and Visualization. Case study – Big data application Distributed Computing. Design Strategy: Divide-and-conquer for Parallel / Distributed Systems - Basic scenarios and Implications.	**09**
Pedagogy:		
References/ Readings:	**Text Books** 1. Seema Acharya and Subhashini Chellappan. Big Data and Analytics. Wiley India Pvt. Ltd. Second Edition **Reference Books** 1. DT Editorial Services. Big Data - Black Book. DreamTech. Press. 2016 2. Kai Hwang, Jack Dongarra, and Geoffrey C. Fox. Distributed and Cloud Computing: From Parallel Processing to the Internet of Things. Morgan	

	Kauffman 2011 3. Martin klepmann, Designing Data Intensive applications, O'Reilly Media, Inc. 2017
Course Outcomes:	After going through this course, the students will be able to: CO 1. A comprehensive understanding of the Big Data ecosystem and along with the typical technologies involved. CO 2. Apply concepts from distributed computing and use framework for solving typical big data problems. CO 3. Identify and use appropriate storage / database platforms for Big data storage along with appropriate querying mechanisms / interfaces for retrieval.

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Name of the Programme : Master of Engineering (Data Sciences)
Course code : DEN-506
Title of the course : Big Data Analytics Lab
Number of Credits : 01(1P)
Effective from AY : 2024-25

Pre- requisites for the Course:	Basic Programming skills
Course Objectives:	This course will enable students to: 1. Student will be equipped with essentials of Big Data Analytics 2. Apply appropriate preprocessing techniques for analysing big data. 3. Course will enable student to analyze real-world data and apply appropriate techniques
List of Programs /Experiments	
	1. Data Preprocessing with Python 2. Perform EDA on a large dataset using statistical methods and visualizations to identify trends and patterns. 3. Implement a classification model (e.g., Logistic Regression) on a large dataset using Spark's MLlib library. 4. Use natural language processing (NLP) techniques to analyze sentiments in a large text dataset 5. Use Hadoop's MapReduce framework to count the frequency of words in a large text file. 6. Use Spark's GraphX to analyze graph data 7. Use Hadoop's MapReduce to filter a large dataset based on specific criteria 8. Time Series Analysis with Spark
Instructions	**Minimum 6 experiments to be performed**
Course Outcomes:	After going through this course, the students will be able to: CO 1. Ability to clean and pre-process large datasets for analysis. CO 2. Apply statistical methods and visualization tools to explore data. CO 3. Implement and evaluate Big Data Analytics algorithms on large datasets. CO 4. Optimize and scale data processing using distributed platforms

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Name of the Programme : Master of Engineering (Data Sciences)
Course code : DEN-507
Title of the course : Digital Marketing Analytics
Number of Credits : 3(3L)
Effective from AY : 2024-25

Pre- requisites for the Course:	Basic knowledge of Data Analytics	
Course Objectives:	This course will enable students to: 1. Identify the elements of digital marketing 2. Evaluate strategic approaches for using digital platforms for digital marketing 3. Study various analytics and goals for successful digital marketing. 4. Identify different digital marketing measurement and benchmark techniques and search analysis.	
Units	**Contents:**	**No of Hours**
Unit-1	**Understanding Digital Analytics Concepts**: Three things every practitioner should know, Owned Social Metrics, Earned Social Media Metrics, Demystifying Web Data, Paid Searches, Organic Searches, Aligning Digital and Traditional Analytics. **Search Analytics:** Understanding basics of Search, Search Analytics Use Cases, Google Trends, YouTube Trends, Google Ad Words Keyword Tool, Paid tools for collecting Insights through Search Data	**12**
Unit-2	**Audience Analysis:** What it is, Audience analysis Use cases, Tool types and analysis techniques. **Content Analysis:** Content Audit Checklist, Real Time Analytics, Optimizing Content Distribution, Analysing Content Consumption, learning agendas, Classifying Results for Content Analysis.	**12**
Unit- 3	**Tools of the Trade**: Social Media Listening Tools, Understanding Social Media Engagement Software **Engagement Analysis**: SMES, Robust Analysis Dashboards, Scheduling Content, Posting and Uploading Media Content, Geo-targeting posts, Post Tagging.	**12**
Unit- 4	**Digital Marketing Measurement:** Challenges of Digital media Measurement, Measurement Fundamentals, Benchmark Research, Strategy Development, Tactical Elements, Measurement Practices, Developing Measurement Reporting Cadence.	**9**
Pedagogy:	Inquiry Based Learning, Reflective, Integrative Learning	
References/ Readings:	**Text Books** 1. Chuck Hemann and Ken Burbary, "Digital Marketing Analytics", 2013, Que Publications **Reference Books** 1. Damian Ryan and Calvin Jones, "Marketing Strategies for Engaging the Digital Generation", 3rd Edition, Kogan Page Ltd. 2. Gauri Ghule, Shraddha Habbu and Nitin Sakhare, "Digital Marketing", First Edition, Nirali Prakashan Publication.	

Course Outcomes:	After going through this course, the students will be able to: CO 1. Understand & compare digital and traditional analytics. CO 2. Identify and describe various tools for Search and Content Analytics. CO 3. Evaluate various Social Media Engagement software CO 4. Understand Digital Marketing Measurements and Benchmarks

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Name of the Programme : Master of Engineering (Data Sciences)
Course Code : DEN-508
Title of the course : Digital Marketing Analytics Lab
Number of Credits : 1(1P)
Effective from AY : 2024-25

Pre- requisites for the Course:	Basic knowledge of Data Analytics
Course Objectives:	This course will enable students to: 1. Identify the elements of digital marketing 2. Evaluate strategic approaches for using digital platforms for digital marketing 3. Study various analytics and goals for successful digital marketing. 4. Identify different digital marketing measurement and benchmark techniques and search analysis.
	List of Programs / Experiments 1. Compare two versions of a webpage, email, ad or any digital asset to see which one performs better in terms of conversions, click through rates etc. 2. Content Analysis: Analyze the performance of different content (blog posts, videos, infographics etc.) to quantify and analyze the presence, meanings, and relationships of such certain words, themes, or concepts. 3. Keyword Analysis: Analyze the performance of different keywords for search engine marketing campaigns (e.g., Google Ads) to identify high-performing keywords and optimize bidding strategy. 4. Social Media Engagement Analysis: Measure the engagement metrics (likes, shares, comments, etc.) of social media posts to understand what type of content generates the most engagement 5. Tools: study of Google Analytics for website performance and audience demographics. 6. Tools: study of Facebook Analytics for engagement metrics, ad performance and audience demographics. 7. Tools: Google Tag Manager to manage and deploy tracking tags (such as Google Analytics tags) on websites. 8. Study of any Social Media Engagement software.
Instructions	All 8 Experiments to be performed
Course Outcomes:	After going through this course, the students will be able to: CO 1. Examine and differentiate between digital and traditional analytics methods. CO 2. Identify and describe various tools for Search and Content Analytics. CO 3. Evaluate various Social Media Engagement software CO 4. Analyse and apply digital marketing measurements and benchmarks

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Name of the Programme : Master of Engineering (Data Sciences)
Course code : DEN-509
Title of the course : Data Visualization and Modeling
Number of Credits : 3 (3L)
Effective from AY : 2024-25

Pre- requisites for the Course:	Basic understanding of data	
Course Objectives:	This course will enable students to: 1. To learn, understand and practice Data Visualization & Modeling 2. Evaluate strategic approaches for using digital platforms for digital marketing 3. Discover best practices of data visualization for different types of data. 4. To solve the real time problems of data science.	
Contents:		**No of Hours**
Unit-1	Basic Data Analytics: Need of Data analytic lifecycle, Key roles for successful analytic projects. Phases of Data analytic lifecycle: Discovery, Data Preparation, Model Planning, Model Building, Communicating Results, Operationalization. Linear regression: Simple linear regression, introduction to multiple linear regressions.	**12**
Unit-2	Statistical hypothesis generation and testing, Chi-Square test, t-Test, Analysis of variance and covariance, Classification: logistic regression, decision trees, SVM., Naïve Bayesian,classifiers, text analysis. Ensemble methods: bagging, random forests, boosting. Clustering: K-means, K-medoids, Hierarchical clustering. Association Rules, Apriori algorithm.	**12**
Unit-3	Power BI for Data Visualization and Dashboard Creation: Power BI for Data Visualization and Dashboard Creation: Introduction to Power BI: Interface, data connection, roles. - Creating Basic Visualizations: Bar charts, line charts, scatter plots. - Building Interactive Dashboards: Design principles, combining visualizations. - Effective Data Storytelling using Power BI.	**12**
Unit-4	Introduction to Tableau Desktop: Connecting to Data,Customizing a Data Source, Filtering Data,Sorting Data,Creating Groups in Data,Creating Hierarchies in Data, Working with Date Fields: Discrete and Continuous Time, Working with Date Fields: Custom Dates, Working with Multiple Measures: Dual Axis and Combo Charts,Working with Multiple Measures: Combined Axis Charts, Showing Relationships between Numerical Values, Mapping Data Geographically, Using Crosstabs: Totals and Aggregation	**09**
Pedagogy:	Inquiry Based Learning, Reflective, Integrative Learning	
References/ Readings:	**Text Books** 1. Chuck Hemann and Ken Burbary, “Digital Marketing Analytics”, 2013, Que Publications 2. Jack A. Hyman, “Microsoft Power BI For Dummies”,January 2023. ISBN: 978-9353645778	

	Reference Books 1. Hastie, T., Tibshirani, R., Friedman, J. (2009). The elements of statistical learning: datamining, inference and prediction. Springer. 2. Richard O. Duda, Peter E. Hart, and David G. Stork. 2000. Pattern Classification (2nd Edition). Wiley- Interscience, New York, NY, USA. 3. Christopher M. Bishop. 2006. Pattern Recognition and Machine Learning (Information Science and Statistics). Springer-Verlag, Berlin, Heidelberg.
Course Outcomes:	After going through this course, the students will be able to: CO 1. Understand the key techniques and theory behind data visualization CO 2. Use effectively the various visualization structures (like tables, spatial data, tree and network etc.) CO 3. Evaluate information visualization systems and other forms of visual presentation for their effectiveness CO 4. Design and build data visualization systems

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Name of the Programme : Master of Engineering (Data Sciences)
Course code : DEN-510
Title of the course : Data Visualization and Modelling Lab
Number of Credits : 1 (1P)
Effective from AY : 2024-25

Pre- requisites for the Course:	Basic understanding of Data
Course Objectives:	This course will enable students to: 1. Analyse various datasets using classification and clustering data models. 2. Understand the fundamental syntax of R. 3. Create well designed visualization using data visualization tools like R 4. Create well designed visualization using data visualization tools like Python
	List of Programs / Experiments 1. Introduction to Tableau/Power BI and Aggregation Methods in Tableau/Power BI. 2. Visual Encodings and Basic Dashboards in Tableau/Power BI. 3. Interactive Plots in Python. 4. Hierarchical and Topographical Data Visualizations in Tableau/Power BI. 5. Calendar Heat maps and Flow Data Visualizations in Python. 6. Time Series Data Visualization in Python. 7. Dashboards, Actions and Story Telling in Tableau/Power BI. 8. Types of charts in tableau, Interactive: visualization in tableau, beautiful visualization in tableau, Tips for More Effective and Engaging 9. Excel: Statistical Capabilities-Average, Mean, Stand Deviation, Median, Graphs Scatter Plot, Bar Graphs.
	Perform at least 8 Experiments
Course Outcomes:	After going through this course, the students will be able to: CO 1. Explain the fundamental concepts of data visualization CO 2. Understand the types of transformation the data has undergone to improve the effectiveness of visualization CO 3. Apply basic algorithms in data visualization CO 4. Create visualization using Tableau and PowerBI

Programme Specific Elective (PSE) Courses

Name of the Programme : Master of Engineering (Data Sciences)
Course code : DEN-533
Title of the course : Neural Networks
Number of Credits : 3 (3L)
Effective from AY : 2024-25

Pre- requisites for the Course:	Knowledge of basic mathematics and programming	
Course Objectives:	This course will enable students to: 1. An understanding of building blocks of Neural Networks. 2. An understanding of the various parameters and options involved in the implementation of a multilayer neural network. 3. An Understanding of the main factors involved in learning and generalization in neural networks. 4. Have a broad knowledge in Fuzzy logic principles and will be able to determine different methods of Deffuzification.	
Units	**Contents:**	**No of Hours**
Unit-1	Basics of Artificial Neural Networks: Characteristics of Neural Networks, Historical Development of Neural Network Principles, Artificial Neural Networks: Terminology, Models of Neuron, Topology, Basic Learning Laws. Activation and Synaptic Dynamics: Introduction, Activation Dynamics Models, Synaptic Dynamics Models, Learning Methods.	**11**
Unit-2	Feedforward Neural Network: Introduction, Analysis of Pattern Association Networks, Analysis of Pattern Classification Networks. Feedback Neural Networks: Introduction, Analysis of Linear Auto associative FF Networks, Analysis of Pattern Storage Networks.	**11**
Unit- 3	Introduction about Fuzzy set theory: Fuzzy versus Crisp, Crisp and fuzzy sets, Crisp and Fuzzy relations.	**11**
Unit- 4	Fuzzy Systems: Crisp Logic, Predicate Logic, Fuzzy logic, Fuzzy rule based system, De-fuzzification Methods, Applications.	**12**
Pedagogy:	Inquiry Based Learning, Reflective, Integrative Learning	
References/ Readings:	**Text Books** 1. B. Yegnanarayana - Artificial neural network PHI Publication.2005 2. S. 2. Raj sekaran, Vijayalakshmi Pari - Neural networks, Fuzzy logic and Genetic Algorithms 3. Bishop, C. M. Neural Networks for Pattern Recognition. Oxford University Press. 1995. 4. Neural Networks,Fuzzy Logic and Genetic Algorithms, by S.Rajasekaran and G.A. Vijayalakshmi Pai. 5. Neuro-Fuzzy Systems, Chin Teng Lin, C. S. George Lee, PHI. **Reference Books** 1. Kevin L. Priddy, Paul E. Keller – Artificial neural networks: An Introduction - SPIE Press, 2005 2. Build_Neural_Network_With_MS Excel_sample by Joe choong.	

Course Outcomes:	After going through this course, the students will be able to: CO 1. List out the basic principles, techniques, and applications of neural network CO 2. Explain the principles and structure of multi-layer neural networks CO 3. Illustrate the working of shallow neural network CO 4. Understand the building blocks of Radial Basis Function Networks

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Name of the Programme : **Master of Engineering (Data Sciences)**
Course code : **DEN-534**
Title of the course : **Neural Network Lab**
Number of Credits : **1 (1P)**
Effective from AY : **2024-25**

Pre- requisites for the Course:	Knowledge of mathematics especially linear algebra, probability and calculus
Course Objectives:	1. Identify appropriate data structures and algorithms for a given contextual problem and develop programs to design and implement applications. 2. Design and manage the large databases and develop their own databases to solve real world problems and to design, build, manage networks and apply wireless techniques in mobile based applications. 3. Design a variety of computer-based components and systems using computer hardware, system software, systems integration process and use standard testing tools for assuring the software quality.
	1. Generate the activation functions- Logistic, Hyperbolic, Identity that are used in Neural networks 2. Program for perceptron net for an AND function with bipolar inputs and targets 3. Generate Or function with bipolar inputs and targets using Adaline network 4. Generate XOR function for bipolar inputs and targets using Madaline network 5. Find the weight matrix of an auto associative net to store the vector (1 1 -1 -1). Test the response by presenting same pattern. 6. Find weight matrix in Bipolar form for BAM network on binary i/p o/p pairs 7. Write a program to implement classification of linearly separable Data with a perceptron 21 7 8. To study Long Short-Term Memory for Time Series Prediction.
	Perform All 6 Experiments
Course Outcomes:	After going through this course, the students will be able to: CO 1. Understand the characteristics and types of artificial neural network and remember activation functions. CO 2. Apply learning algorithms on perceptron and apply back propagation learning on Neural Network. CO 3. Apply different types of auto encoders with dimensionality reduction and regularization. CO 4. Generate and OR function using Adaline network.

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Name of the Programme : Master of Engineering (Data Sciences)
Course code : DEN-535
Title of the course : Business Intelligence
Number of Credits : 3(3L)
Effective from AY : 2024-25

Pre- requisites for the Course:	Basic understanding of analytical and problem-solving skills	
Course Objectives:	This course will enable students to: 1. Explain the Business Intelligence, Analytics and Decision Support system 2. Elaborate the technologies for Decision making, Automated decision systems 3. Explain sentiment analysis techniques 4. Illustrate Multi-criteria Decision making systems, predictive modelling techniques	
Contents:		**No of Hours**
Unit-1	**Business intelligence:** Effective and timely decisions, Data, information and knowledge, The role of mathematical models, Business intelligence architectures, Ethics and business intelligence **Decision support systems:** Definition of system, Representation of the decision-making process, Evolution of information systems, Definition of decision support system, Development of a decision support system	**11**
Unit-2	**Mathematical models for decision making:** Structure of mathematical models, Development of a model, Classes of models **Data mining:** Definition of data mining, Representation of input data, Data mining process, Analysis methodologies **Data preparation:** Data validation, Data transformation, Data reduction	**11**
Unit-3	**Classification**: Classification problems, Evaluation of classification models, Bayesian methods, Logistic regression, Neural networks, Support vector machines. **Clustering**: Clustering methods, Partition methods, Hierarchical methods, Evaluation of clustering models	**11**
Unit-4	**Business intelligence applications:** Marketing models: Relational marketing, Sales force management. **Logistic and production models**: Supply chain optimization, Optimization models for logistics planning, Revenue management systems. **Data envelopment analysis:** Efficiency measures, Efficient frontier, The CCR model, Identification of good operating practices	**12**
Pedagogy:	Inquiry Based Learning, Reflective, Integrative Learning	
References/ Readings:	**Text Books** 1. Carlo Vercellis , "Business Intelligence: Data Mining and Optimization for Decision Making" 1st edition, Wiley, 2009.Authors Names , "BookTitle", Version/Edition details, Publication house details **Reference Books** 1. Efraim Turban, Ramesh Sharda, Dursun Delen "Decision support and	

	Business Intelligence Systems", 9th edition, Pearson, 2011. 2. U. Dinesh Kumar ,Business Analytics :The Science of Data-Driven Decision Making, 2ed, November 2021
Course Outcomes:	After going through this course, the students will be able to: CO 1. Analyse Business Intelligence, Analytics and Decision Support CO 2. Explain the technologies for Decision making CO 3. Explore and explain various sentiment analysis techniques CO 4. Illustrate Multi-criteria Decision making systems, predictive modelling Technique

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Name of the Programme : Master of Engineering (Data Sciences)
Course code : DEN-536
Title of the course : Business Intelligence Lab
Number of Credits : 1 (1P)
Effective from AY : 2024-25

Pre- requisites for the Course:	Basic understanding of data analysis techniques
Course Objectives:	1. To equip students with foundational knowledge in business intelligence and decision support systems, enabling them to develop effective decision-making tools and data-driven strategies in a business context. 2. To develop proficiency in mathematical modelling, data mining, and data preparation techniques, fostering the ability to handle, analyse, and interpret large datasets for meaningful insights. 3. To enhance skills in supervised and unsupervised learning models, with a focus on implementing classification and clustering algorithms for real-world applications. 4. To prepare students for applying advanced data science methods in business intelligence applications, such as supply chain optimization, marketing analytics, and operational efficiency analysis.
	List of Programs / Experiments 1. Building a Basic Decision Support System (DSS) 2. Business Intelligence Dashboard Creation 3. Development of Mathematical Models for Decision-Making 4. Data Mining Workflow with Real-World Dataset 5. Classification Model for Customer Segmentation 6. Clustering Analysis on Customer Purchase Data 7. Optimization for Supply Chain Management 8. Efficiency Measurement Using Data Envelopment Analysis (DEA)
	Perform All 8 Experiments
Course Outcomes:	After going through this course, the students will be able to: 1. Design and develop decision support systems and business intelligence dashboards that support effective and ethical decision-making within an organizational setting. 2. Build, evaluate, and apply mathematical models and data mining techniques for analyzing and interpreting complex datasets, addressing real-world business challenges. 3. Implement and assess various machine learning algorithms for classification and clustering tasks, demonstrating an understanding of model evaluation and performance metrics. 4. Apply data science methodologies to optimize business processes in areas like supply chain management, marketing analytics, and efficiency measurement, delivering data-driven solutions to enhance organizational performance.

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Research Specific Elective (RSE) Courses

Name of the Programme : Master of Engineering (Data Sciences)
Course Code : REC-563
Title of the Course : Statistics and Data Analysis for Engineering Research
Number of Credits : 2
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic Knowledge of Statistics	
Course Objectives:	The course will enable the students to 1. Explain the different types of data and parameter estimations 2. Explain standard probability distributions 3. Select the appropriate parameter estimation & distribution method 4. Co-relate different Hypotheses	
Content:		**No of Hours**
Unit -1	**Data Analysis:** Types of data, data collection techniques, Quantitative methods for analysis of data – statistical tools, experimental data, Qualitative data collection, questioners, rating scale, conducting survey. Statistical Modeling and Graphical Diagnostics - Scatter Plot, Stem-and-Leaf Plot, Histogram, Box Plot **Correlation and Regression Modeling:** Basic concept and numericals.	**9**
Unit -2	**Probability distributions and Sampling distributions:** Basic introduction to Bernoulli, Binomial and Normal distribution. Basic introduction to Sampling distributions- Normal, t-distribution, Chi-square and F- distributions.	**7**
Unit -3	**Parameter estimation:** Point Estimation – Concept, unbiased estimator, method of maximum likelihood. Parameter estimation of standard distributions- Binomial and Normal. Confidence Interval Estimation - Concept, Confidence interval on mean of single normal population with variance known, Confidence interval on the ratio of variances of two normal distributions	**7**
Unit- 4	**Tests of Hypotheses:** Introduction, Type I and type II errors, significance level and power of the test, Test of hypotheses - on mean of single normal population with variance known, on variance of single normal population.	**7**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
References/ Readings:	1. D. V Thiel, 'Research Methods for Engineers', Cambridge Press, 2014, ISBN:978-110-70-3-488 2. T. Mustafy, T. U Rahman, 'Statistics & Data Analysis for Engineers and Scientists', Springer, 2024, ISBN:9789819946600. 3. D. C. Montgomery, C. G. Runger, 'Applied Statistics and Probability for	

	Engineers', 6th Edition, Wiley India, 2016, ISBN 0-471-20454-4 4. R. E. Walpole, R. H. Myers, S. L. Myers, K. E. Ye; Probability and Statistics for Engineers and Scientists ,9th Edition, Pearson Education India, 2013, ISBN 978-0-321-62911-1 5. J. Schmuller, Statistical Analysis with Excel for Dummies, 5th Edition, John Wiley & Sons, 2022.
Course Outcomes:	After taking this course, student will be able to: CO 1. Explain the different types of data and probability distributions. CO 2. Select the appropriate parameter estimation & distribution method CO 3. Apply estimators for the given situations. CO 4. Evaluate Hypotheses based on the statistical considerations.

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Name of the Programme : Master of Engineering (Data Sciences)
Course Code : REC-564
Title of the Course : Statistics and Data Analysis Lab
Number of Credits : 2
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic Knowledge of Statistics	
Course Objectives:	The course will enable the students to 1. Apply the different types of data and parameter estimations 2. Analyze standard probability distributions 3. Demonstrate parameter estimation & distribution methods 4. Co-relate different Hypotheses	
Content:		**No of Hours**
	Using open-source software like libreoffice or any proprietary software perform following experiments: 1. Obtain measures of central tendency and dispersion. 2. Obtain Quartiles, Percentiles and prepare Box-and-Whisker Diagram 3. Develop Pie chart, Bar Chart, Histogram and Stem-and-Leaf Plot, 4. Develop_correlation using Pearson's Correlation Coefficient and showing Scatter Diagrams and Trendlines 5. Develop Linear and Nonlinear Regression Models 6. Obtain probability values involving probability distributions – Binomial and Normal 7. Obtain values of Normal, t-distribution, Chi-square and F-statistic. 8. Develop confidence interval for single population and two populations with variance known. 9. Develop confidence interval on the ratio of variances of two normal distributions. 10. Perform test of hypotheses on mean/variance of single/ two population(s).	**60**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
References/ Readings:	1. D. V Thiel, 'Research Methods for Engineers', Cambridge Press, 2014, ISBN:978-110-70-3-488 2. T. Mustafy, T. U Rahman, 'Statistics & Data Analysis for Engineers and Scientists', Springer, 2024, ISBN:9789819946600. 3. D. C. Montgomery, C. G. Runger, 'Applied Statistics and Probability for Engineers', 6th Edition, Wiley India, 2016, ISBN 0-471-20454-4 4. R. E. Walpole, R. H. Myers, S. L. Myers, K. E. Ye; Probability and Statistics for Engineers and Scientists ,9th Edition, Pearson Education India, 2013, ISBN 978-0-321-62911-1 5. J. Schmuller, Statistical Analysis with Excel for Dummies, 5th Edition,	

	John Wiley & Sons, 2022.
Course Outcomes:	After taking this course, student will be able to: CO 1. Apply the different types of data and parameter estimations CO 2. Analyze standard probability distributions CO 3. Demonstrate parameter estimation & distribution methods CO 4. Co-relate different Hypotheses

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Name of the Programme : **Master of Engineering (Data Sciences)**
Course Code : **REC-565**
Title of the Course : **Statistical Techniques for Engineering Research**
Number of Credits : **2**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Basic knowledge of Statistics and Probability	
Course Objectives:	The course will enable the students to 1. Understand the importance of statistical methods for research 2. Select the appropriate factorial design method for a given set of experimental plan. 3. Apply basic probability theorems and draw relevant inferences. 4. Analyze suitable probability model for given set of data	
Content:		**No of Hours**
Unit-1	**Overview on Statistical methods**, collection of data, one dimensional and two-dimensional statistical analysis, computation of central tendency and dispersion for grouped and ungrouped data, correlation preliminary, understanding variability in data.	**6**
Unit-2	**Design of Experiments**, Preparation of experimental plan, full factorial design, fractional factorial design, identification of parameters and levels, randomization, replication, blocking, interaction; numerical; Optimization methods for two parameters.	**9**
Unit-3	**Probability Preliminary**: Introduction to Probability, definition, Sample Space, Events, Conditional Probability, Theorem on total probability, Bayes' theorem. Random Variable: Introduction, Discrete and Continuous distribution, Characteristics- Mean, Variance and distribution function.	**8**
Unit-4	**Probability and Sampling Distribution**: Bernoulli, Binomial, Exponential, Normal, distribution. Mean, variance and distribution function, important properties, approximations and applications. Statistic and Sampling Distribution: Population and Sample. Statistic, Sampling distributions- Normal, t-distribution, Chi-square and F- distributions.	**7**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
References/ Readings:	1. Tahvir Mustafy, Tauhid U Rahman, 'Statistics & Data Analysis for Engineers and Scientists', Springer, 2024, ISBN:9789819946600. 2. Jiju Antony, 'Design of Experiments for Engineers & Scientists', Elsevier, 2023, ISBN 978-044-315-1736 3. Douglas Montgomery, 'Design and Analysis of Experiments', Wiley India, Eighth Edition, 2013, 9788126540501 4. J. Ravichandran, Probability and Statistics for Engineers, Wiley India, 2010, ISBN: 9788126523504	

	5. R. Johnson, Probability and Statistics for engineers, Eighth Edition, Prentice Hall of India, New Delhi, 2015, ISBN 978-1-292-17601-7 6. J. Schmuller, Statistical Analysis with Excel for Dummies, 5th Edition, John Wiley & Sons, 2022.
Course Outcomes:	After taking this course, student will be able to: CO 1. Understand the importance of statistical methods for research CO 2. Select the appropriate factorial design method for a given set of experimental plans. CO 3. Apply basic probability theorems and draw relevant inferences. CO 4. Analyze suitable probability model for given set of data

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Name of the Programme : Master of Engineering (Data Sciences)
Course Code : REC-566
Title of the Course : Probability & Statistical Analysis Lab
Number of Credits : 2
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic knowledge of Statistics and Probability	
Course Objectives:	The course will enable the students to 1. Apply basic probability theorems and draw relevant inferences. 2. Analyze suitable probability model for given set of data 3. Demonstrate factorial design methods 4. Synthesize fractional and full factorial experimental design data	
Content:		**No of Hours**
	Using open-source software like libreoffice or any proprietary software perform following experiments: 1. Obtain probability values involving discrete probability distributions - Bernoulli, Binomial. 2. Obtain probability values involving continuous probability distributions - Exponential and Normal distributions. 3. Obtain values of Normal, t-distribution, Chi-square and F-statistic. 4. Obtain values of Mean, Variance and distribution function of Bernoulli and Binomial distribution. 5. Obtain values of Mean, Variance and distribution function of Exponential and Normal distributions. 6. Obtain values of central tendency of grouped and ungrouped data. 7. Obtain values of dispersion of grouped and ungrouped data. 8. Analyse experimental output using full factorial design. 9. Analyse experimental output using fractional factorial design. 10. Analyse a full case study in involving full factorial design or fractional factorial design.	**60**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
References/ Readings:	1. Tahvir Mustafy, Tauhid U Rahman, 'Statistics & Data Analysis for Engineers and Scientists', Springer, 2024, ISBN:9789819946600. 2. Jiju Antony, 'Design of Experiments for Engineers & Scientists', Elsevier, 2023, ISBN 978-044-315-1736 3. Douglas Montgomery, 'Design and Analysis of Experiments', Wiley India, Eighth Edition, 2013, 9788126540501 4. J. Ravichandran, Probability and Statistics for Engineers, Wiley India, 2010, ISBN: 9788126523504 5. R. Johnson, Probability and Statistics for engineers, Eighth Edition, Prentice Hall of India, New Delhi, 2015, ISBN 978-1-292-17601-7 6. J. Schmuller, Statistical Analysis with Excel for Dummies, 5th Edition,	

	John Wiley & Sons, 2022.
Course Outcomes:	After taking this course, student will be able to: CO 1. Apply basic probability theorems and draw relevant inferences. CO 2. Analyze suitable probability model for given set of data CO 3. Demonstrate factorial design methods CO 4. Synthesize fractional and full factorial experimental design data

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SEMESTER III

Programme Specific Core Courses

Name of the Programme: : Master Of Engineering (Data Sciences)
Course Code : DEN-600
Title of the Course : Machine Learning for Data Science
Number of Credits : 03 (3L)
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic knowledge of Artificial Intelligence.	
Course Objectives:	The course will enable the students: 1. To introduce the fundamental concepts of machine learning, including problem formulation, data representation, forms of learning, and key concepts like bias-variance tradeoff and overfitting. 2. To enable understanding and application of basic statistical and decision tree-based classification techniques for structured data analysis. 3. To explore various clustering techniques and data transformation methods, along with introducing the basic principles. 4. To provide a foundational understanding of artificial neural networks, their biological inspiration, neuron models, and training rules including linear and non-linear classification.	
Content:		**No. of hours**
Unit - 1	Introduction: Towards Intelligent Machines, Well-Posed Machine Learning Problems, Examples of Applications in Diverse Fields, Data Representation, Domain Knowledge for Productive use of Machine Learning, Diversity of Data: Structured/Unstructured, Forms of Learning. Supervised Learning: Learning from Observations, Bias and Variance, Computational Learning Theory, Occam's Razor Principle and Overfitting Avoidance	**11**
Unit - 2	Statistical Learning: Naive Bayes Classifier, k-Nearest Neighbor (k-NN) Classifier, Linear and Logistic regression. Decision Tree Learning: Introduction, Example of a Classification Decision Tree, Measures of Impurity for Evaluating Splits in Decision Trees, ID3 and C4.5 Decision Trees, Pruning the Tree, Strengths and Weaknesses of Decision-Tree Approach, Random Forest algorithm.	**11**
Unit - 3	Data Clustering and Data Transformations: Clustering, Engineering the Data, Different Clustering Methods such as Partitional Clustering, Hierarchical Clustering, Clustering using Self-Organizing Maps, Fuzzy K-Means Clustering, Expectation-Maximization (EM) Algorithm, Data transformation techniques.	**12**
Unit - 4	Artificial Neural Networks: Introduction to neural networks, structure of biological neuron, Mc-Culloch Pitts neuron model,	**11**

	Logic network realization by using Mc-Culloch Pitts neuron model, Neuron modelling for artificial neuron systems. Single layer network: Concept of linear separability and non-linear separability. Training rules: Hebbian learning rule, perceptron learning rule, Delta learning rule and related problems.	
Pedagogy:	This course adopts an applied, student-centered pedagogy that integrates **interactive lectures** with **coding exercises** and **real-world case studies** to bridge theory and practice. **Quizzes and assignments** are strategically placed to reinforce key concepts, assess comprehension, and promote independent problem-solving.	
References/ Readings:	Text Books: 1. Kishan Mehrotra, Chilukuri Mohan, Sanjay Ranka, "Elements of Artificial Neural Network", Penram Publications, 2nd Edition, 1995, ISBN: 978-8187972204 2. M. Gopal, "Applied Machine Learning|2nd Edition", Mc Graw Hill Publication, 2nd Edition, 2021, ISBN 9353160251 3. Siddhanta Bhatta, "Applied Machine Learning Solutions with Python", BPB Publication, 2nd Edition, 2021, ISBN 9391030432 4. Tom M Mitchell, "Machine Learning", Indian edition, McGraw Hill Publication, 1997, ISBN 1259096955 Reference Books: 1. Ethem Alpaydin, "Introduction to Machine Learning", MIT Press, Prentice Hall of India, 4th Edition, 2020, ISBN 0262043793. 2. J. Zurada, "Introduction to Artificial neural network", Jaico Publications, 1996, ISBN: 978-8125914259. 3. Satish Kumar, "Neural Networks A Classroom Approach", VISIONIAS Publication, 2nd Edition, 2020, ISBN 1259006166.	
Course Outcomes:	After taking this course, student will be able to: CO1. **Describe** the fundamentals of machine learning, including problem types, learning paradigms, the bias-variance trade-off, and overfitting. CO2. **Apply** statistical and decision tree algorithms for classification tasks, and **evaluate** model performance using appropriate metrics CO3. **Analyse** the working of clustering methods such as k-means and hierarchical clustering and **explain** their principles. CO4. **Implement** basic neural network models and **apply** learning rules for training single-layer networks.	

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Name of the Programme : **Master of Engineering (Data Sciences)**
Course Code : **DEN-601**
Title of the Course : **Machine Learning for Data Science Lab**
Number of Credits : **01 (2P)**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Basic knowledge of python programming.	
Course Objectives:	The course will enable the students to: 1. Understand the concepts of Machine learning and learn about Python libraries. 2. Demonstrate the knowledge of various supervised learning algorithms. 3. Implement Python programs for data clustering, transformation and dimensionality reduction techniques. 4. Illustrate knowledge of logic functions, linear and non-linear separability concept and different training rules.	
Content:	**List of Programs /Experiments**	**No. of hours**
	1. Study experiment on Machine learning. 2. Study of various Python machine learning libraries. 3. Implementation of KNN classifier. 4. Implementation of Naive Bayes Classifier. 5. Implementation of Decision tree classifier ID3. 6. Implementation of Decision tree classifier C4.5. 7. Implementation of Random Forest algorithm for application 8. Implementation of Hierarchical clustering algorithm 9. Implementation of Hierarchical clustering algorithm 10. Implementation of clustering using SOM	**30**
Pedagogy:	Constructive, Collaborative and Inquiry Based Learning	
References/ Readings:	Text Books: 1. Kishan Mehrotra, Chilukuri Mohan, Sanjay Ranka, "Elements of Artificial Neural Network", Penram Publications, 2nd Edition, 1995, ISBN: 978-8187972204 2. M. Gopal, "Applied Machine Learning|2nd Edition", Mc Graw Hill Publication, 2nd Edition, 2021, ISBN 935316025	
Course Outcomes:	After taking this course, student will be abwle to: CO1. Demonstrate an understanding of machine learning fundamentals and effectively utilize Python libraries for data analysis and model development. CO2. Design and implement supervised learning algorithms to solve real-world problems across various domains. CO3. Apply data clustering, transformation, and dimensionality reduction techniques for pattern discovery and feature optimization.	

	CO4. Implement logic functions and neural network models, and apply training rules to address linearly and non-linearly separable problems.

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Name of the Programme : Master of Engineering (Data Sciences)
Course Code : DEN-602
Title of the Course : Deep Learning for Data Science
Number of Credits : 03 (3L)
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic knowledge of Artificial Intelligence.	
Course Objectives:	The course will enable the students to: 1. To introduce the idea of artificial neural networks and their architecture 2. To introduce techniques used for training artificial neural networks 3. To enable design of an artificial neural network for classification 4. To enable design and deployment of deep learning models for machine learning problems	
Content:		**No. of hours**
Unit-1	**Artificial Neural Networks**: The Neuron-Expressing Linear Perceptrons as Neurons-Feed-Forward Neural Networks- Linear Neurons and Their Limitations –Sigmoid – Tanh – and ReLU Neurons -Softmax Output Layers **Training Feed-Forward Neural Networks:** Gradient Descent -Delta Rule and Learning Rates- Gradient Descent with Sigmoidal Neurons- The Backpropagation Algorithm-Stochastic and Minibatch Gradient Descent	**12**
Unit-2	**Implementing Neural Networks in TensorFlow** **Beyond Gradient Descent:** Local Minima in the Error Surfaces of Deep Networks- Model Identifiability- Spurious Local Minima in Deep Networks- Flat Regions in the Error Surface – Momentum-Based Optimization.	**11**
Unit-3	**Convolutional Neural Networks (CNN)**: Architecture - Accelerating Training with Batch Normalization- Building a Convolutional Network using TensorFlow- Visualizing Learning in Convolutional Networks.	**11**
Unit-4	**Embedding and Representation Learning:** Autoencoder Architecture **Models for Sequence Analysis**: Recurrent Neural Networks- Vanishing Gradients Long Short-Term Memory (LSTM) Units.	**11**
Pedagogy:	This course employs a blended, learner-centered pedagogy that combines **interactive lectures**, **hands-on lab sessions**, and **problem-based learning** to promote deep understanding and practical application of concepts. **Quizzes and assignments** are integrated throughout the course to reinforce learning.	
References/ Readings:	**Text Books** 1. Nikhil Buduma, "Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithm", O'Reilly, 2017, ISBN 1491925582	

	2. Ian Goodfellow, Yoshua Bengio and Aaron Courville, "Deep Learning", MIT Press, 2016, ISBN 0262035618 **Reference Books** 1. Aurélien Géron, "Hands-On Machine Learning with Scikit- Learn and TensorFlow", O'Reilly, 2017, ISBN 1492032611. 2. Nikhil Ketkar, "Deep Learning with Python: A Hands-on Introduction", Apress,1ST Edition, 2017, 1484227662
Course Outcomes:	After taking this course, student will be able to: CO1. **Describe** the structure and functioning of artificial neurons, including activation functions, and **analyse** the architecture and limitations of feed-forward neural networks CO2. **Implement** neural network training using gradient descent and backpropagation and **evaluate** model performance using relevant metrics. CO3. **Design** and **develop** convolutional neural networks (CNNs) using TensorFlow, incorporating model optimization and visualization techniques. CO4. **Apply** deep learning architectures such as autoencoders and RNNs with LSTM units to tasks involving sequential data and feature representation

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Name of the Programme : **Master of Engineering (Data Sciences)**
Course Code : **DEN-603**
Title of the Course : **Deep Learning for Data Science Lab**
Number of Credits : **01 (2P)**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Basic knowledge of artificial intelligence	
Course Objectives:	The course will enable the students: 1. To introduce the fundamental concepts of artificial neurons, activation functions, and feedforward neural networks. 2. To equip students with training techniques for deep neural networks, including gradient-based optimization and overfitting prevention strategies. 3. To enable students to design and implement convolutional neural networks (CNNs) and optimize deep models using advanced techniques like batch normalization. 4. To explore representation learning using autoencoders and sequential data modeling using recurrent neural networks and LSTM architectures.	
Content:	**List of Programs /Experiments**	**No. of hours**
	1. **Implement a basic perceptron model** for binary classification using NumPy or TensorFlow. 2. **Visualize and compare activation functions**: Sigmoid, Tanh, and ReLU. 3. **Build a feedforward neural network** with softmax output for multi-class classification. 4. **Demonstrate gradient descent optimization** with different learning rates on a simple dataset. 5. **Implement backpropagation algorithm** for training a neural network. 6. **Apply dropout and L2 regularization** to reduce overfitting in a neural network. 7. **Develop a CNN model** for image classification using MNIST or CIFAR-10 datasets. 8. **Integrate batch normalization** into a CNN and observe its impact on training. 9. **Train neural networks using momentum-based optimizers** like SGD, RMSProp, and Adam. 10. **Build an autoencoder model** for dimensionality reduction or data denoising.	**30**
Course Outcomes:	After taking this course, student will be able to: CO1. **Understand** and **analyse** various artificial neuron models, activation functions, and feedforward architectures.	

	CO2. **Implement** and **train** neural networks using backpropagation, gradient descent, and **apply** regularization to prevent overfitting. CO3. **Design** and **evaluate** convolutional neural networks (CNNs) using TensorFlow and **optimize** them using techniques like batch normalization and advanced optimizers. CO4. **Apply** autoencoders for representation learning.

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Programme Specific Elective (PSE) Courses

Name of the Programme : Master of Engineering (Data Sciences)
Course Code : DEN-631
Title of the Course : Information Retrieval
Number of Credits : 03 (3L)
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic knowledge of Artificial Intelligence.	
Course Objectives:	The course will enable the students to: 1. Will be able to explain the basics of information retrieval, and the heart of search engines. 2. Will be able to evaluate an information retrieval system based on the relevance feedback, query expansion 3. Apply clustering and classification techniques to a corpus of texts for a specific information need 4. Understand and apply different IR techniques	
Content:		**No. of hours**
Unit-1	Introduction to Information Retrieval Systems: Definition of Information Retrieval System, Objectives of Information Retrieval Systems, Functional Overview, Relationship to Database Management Systems, Digital Libraries and Data Warehouses. Information Retrieval System Capabilities: Search Capabilities, Browse Capabilities, Miscellaneous Capabilities.	**12**
Unit-2	Cataloging and Indexing: History and Objectives of Indexing, Indexing Process, Automatic Indexing, Information Extraction	**11**
Unit-3	Automatic Indexing: Classes of Automatic Indexing, Statistical Indexing, Hypertext Linkages Document and Term Clustering: Introduction to Clustering, Thesaurus Generation, Item Clustering	**11**
Unit-4	User Search Techniques: Search Statements and Binding, Similarity Measures and Ranking, Relevance Feedback, Selective Dissemination of Information Search, Weighted Searches of Boolean Systems, Searching the INTERNET and Hypertext	**11**
Pedagogy:	This course adopts a **blended**, **concept-to-practice pedagogical approach**, combining **interactive lectures**, **hands-on coding exercises**, and **problem-based learning** to help students understand and apply core principles of Information Retrieval (IR). Learning is reinforced through a mix of **quizzes, assignments**, and **case-based discussions.**	
References/ Readings:	**TEXTBOOKS** 1. Gerald J. Kowalski, Mark T. Maybury, "Information Storage and Retrieval Systems – Theory and Implementation", Second Edition, Springer **REFERENCES** 1. Bruce Croft, Donald Metzler, and Trevor Strohman ,"Search Engines: Information Retrieval in Practice", Pearson Education, 2009.	

	2. R. R. Korfhage, "Information Storage and Retrieval", John Wiley & Sons, 1997, ISBN 0-471-14338-3 3. R. Baeza-Yates, B. Ribeiro-Neto, "Modern Information Retrieval", Addison-Wesley, 1999, Pearson Publishers, ISBN 978-81-317-0977-1. 4. C.D., Raghavan, P. and Schütze, H.," Introduction to Information Retrieval by Manning", 2008, Cambridge University Press, ISBN-13: 978-1-107-66639-9.
Course Outcomes:	After taking this course, student will be able to: CO1. **Define** the Information retrieval system and its objectives along with various capabilities. CO2. **Explain** and **apply** IR principles to locate relevant information from large datasets using various indexing methods. CO3. **Implement** different user search techniques and **document** clustering algorithms. CO4. **Analyze** different Text Search Algorithms

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Name of the Programme : **Master of Engineering (Data Sciences)**
Course Code : **DEN-632**
Title of the Course : **Information Retrieval Lab**
Number of Credits : **01 (2P)**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Basic knowledge of Artificial Intelligence.	
Course Objectives:	The course will enable the students to: 1. To understand the architecture and functionality of information retrieval systems. 2. To gain hands-on experience with cataloging, indexing, and automatic information extraction techniques. 3. To implement document clustering, similarity measures, and ranking methods for IR tasks. 4. To explore practical search techniques and web-based information retrieval systems.	
Content:	**List of Programs /Experiments**	**No. of hours**
	1. Implement a basic information retrieval system for text document storage and retrieval. 2. Demonstrate metadata generation and cataloging using a sample dataset. 3. Perform manual and automatic indexing on a text collection. 4. Extract key terms from documents using basic NLP techniques. 5. Implement statistical indexing using term frequency and inverse document frequency (TF-IDF). 6. Generate a simple thesaurus from a text corpus. 7. Perform document clustering using K-Means or hierarchical clustering. 8. Calculate cosine similarity between documents and a query. 9. Implement a ranked retrieval system using vector space model. 10. Apply relevance feedback to refine search results.	**30**
Course Outcomes:	After taking this course, student will be able to: CO1. **Demonstrate** the core components and capabilities of information retrieval systems through practical tools. CO2. **Implement** indexing and information extraction methods for organizing and retrieving documents. CO3. **Apply** document clustering and statistical techniques to improve information retrieval performance. CO4. **Apply** search strategies, ranking algorithms, and relevance feedback mechanisms in real-world information retrieval scenarios.	

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Name of the Programme : **Master of Engineering (Data Sciences)**
Course Code : **DEN-633**
Title of the Course : **Cyber Security and Threat Analysis**
Number of Credits : **03 (3L)**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Basic knowledge of computer networks	
Course Objectives:	The course will enable the students to: 1. **Explain** foundational cybersecurity principles, including authentication, cryptography, and network security mechanisms. 2. **Analyse** attacker techniques, common vulnerabilities, and exploitation methods used in real-world cyber-attacks. 3. **Identify** malware types, privilege escalation techniques, and methods for detecting and analysing malicious code. 4. **Explain** defence mechanisms such as memory forensics, intrusion detection systems, and strategies for protecting critical infrastructure and the human element.	
Content:		**No. of Hours**
Unit-1	**Cyber Security Fundamentals:** Authentication, Authorization, Nonrepudiation, Confidentiality, Integrity, Availability, Basic Cryptography, Symmetric Encryption, Public Key Encryption, The Domain Name System, Packet-Filtering Firewalls, Stateful Firewalls, Application Gateway Firewalls, The virtualization Menu, Full Virtualization. **Attacker Techniques and Motivations:** How and why Attackers use proxies, Types of proxies, Detecting the use of proxies, Tunnelling Techniques – HTTP, DNS, ICMP, Detection and prevention, Fraud Techniques, Rogue Antivirus, Threat Infrastructure.	**11**
Unit-2	**Exploitation:** Shellcode, Integer Overflow Vulnerabilities, Stack based buffer overflows, Format String Vulnerabilities, SQL Injection, Race Conditions, Web Exploit Tools, DoS Conditions, Cross-Site Scripting, Social Engineering, DNS Amplification Attacks. **Malicious Code:** Worms, Viruses, Evading Detection and Elevating Privileges, Rootkits, Spyware, Attacks against Privileged User Accounts and Escalation of Privileges, Token Kidnapping, Virtual Machine Detection, Stealing Information and Exploitation.	**11**
Unit-3	**Defense and Analysis Techniques:** Why memory Forensics is important, Capabilities of Memory Forensics, Memory Analysis Frameworks, Dumping Physical Memory, Installing and using Volatility, Finding Hidden Processes, Volatile Analyst Pack, Honeypots, Malicious Code Naming, Automated Malicious Code Analysis Systems, Intrusion Detection Systems.	**11**

Unit-4	**Protecting Critical Infrastructure:** Introduction, Technology Background Process Control Systems, Threats and Convergence, Real-Life Examples, Plant Meltdown. Why PCI is Important: Introduction, what is PCI, Overview of PCI Requirements, Risks and Consequences, Benefits of Compliance. Social Engineering: Introduction, Attack the People Layer, Phreaking, Defending the People Layer, Making the Case for stronger Security, People Layer Security Project.	**12**
Pedagogy:	This course employs a **learner-centered pedagogical approach** that integrates **interactive lectures**, **hands-on labs**, and **case-based problem solving** to equip students with both theoretical foundations and practical skills in cybersecurity and threat analysis. **Laboratory sessions** emphasize experiential learning through simulations, malware analysis, and penetration testing exercises, enabling students to apply techniques in realistic scenarios.	
References/ Readings:	**Text Books** 1. J. Graham, R. Howard, and R. Olson, *Cyber Security Essentials*. Boca Raton, FL, USA: Auerbach Publications, 2011, ISBN 978-1439851265 2. C. Schiller, S. Fogie, C. De Rodeff, and M. Gregg, *Infosecurity 2008 Threat Analysis*. Burlington, MA, USA: Syngress Publishing, 2007, ISBN 0080558690 **Reference Books** 1. A. Singh, *Introduction to Cyber Security: Concepts, Principles, Technologies and Practices*. Hyderabad, India: Universities Press (India) Pvt. Ltd., 2021, ISBN: 9789393330314	
Course Outcomes:	After taking this course, student will be able to: CO1. **Explain** fundamental cybersecurity principles, including authentication, encryption, firewalls, and virtualization, and their role in securing systems and networks. CO2. **Analyse** attacker techniques, vulnerabilities, and exploitation methods such as tunnelling, buffer overflows, and SQL injection, and assess their impact on systems. CO3. **Apply** threat detection and defence mechanisms, including memory forensics, intrusion detection systems, and malicious code analysis tools. CO4. **Evaluate** strategies for protecting critical infrastructure and the human layer, including compliance frameworks, social engineering defences, and real-world case scenarios.	

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Name of the Programme : **Master of Engineering (Data Sciences)**
Course Code : **DEN-634**
Title of the Course : **Cyber Security and Threat Analysis Lab**
Number of Credits : **01 (2P)**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Basic knowledge of computer networks	
Course Objectives:	The course will enable the students to: 1. To provide practical exposure to core cybersecurity principles including authentication, encryption, and network defenses. 2. To simulate and analyze common cyber-attacks such as buffer overflows, SQL injection, and DoS. 3. To explore detection, analysis, and mitigation techniques for malware and privilege escalation. 4. To familiarize students with forensic tools and intrusion detection systems for real-world cyber incident analysis.	
Content:	**List of Programs /Experiments**	**No. of hours**
	1. Create strong passwords and test password strength using online tools or Python scripts. 2. Demonstrate basic file encryption and decryption using tools like gpg or a simple Python script. 3. Explore different types of malware (viruses, worms, spyware) through case studies or simulations. 4. Use Wireshark to capture and analyze basic network traffic and identify protocol types. 5. Configure a basic firewall using Windows Defender or Linux ufw to block/allow ports. 6. Simulate a phishing attack using a dummy email and identify red flags in phishing messages. 7. Perform port scanning using Nmap and interpret scan results. 8. Set up a Virtual Machine (VM) and isolate it for safe testing of tools or suspicious files. 9. Use Task Manager and Process Explorer to identify suspicious processes on a Windows system. 10. Check system for vulnerabilities using tools like Microsoft Baseline Security Analyzer (MBSA) or Nessus (free trial).	**30**
Course Outcomes:	After taking this course, student will be able to: CO1. **Apply** cryptographic techniques and firewall configurations to secure systems and networks. CO2. **Demonstrate** the ability to exploit and **analyze** common vulnerabilities and attacks. CO3. **Analyze** and **detect** malicious software behavior and privilege escalation attempts.	

	CO4. **Utilize** memory forensics and IDS tools for detecting, analyzing, and mitigating security breaches.

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Research Specific Elective (RSE) Courses

Name of the Programme : Master of Engineering (Data Sciences)
Course Code : DEN-661
Title of the Course : Web Mining
Number of Credits : 02 (2L)
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic knowledge of Data Analysis	
Course Objectives:	The course will enable the students to: 1. Understand the concepts behind web mining. 2. Applying knowledge and understanding to apply supervised and unsupervised techniques 3. Understand information retrieval and web search techniques 4. Will be able to describe Link Analysis and Web Crawling and Opinion Mining and Web Usage Mining Opinion Mining concepts and techniques.	
	Contents	**No. of Hours.**
Unit-1	**Introduction to Web Data Mining and Data Mining Foundations** Introduction – World Wide Web (WWW), A Brief History of the Web and the Internet, Web Data Mining-Data Mining, Web Mining. Data Mining Foundations – Association Rules and Sequential Patterns – Basic Concepts of Association Rules, Apriori Algorithm- Frequent Itemset Generation, Association Rule Generation	**7**
Unit-2	**Supervised and Unsupervised Learning Supervised Learning** – Basic Concepts, Decision Tree Induction – Learning Algorithm, Impurity Function, Handling of Continuous Attributes, Classifier Evaluation, Rule Induction – Sequential Covering, Rule Learning, Classification Based on Associations, Naïve Bayesian Classification, Naïve Bayesian Text Classification – Probabilistic Framework, Naïve Bayesian Model. Unsupervised Learning – Basic Concepts, K-means Clustering – K-means Algorithm, Representation of Clusters, Hierarchical Clustering – Single link method, Complete link Method, Average link method, Strength and Weakness.	**8**
Unit-3	**Information Retrieval and Web Search:** Basic Concepts of Information Retrieval, Information Retrieval Methods – Boolean Model, Vector Space Model and Statistical Language Model, Relevance Feedback, Evaluation Measures, Text and Web Page Preprocessing – Stopword Removal, Stemming, Web Page Preprocessing	**7**
Unit-4	**Link Analysis and Web Crawling:** Link Analysis – Social Network Analysis, Co-Citation and Bibliographic Coupling, Page Rank Algorithm, HITS Algorithm, Community Discovery-Problem Definition, Bipartite Core	**8**

	Communities, Maximum Flow Communities, Email Communities. Web Crawling – A Basic Crawler Algorithm- Breadth First Crawlers	
Pedagogy:	**Inquiry Based Learning, Reflective**	
References/ Readings:	**TEXTBOOKS** 1. *B. Liu, Web Data Mining: Exploring Hyperlinks,Contents, and Usage Data, 2nd ed. Berlin, Germany: Springer, 2011. ISBN: 978-3-642-19459-7.* **REFERENCES BOOKS:** 2. *J. Han and M. Kamber, Data Mining: Concepts and Techniques, 2nd ed. San Francisco, CA, USA: Elsevier, 2006. ISBN: 978-1-55860-901-3.* 3. *S*. Chakrabarti, *Mining the Web: Discovering Knowledge from Hypertext Data*. San Francisco, CA, USA: Morgan Kaufmann, 2002. ISBN: 978-1-55860-754-5.	
Course Outcomes:	After taking this course, student will be able to: CO1. **Explain** the fundamentals of web data mining and the evolution of the World Wide Web and **apply** the A-priori algorithm to generate frequent item sets and discover association rules from web data. CO2. **Implement** and **compare** classification and clustering algorithms for effective analysis of web data. CO3. **Use** information retrieval models and perform text preprocessing to support accurate and relevant web search outcomes. CO4. **Analyse** web link structures using algorithms such as PageRank and HITS and **develop** a basic web crawler for structured data collection.	

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Name of the Programme : **Master of Engineering (Data Sciences)**
Course Code : **DEN-662**
Title of the Course : **Web Mining Lab**
Number of Credits : **02 (4P)**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Basic knowledge of Data Analysis	
Course Objectives:	The course will enable the students: 1. To introduce tools and techniques for mining structured and unstructured web data. 2. To provide hands-on experience with supervised and unsupervised learning methods for web content analysis. 3. To develop practical skills in information retrieval and web search evaluation. 4. To understand and implement web link analysis and crawling algorithms.	
Content:	**List of Programs /Experiments**	**No. of hours**
	1. Implement the A-priori algorithm for frequent itemset generation and rule extraction. 2. Perform association rule mining using any dataset and the mlxtend library in Python. 3. Build a decision tree classifier using scikit-learn and visualize it with graphviz. 4. Implement Naïve Bayes classifier for classifying text documents from the web. 5. Apply K-means clustering to group web content (e.g., news articles or HTML text). 6. Perform hierarchical clustering and plot dendrograms using SciPy, cluster, hierarchy. 7. Preprocess textual web data by removing stop words, tokenizing, and applying stemming or lemmatization. 8. Implement the Boolean retrieval model for keyword-based document matching. 9. Develop a vector space model and compute TF-IDF scores for a set of documents. 10. Calculate cosine similarity between documents and rank them for a user query. 11. Simulate the PageRank algorithm on a small manually defined web graph. 12. Implement the HITS algorithm to identify authority and hub scores in a hyperlink graph. 13. Develop a simple web crawler using requests, urllib, and BeautifulSoup. 14. Extract hyperlinks and metadata (e.g., titles, keywords) from	**60**

	a set of web pages. 15. Build a basic search engine interface to query a small local document collection.	
Course Outcomes:	After taking this course, student will be able to: CO1. Extract frequent patterns and associations from web data using data mining algorithms. CO2. Apply classification and clustering techniques to analyze web content CO3. Implement text pre-processing and evaluate search models for web information retrieval. CO4. Analyze web link structures and develop basic web crawlers.	

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Name of the Programme : **Master of Engineering (Data Sciences)**
Course Code : **DEN-663**
Title of the Course : **Recommender Systems**
Number of Credits : **02 (2L)**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Basic knowledge of Data Analysis	
Course Objectives:	The course will enable the students to: 1. To introduce the fundamentals of recommender systems and familiarize students with neighbourhood-based collaborative filtering methods. 2. To enable students to implement model-based collaborative filtering and content-based recommendation techniques. 3. To explore knowledge-based and hybrid recommender system approaches for more personalized recommendations. 4. To evaluate recommender systems using suitable metrics and incorporate contextual information for improved recommendations.	
	Content	**No. of Hours**
Unit-1	An Introduction to Recommender Systems: Introduction, Goal of recommender system, Goal of recommender system, Basic model of recommender system, Domain specific challenges of recommender system, Neighborhood Based Collaborative Filtering: Introduction, Key properties of rating matrix, predicting rating with neighbourhood-based methods, Clustering and neighborhood based methods, Dimensionality reduction and neighborhood methods	**7**
Unit-2	Model Based Collaborative Filtering: Introduction, Decision and Regression Trees, Rule based Collaborative Filtering, Naïve Bayes collaborative Filtering, Using arbitrary classification model as black box, Content Based Recommender Systems: Basic components of content based models, Preprocessing and Feature extraction, Feature Representation and Cleaning, Collecting user likes and dislikes, Supervised feature selection and weighting,	**8**
Unit-3	Knowledge Based Recommender Systems: Constraint based recommender system, Persistent personalization in Knowledge based system, Case based recommender, Ensemble Based and Hybrid Recommender Systems: Ensemble Methods from classification perspective, Weighted Hybrids, Switching Hybrids, Cascade Hybrids, Feature Augmentation Hybrid, Meta Level Hybrids, Feature Combination Hybrid, Mixed Hybrid	**7**
Unit-4	Evaluating Recommender Systems: Evaluation Paradigm, General goals of paradigm design, Design issues in offline recommender evaluation, Accuracy metrics in Offline evaluation, limitation of evaluation measures, Context Sensitive Recommender Systems:	**8**

	Multidimensional approach, Contextual pre-filtering, post filtering, Contextual modelling	
Pedagogy:	The course will be taught through **interactive lectures**, **coding labs**, **case studies**, and **hands-on projects**. Students will implement algorithms, analyze real-world recommender systems, and engage in **quizzes**, **assignments**, and **peer-reviewed presentations** to apply, evaluate, and create effective recommendation models.	
References/ Readings:	**Textbooks** 1. C. C. Aggarwal, *Recommender Systems: The Textbook*. Cham, Switzerland: Springer, 2016. ISBN: 978-3-319-29659-3. **Reference Books** 1. Francesco Ricci, Lior Rokach, Bracha Shapira, *Recommender Systems Handbook*, Springer, 1st Ed., 2011. 2. Yehuda Koren, Robert Bell, and Chris Volinsky, *Matrix Factorization Techniques for Recommender Systems*, IEEE Computer, 2009.	
Course Outcomes:	After taking this course, student will be able to: CO1. **Apply** neighbourhood-based collaborative filtering techniques to build basic recommender systems. CO2. **Implement** model-based and content-based recommendation approaches using machine learning methods. CO3. **Design** knowledge-based and hybrid recommender systems for personalized recommendations. CO4. **Evaluate** recommender systems using standard metrics and **integrate** contextual information for enhanced relevance.	

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Name of the Programme : **Master of Engineering (Data Sciences)**
Course Code : **DEN-664**
Title of the Course : **Recommender Systems Lab**
Number of Credits : **02 (2P)**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Basic knowledge of Data Analysis	
Course Objectives:	The course will enable the students to: 1. To introduce the practical implementation of various recommender system models. 2. To apply collaborative and content-based filtering techniques using real-world datasets. 3. To develop and evaluate hybrid and advanced recommender algorithms using modern libraries. 4. To equip students with skills to analyze performance using standard evaluation metrics.	
Content:	**List of Programs /Experiments**	**No. of hours**
	1. Implement user-based collaborative filtering using cosine similarity. 2. Implement item-based collaborative filtering using Pearson correlation. 3. Build a recommender using the MovieLens dataset with k-Nearest Neighbor (KNN). 4. Apply matrix factorization (SVD) using the Surprise library. 5. Use Alternating Least Squares (ALS) model with PySpark for collaborative filtering. 6. Implement content-based filtering using TF-IDF features for movie recommendation. 7. Construct a hybrid recommender by combining content-based and collaborative approaches. 8. Train a Naive Bayes classifier for text-based recommendation. 9. Build a deep learning-based recommender using TensorFlow Recommenders (TFRS). 10. Evaluate a recommender system using RMSE, MAE, Precision, and Recall. 11. Deploy a simple Flask-based movie recommender web app. 12. Perform A/B testing simulation on different recommendation algorithms. 13. Visualize user-item interaction matrix using heatmaps. 14. Perform cold-start analysis and suggest strategies for new users or items 15. Develop a recommender system using implicit feedback (e.g., clicks, views).	**60**

Course Outcomes:	After taking this course, student will be able to: CO1. Implement user-based and item-based collaborative filtering using similarity measures. CO2. Demonstrate matrix factorization techniques for building scalable recommender systems. CO3. Design content-based and hybrid recommendation models using real datasets. CO4. Evaluate recommender systems using metrics like RMSE, MAE, Precision, Recall, and deploy models using libraries.

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Generic Elective (GE) Courses

Name of the Programme : Master of Engineering (Data Sciences)
Course Code : GEC-681
Title of the Course : Sustainability - Principles & Practices
Number of Credits : 03
Effective from AY : 2024-25

Pre-requisites for the Course:	Undergraduate level knowledge of any branch of engineering	
Course Objectives:	The course aims to provide the student with an: 1. Understanding of importance of Sustainability Practices 2. Explanation of Assessment, Planning and Implementation of Sustainability Principles 3. Description of the steps involved in implementing sustainable solutions 4. Apply the knowledge of sustainability practices to real life situations.	
Content:		**No. of Hours**
Unit-1	**Overview on Global Sustainability Goals (SDGs):** Industry-Innovation-Infrastructure, Health & Well Being, Clean Water & Sanitation, Education, Responsible Consumption and production, Climate Action, Quality Education, Economic growth, sustainable community living,	**10**
Unit-2	**Sustainability:** Requirements for Sustainability, Approaches towards Sustainable Engineering, Sustainability Challenges, Environmental Challenges; **Reasons for Un-sustainability** – Economics and Environment, Corporate View of Sustainability, Social Attitude, Approach, Cultural Narratives, Political Aspects, Ethics and Morals. Steps in life cycle impact assessment	**13**
Unit-3	**Sustainability Assessment:** Steps in assessing life cycle, data availability, process network analysis, Input-Output Analysis, Hybrid Models; Carbon footprint, Water footprint, Energy analysis of technologies, processes and its economics; Concept of Exergy and Emergy Analysis; Ecosystem Services in Sustainability Assessment; Case Studies	**10**
Unit-4	**Solutions for Sustainability:** Designing sustainable processes and products; Techno-Economic Analysis; Energy Ecosystem and its dynamic characteristics; Circular Economy; Nature based solutions, Green infrastructure, Techno-ecological synergy; Economic Policies, Societal Developments; Case Studies.	**12**
Pedagogy	Interactive learning, reflective thinking, critical analysis, and problem-	

	solving.
References/ Readings:	1. Raj Gaurang Tiwari, 'Sustainability Principles and Applications in Engineering Practices', Nova Science Publishers, 2024, ISBN:9798891136403 2. Bhavik R Bakshi, 'Sustainable Engineering', Cambridge University Press, 2019, ISBN:9781108420457 3. Margaret Robertson, 'Sustainability – Principles & Practices', Routledge Publishers, 2017, ISBN: 97811138650244
Course Outcomes:	After going through this course, student will be able to: CO 1. Understand the importance of sustainability practices CO 2. Assess, Plan and Suggest basic sustainability practices CO 3. Explain the steps involved in implementing sustainable solutions CO 4. Prepare a plan for sustainability practices to real life situations.

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Name of the Programme : **Master of Engineering (Data Sciences)**
Course Code : **GEC-682**
Title of the Course : **Sustainability - Principles & Practices Lab**
Number of Credits : **01**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Undergraduate level knowledge of any branch of engineering	
Course Objectives:	The course aims to provide the student with an: 1. Understanding of importance of Sustainability Development Goals (SDG) 2. Explanation on Assessment, Planning and Implementation of SDG 3. Description of the steps involved in order to achieve the SDG. 4. Apply the knowledge of sustainability practices to real life situations.	
Content:		**No. of Hours**
	The United Nations has promulgated Sustainable Development Goals (SDG)s. Every student has to prepare a detail report and presentation, based relevant literature, field visits and data collection, interaction with experts, on ANY TWO topics of SDG as applied to the local region or State of Goa. (1) No Poverty (2) Zero Hunger (3) Good Health & Well Being (4) Quality Education (5) Gender Equality (6) Clean Water & Sanitation (7) Affordable & Clean Energy (8) Decent Work and Economic Growth (9) Industry, Innovation and Infrastructure (10) Reduce Inequalities (11) Sustainable Cities & Communities (12) Responsible Consumption and Production (13) Climate Action (14) Life Below Water (15) Life on Land (16) Peace, Justice & Strong Institutions	**30**
Pedagogy	Instructional learning, Inquiry based learning, Constructive learning, Collaborative learning and problem solving	
References/ Readings:	1. Raj Gaurang Tiwari, 'Sustainability Principles and Applications in Engineering Practices', Nova Science Publishers, 2024, ISBN:9798891136403 2. Bhavik R Bakshi, 'Sustainable Engineering', Cambridge University Press, 2019, ISBN:9781108420457	

	3. Margaret Robertson, 'Sustainability – Principles & Practices', Routledge Publishers, 2017, ISBN: 97811138650244
Course Outcomes:	After going through this course, student will be able to: CO 1. Understand the importance of sustainability Development Goals (SDGs) CO 2. Assess, Plan and Suggest basic sustainability practices CO 3. Explain the steps involved in order to achieve the SDG CO 4. Prepare a plan for sustainability practices to real life situations.

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Name of the Programme : Master of Engineering (Data Sciences)
Course Code : GEC-683
Title of the Course : Project Management
Number of Credits : 03
Effective from AY : 2024-25

Pre-requisites for the Course:	Undergraduate level knowledge of any branch of engineering	
Course Objectives:	The course aims to provide the student with an: 1. Understanding of the various features of project management 2. Explanation of the relevance of human resource planning and management 3. Describes the importance of procurement planning, cost estimation, and quality management. 4. Detailed explanation on time and risk management.	
Content:		**No. of Hours**
Unit-1	**Overview on Project Management**: Need for Project Management, Project Life Cycle and its Phases, Scope of the project, requirements and scope, Organizational Influences, Project Management Plan, Integrated Change Control Plan, Agile Project Management and Lean Project Management, Project selection and portfolio management. **Economics & Cost Management**: Time Value of Money, Cost-Benefit Ratio, Cost estimation, methods of preparing estimates, budgeting, Cost monitoring and Control, cost on completion.	**10**
Unit-2	**Human Resource Management,** Planning Human Recourses, Acquiring human resources, developing and strategizing deployment of resources, leadership qualities, team management – motivation, monitoring and control, conflict management and interpersonal relationship management. Importance of Communication and communication management – tools and techniques; basic human fundamentals, ethics and professional conduct,	**12**
Unit-3	**Procurement Management**- Planning, Implementation – Monitoring and control of goods and services; Stakeholders Management, Contracts drafting, preparation, approval, implementation and closure. **Quality Management:** Introduction, quality planning tools and techniques, quality monitoring and control, tools and techniques,	**13**
Unit-4	**Time Management**: Purpose of Time Management, Time Planning, different methods of activity planning, milestones,	**10**

	resource assignment and time lines. Time monitoring and control - different types of charts; Path Planning – forward, backward, critical, lag and lead time lines. **Risk Management** – Risk Identification, Risk Qualitative Analysis, Risk Quantitative Analysis, Risk Response, Monitoring and Control	
Pedagogy	Interactive learning, reflective thinking, critical analysis, and problem-solving.	
References/ Readings:	1. J.Michael Bennet, Danny S.K.Ho, 'Project Management for Engineers', World Scientific Publishing, 2014, ISBN: 13-978-981444-7928. 2. J. M. Nicholas, Herman Steyn, 'Project Management for Engineering, Business and Technology, 6th Edn, Taylor & Francis Publications, 2021, ISBN: 978-0-367-277730-7 3. Neil G Siegel, Engineering Project Management, Wiley Publications, 2019, ISBN: 9781119525769. 4. Khanna.R.B., Project Management, PHI Publishing, 2011, ISBN: 978-81-203-4288.	
Course Outcomes:	After going through this course, student will be able to: CO 1. Explain the importance of Project Management CO 2. Describe the various components of Project Management CO 3. Analyze the importance of cost, human resource, procurement, quality, time and risk management CO 4. Apply project management knowledge in their professional life.	

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Name of the Programme : Master of Engineering (Data Sciences)
Course Code : GEC-684
Title of the Course : Project Management Lab
Number of Credits : 01
Effective from AY : 2024-25

Pre-requisites for the Course:	Undergraduate level knowledge of any branch of engineering	
Course Objectives:	The course aims to provide the student with an: 1. Understanding of the various features of project management 2. Explanation of the relevance of applying project management knowledge to any one domain 3. Describes the advantages of applying project management tools & techniques to address specific problems 4. Ability to prepare reports and presentation on specific areas by applying knowledge of Project Management	
Content:		**No. of Hours**
	Project Management is applicable to all types of Human Activities. Every Student has to choose ANY TWO topics, prepare a detail report and presentation, based relevant literature, field visits and data collection, interaction with experts in the local region or State of Goa. The student shall apply project management knowledge to any ONE topics given below, the list is only indicative, students can choose topics from related / allied areas: (1) Large construction site (on-going projects) – residential, commercial, highways, ports, airports (2) Large Manufacturing Industry in any of the Industrial Areas in Goa, scaling up production, sales / marketing. (3) Waste Management; Water Management; (4) Application of Project Management to Law Enforcement (5) Project Management in Education – infrastructure, skill training (6) Project Management as applied to consumer goods / supplies (7) Manpower Management in the context of AI in software industry (8) Project Management – Global markets for local products using Digital Marketing platforms (9) Project management for Logistics and Transportation (10) Project management for Hospital & Health Management	**30**
Pedagogy	Instructional learning, Inquiry based learning, Constructive learning,	

	Collaborative learning and problem solving
References/ Readings:	1. J.Michael Bennet, Danny S.K.Ho, 'Project Management for Engineers', World Scientific Publishing, 2014, ISBN: 13-978-981444-7928. 2. J. M. Nicholas, Herman Steyn, 'Project Management for Engineering, Business and Technology, 6th Edn, Taylor & Francis Publications, 2021, ISBN: 978-0-367-277730-7 3. Neil G Siegel, Engineering Project Management, Wiley Publications, 2019, ISBN: 9781119525769. 4. Khanna.R.B., Project Management, PHI Publishing, 2011, ISBN: 978-81-203-4288.
Course Outcomes:	After going through this course, student will be able to: CO 1. Understanding of the various features of project management CO 2. Explanation of the relevance of applying project management knowledge to any one domain CO 3. Describes the advantages of applying project management tools & techniques to address specific problems CO 4. Ability to prepare reports and presentation on specific areas by applying knowledge of Project Management

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Semester IV

Generic Elective (GE) Courses

Name of the Programme : Master of Engineering (Data Sciences)
Course Code : GEC-685
Title of the Course : Financial Management
Number of Credits : 04
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic knowledge of Finance, Economics	
Course Objectives:	The course aims to provide the student with an: 1. Understanding of Financial Systems and Its Management 2. Explanation of Financial Planning, Fund Flow and Cost Analysis 3. Analysis of Capital & Working Capital Management, Valuation, Long Term Financing 4. Description of product cost analysis, break even analysis and investment management.	
Content:		**No. of Hours**
Unit-1	**Financial Management: An Overview –** Types of Business organizations, Fundamental principle of finance. **The Financial System-** Functions, Financial Assets and Markets, **Financial Statements, Taxes, and Cash Flow**- Balance Sheet, Profit and loss Account, Profits Vs Cash Flow, Taxes; Financial decision making.	**15**
Unit-2	**Financial Statement Analysis**- Financial Ratios- Liquidity Ratios, Leverage & Profitability Ratios; **Fund Flow Analysis** - Fund Flow Statement; **Breakeven Analysis and Leverages**- Cost Volume Profit Analysis; **Financial Planning & Forecasting-** Financial Planning, Sales Forecast; **Cost Analysis-** Determination of product cost, overhead cost, volume and profits, planning and control on costs and decision making using costs.	**16**
Unit-3	**Fundamental Valuation Concepts -**The Time Value of Money, Risk and Return. **Capital Budgeting -**Techniques of Capital Budgeting – Capital Budgeting Process, project classification; cash flows, risk analysis, cost of capital; **Investment Criteria**- Net Present value, Benefit Cost Ratio, Internal Rate of return, Payback Period, Accounting rate of Return.	**15**

Unit-4	**Working Capital Management** -Working Capital Policy, Cash and Liquidity Management, Credit Management, Inventory Management, Working Capital Financing; **Corporate Valuation:** Debt analysis and management, Leasing, Hire Purchase, Valuation, Mergers, acquisitions and Restructuring; **Long Term Financing:** Sources of Long Term Finance, Raising Long Term Finance.	**14**
Pedagogy	Interactive learning, reflective thinking, critical analysis, and problem-solving.	
References/ Readings:	1. Prasanna Chandra "Financial Management: Theory and Practice" 11th Edition, McGraw Hill Education Publishers, 2023, ISBN: 978-9355-322-203 2. Pandey I.M., Finance- A Management Guide for Managing Company Funds and Profits, Prentice Hall India Publications, 1995, ISBN:978-8120-309-180 3. Van Horne, J.C, "Fundamentals of Financial Management", 13th Edition, Pearson Publications, 2015, ISBN:978-933-255-8670. 4. Khan, M.Y. and Jain, P.K., "Financial Management", 8th Edition, McGraw-Hill Education Publishers, 2018, ISBN:978-9353-1622-184	
Course Outcomes:	After going through this course, student will be able to: CO 1. Understand the Financial Systems and Its Management CO 2. Explain Financial Planning, Fund Flow and Cost Analysis CO 3. Analyze Capital & Working Capital Management, Valuation, Long Term Financing CO 4. Describe product cost analysis, break even analysis and investment management.	

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Name of the Programme : **Master of Engineering (Data Sciences)**
Course Code : **GEC-686**
Title of the Course : **Entrepreneurship**
Number of Credits : **04**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Basic knowledge of Creative Thinking, Innovation, Finance, Economics	
Course Objectives:	The course aims to provide the student with an: 1. Understanding of entrepreneurial skill sets and different types of entrepreneurship. 2. Explanation of Differences between New Enterprise, Social Enterprise and Family Business 3. Describes the process of preparing business plan, operational plans to start an enterprise 4. Apply the knowledge of market analysis, product planning, customer requirements, costing and finance	
Content:		**No. of Hours**
Unit-1	**Entrepreneurial Characteristics:** Overview on Entrepreneurship, Broad classification of entrepreneurs; Leadership, Goal Setting, Time and resource Planning, Communication, Networking, Knowledge & Skill Upgradation; Awareness of Social and Industrial Eco-system; Awareness of Government Policies and Schemes; Digital marketing and business promotion; Local and global market; Basic understanding of Legal and regulatory system, Intellectual Property Rights; Financial Literary; Decision making and risk taking abilities	**18**
Unit-2	**Creation of New Enterprise:** Creativity, Innovation, technology, wealth creation, social impact, Team building, Business Plan, project formulation and feasibility analysis; business simulation; designing and configuring business models and customers, Enterprise management tools and techniques; Launching and managing enterprises; Sales & Marketing Strategies; Human Resources; Incubation, Costing and Financial Plans, Case Studies	**14**
Unit-3	**Social Entrepreneurship:** Overview**,** project formulation and feasibility analysis; understanding customer needs, positioning the firm for social change and strategic advantage; social business model; participatory development; stakeholders; social impact assessment; networking; regional economic models; banking and loans; Women Entrepreneurship; Case Studies	**14**

Unit-4	**Family Business Management :** Small and Medium Business Enterprises; Growth plan formulation; Vision, Values and Strategies, Turn around strategies, cost management, finance and liquidity, family to corporate culture; Case Studies;	**14**
Pedagogy	Interactive learning, reflective thinking, critical analysis, and problem-solving.	
References/ Readings:	1. Nagasubba Rayudu, 'A Textbook on Entrepreneurship & Incubation', Mahi Publications, 2023, ISBN: 978811949282 2. Balasubramanya. M.H., 'Entrepreneurial Ecosystems for Tech Startup in India', Verlag Max Publications, 2021, 9783110679298. 3. Kenji Uchino, 'Entrepreneurship for Engineers', CRC Press, 2010, ISBN: 978143980063 4. Ryszard Praszkier, Andrzej Nowak, 'Social Entrepreneurship', Theory and Practice, Cambridge University Press, 2011, ISBN 9781139504331 5. Peter Leach, Tatwamasi Dixit, 'Indian Family Business Mantras', Rupa Publications, 2016, ISBN: 9788129136945 6. Bill Bolton, John Thompson, 'Entrepreneurs – Talent, Temperament, Opportunity', Elsevier Publications, 2004, ISBN:0750661283 7. John Bessant, Joe Tidd, 'Entrepreneurship', John Wiley Publications, 2015, ISBN: 9781118993095	
Course Outcomes:	After going through this course, student will be able to: CO 1. Understand entrepreneurial skill sets and different types of entrepreneurship. CO 2. Classify New Enterprise, Social Enterprise and Family Business CO 3. Explain process of preparing business plan, operational plans to start an enterprise CO 4. Apply the knowledge of market analysis, product planning, customer requirements, coting and finance	

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