



M Sc.-Data Science with Logistic and Supply Chain Management – (2 Years)

CURRICULUM AND SYLLABUS

(From 2026 Admission Onwards)

Program Outcomes

PO1 Knowledge in Basic Data Science, Logistic and Supply Chain Management: Understand the basic concepts, fundamental principles and the scientific theories related to Data Science, Logistic and Supply Chain Management.

PO2 Abstract thinking: Ability to absorb and understand the abstract concepts that lead to various advanced theories in mathematics and Statistics.

PO3 Modelling and solving: Ability in modelling and solving problems by identifying and employing the appropriate existing theories and methods.

PO4 Advanced theories and methods: Understand advanced theories and methods to design solutions for complex logistics problems.

PO5 Applications in Industries: Understand the role of data analytics and apply the same to solve the real time industrial problems in logistic and supply chain industries.

PO6 Modern software tool usage: Acquire the skills in handling scientific tools towards solving problems and solution analysis in Data Science.

PO7 Environment and sustainability: Understand the significance of preserving the environment towards sustainable development.

PO8 Ethics: Imbibe ethical, moral and social values in personal and social life leading to highly cultured and civilized personality. Continue to enhance the knowledge and skills in applied statistics and data analytics for constructive activities and demonstrate highest standards of professional ethics.

PO9 Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10 Communication: Develop various communication skills such as reading, listening, speaking and discussing which will help in expressing ideas and views clearly and effectively.

PO11 Project management and Research: Demonstrate knowledge, understand the scientific and management principles and apply these to one's own work, as a member/ leader in a team to manage projects and multidisciplinary research environments. Also use the research-based knowledge to analyse and solve advanced problems in data sciences.

PO12 Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Curriculum

Semester -I

Course code	Course	L T P	Credit	ES
26DLS501	Linear Algebra	3 0 2	4	A
26DLS502	Probability and Statistics	3 0 2	4	B
26DLS503	Logistic	3 0 2	4	C
26DLS504	Optimization Techniques	3 1 0	4	D
26DLS505	Foundation of Data Science with R Programming	3 0 2	4	E
26DLS506	Python Programming	3 0 2	4	F
22ADM501	Glimpses of Indian Culture	2 0 1	P/F	G
Total			24	

Semester -II

Course code	Course	L T P	Credit	ES
26DLS511	Supply Chain Management	3 0 2	4	A
26DLS512	Advanced Data Mining	3 0 2	4	B
26DLS513	Machine Learning	3 0 2	4	C
26DLS514	Information System Management	3 1 0	4	D
26DLS515	Pricing and Revenue Management	3 1 0	4	E
26DLS516	Warehouse and Production Management	3 1 0	4	F
	Amrita Value Programme	1 0 0	1	G
25AVP501	Mastery Over Mind	1 0 2	2	
26CUL500	Integrated Amrita Meditation Technique	0 0 2	1	
	Total		28	

Semester III

Course code	Course	L T P	Credit	ES
26DLS601	Inventory and Marketing Management	3 1 0	4	A
26DLS602	Deep Learning	3 0 2	4	B
	Elective I	3 0 0	3	D
	Elective II	3 0 0	3	E
	Elective III	3 0 0	3	F
	Total		17	

Semester IV

Course code	Course	L T P	Credit	ES
26DLS699	Dissertation		10	P
	Total		10	

Total credits for the programme: 78

ELECTIVES (any three)

Course code	Course	L T P	Credit	ES
26DLS631	Pattern Recognition	3 0 0	3	D/E
26DLS632	Stochastic Process	3 0 0	3	D/E
26DLS633	Queuing Theory	3 0 0	3	D/E
26DLS634	Survival Analysis	3 0 0	3	D/E
26DLS635	Sampling Techniques	3 0 0	3	D/E
26DLS636	Demography and Actuarial Statistics	3 0 0	3	D/E
26DLS637	Official Statistics	3 0 0	3	D/E
26DLS638	Reinforcement Learning	3 0 0	3	D/E
26DLS639	Social Network Analytics	3 0 0	3	D/E
26DLS640	Mining of Massive Datasets	3 0 0	3	D/E
26DLS641	Parallel and Distributed Systems	3 0 0	3	D/E
26DLS642	Taguchi Techniques	3 0 0	3	D/E
26DLS643	Special Distribution Functions	3 0 0	3	D/E

**** Amrita Value Programme**

22ADM502	Vedanta in day-to-day life	1-0-0	1
22AVP506	Message of Swami Vivekananda	1-0-0	1
22AVP508	Indian Arts and Literature	1-0-0	1
22AVP510	Appreciation of Kerala Mural Arts Forms	1-0-0	1
22AVP501	Message of Śrī Mātā Amritanandamayī Devī	1-0-0	1
22AVP502	Insights from the Ramayana	1-0-0	1
22AVP503	Insights from the Mahabharata	1-0-0	1
22AVP504	Insights from the Upanishads	1-0-0	1
22AVP505	Insights from Bhagavad Gita	1-0-0	1
22AVP512	Ancient Indian Science and Technology	1-0-0	1
22AVP507	Great Spiritual Teachers of India	1-0-0	1
22AVP509	Yoga and Meditation 1	1-0-0	1

Evaluation Pattern:

S.No	Course Type	Theory / Lab	Mid Term marks	CA marks	End Semester marks
1	Theory / Theory with Lab courses	Theory	30	30	40
3	Lab courses (0- 0- 2- 1)	Lab	-	60	40

Syllabus

Semester-I

26DLS501

Linear Algebra

3 0 2 4

Course Outcomes	
CO1	To understand the axioms in the definition of a vector space, subspaces, basis, dimension; To learn to change the basis.
CO2	To understand and compute inner products, the length of a vector, angle and distance between vectors, orthogonal complement, projection and orthonormal basis from any arbitrary basis. To learn the least square principle.
CO3	To understand the concepts of linear transformations and matrices for linear transformations.
CO4	To understand the concepts of eigen values, eigen vectors and diagonalization.
CO5	To learn to decompose matrices using various techniques.

Unit I General Vector Spaces: Real Vector Spaces - Sub Spaces - Linear Independence – Coordinates and Basis – Dimension-Change of Basis. **(10 Hrs)**

Unit II Inner Product Spaces: Inner Products – Angles, Length and Distance-Orthogonality-Orthogonal Complements – Orthogonal Projections -Orthogonal Basis- Gram Schmidt Process-Least Square Principle. **(Case Study)** **(15 Hrs)**

Unit III Linear Transformations: General Linear Transformation – Kernel and Range of a Linear Transformation - Compositions and Inverse of Linear Transformation - Matrices of Linear Transformations – Positive Definite Matrices - Symmetric and Skew Symmetric Matrices-Matrix Norm. **(15 Hrs)**

Unit IV Eigen values and Eigen vectors: Problems in Eigen Values and Eigen Vectors, Orthogonal Diagonalization, Quadratic Forms, Diagonalizing Quadratic Forms. **(10 Hrs)**

Unit V LU, QR and Singular Value decompositions. **(10 Hrs)**

TEXT BOOKS

1. Howard Anton and Chris Rorres, "Elementary Linear Algebra with Supplemental Applications", 11th Edition, John Wiley & Sons, Inc., 2016.
2. Gilbert Strang, "Introduction to Linear Algebra", 5th Edition, Wellesley-Cambridge Press, 2016.

REFERENCES

1. Kenneth Hoffmann and Ray Kunze, "Linear Algebra" Second Edition, Prentice Hall, 1971.
2. Mike Cohen, Practical Linear Algebra for Data Science, O'Reilly Media, Inc., Publisher, 2022.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	3	3		2						2	3
CO2	3	3	3	2	2	3					3	3
CO3	3	3	3	2	2	2					2	2
CO4	3		3	3	3	3					3	3
CO5	3		3	2	2	3					2	2

26DLS502

Probability and Statistics

3 0 2 4

Course Outcomes	
CO1	Understand the basics of probability and random variables.
CO2	Gain knowledge about standard statistical distributions and their properties
CO3	Apply and analyse problems based on hypothesis testing
CO4	Understand the concept of ANOVA and analyse them using real time data set

Unit I

Sample Space and Events, Interpretations and Axioms of Probability, Addition rules, Conditional Probability, Multiplication and Total Probability rules, Independence, Bayes theorem. Random variables, Probability Distributions and Probability mass functions, Cumulative Distribution functions, mathematical expectation, variance .

(20 Hrs)

Unit II

Standard discrete distributions - Binomial, Poisson, Uniform, Geometric distributions, Negative binomial and Hypergeometric Distributions -Standard continuous distributions - Uniform, Exponential and Normal distributions, Correlation and Regression. **(20 Hrs)**

Unit III

Tests of Hypotheses: General Procedure for Hypothesis Tests, Problems based on large sample tests and small sample tests - Z, t, F test and chi-square tests. Analysis of variance- One way classification, Two-way classification, Latin square design. **(20 Hrs)**

TEXT BOOKS

1. Douglas C. Montgomery and George C. Runger, Applied Statistics and Probability for Engineers, John Wiley and Sons Inc., 2005
2. Amir D Azcel, Jayavel Sounderpandian, Palanisamy Saravanan and Rohit Joshi, Complete Business Statistics, 7th edition McGrawHill education 2012.
3. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye, Probability and Statistics for Engineers and Scientists, 8th Edition, Pearson Education Asia, 2007.

REFERENCES

1. Ross S.M., Introduction to Probability and Statistics for Engineers and Scientists, 3rd edition, Elsevier Academic Press.
2. Ravichandran, J. Probability and Statistics for engineers, First Reprint Edition, Wiley India, 2012.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3	3	3					2
CO2	3	3	2	2	3	3	3					2
CO3	3	3	2	2	3	3	3					2
CO4	3	3	2	2	3	3	3					2

	Course Outcomes
CO01	Understand various concepts and critical elements in the logistics framework
CO02	Apply the logistics framework to enable enterprises improve business performance, provide customer value and achieve competitive advantage
CO03	Apply the logistics network to optimize the supply chain and transform them to ICT enabled, green and circular value chains using relevant technology tools and software
CO04	Analyse the logistics distribution systems to reduce the transportation, warehousing and supply chain costs as also address inefficiencies

Unit I:

Logistics: Logistics, SCM & competitive strategy, Competitive advantage, Value chain, Logistics & customer value: Marketing & logistics interface, customer service, out-of-stock, customer retention, customer-service priorities, service standards, market-driven supply chains, Logistics cost: Costing, Cost analysis, Logistics & bottom line, Shareholder value, Profitability analysis, Cost drivers, ABC analysis

(20 Hrs)**Unit II:**

Matching Supply & Demand: Lead-time gap, Demand forecasting & management, CPFR, Supply Chain fulcrum, Responsive Supply Chain: Push & pull, Agility, Responsiveness, Strategic lead-time management: Lead-time concepts, pipeline management, Risk Management: Developing a risk profile, Managing risk, Achieving supply chain resilience, 3PL to 4PL, Supply Chain Integration: Developing the logistics organization, Logistics as the vehicle of change, Logistics core card .

(20 Hrs)**Unit III:**

Synchronous Supply Chain: Extended enterprise, Virtual supply chain, Bull whip effect, QR logistics, Logistics system dynamics, AI, ML, Data science & block chain for logistics, Globalization: Visibility in the global pipeline, sourcing. Sustainable supply chains: Triple bottom line, Green supply chains and reducing carbon footprint.

(20Hrs)**Text Book**

1. Martin Christopher, Logistics and Supply Chain Management, Prentice-Hall, 2011.

Reference Books

2. Donald J. Bowersox & David J. Closs: Logistical Management, Tata McGraw Hill Publishing Co. Ltd, New Delhi, 2004.
3. Satish C. Ailawadi & Rakesh Singh: Logistics Management, Prentice-Hall of India Pvt Ltd., New Delhi, 2005.
4. Sunil Chopra, Peter Meindl, 'Supply Chain Management', Pearson Education, 2016

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3	3	3					2	1
CO2	3	3	2	2	3	3	3					2	1
CO3	3	3	2	2	3	3	3					2	2
CO4	3	3	2	2	3	3	3					2	2

26DLS504

Optimization Techniques

3 1 0 4

Course Outcomes	
CO1	To learn Linear Programming Problems.
CO2	To learn single variable optimization techniques
CO3	To understand the basics of unconstrained optimization problems and direct search, unidirection search methods for multivariable problems.
CO4	To learn the various unconstrained optimization techniques for multivariable.
CO5	To understand and solve the nonlinear optimization problem with equality and inequality constrained problems and to learn theory of few significant genetic evolutionary algorithms.

Unit I: Introduction to LPP: Lines and hyperplanes, Convex sets, Convex hull, Formulation of a Linear Programming Problem, Linear Programming Problem; Graphical Method; Simplex method.

(10 Hours)

Unit II: Introduction to optimization: classical optimization, Optimality criteria – Necessary and sufficient conditions for existence of optimum point. Fundamental Region Elimination Rules to eliminate a region. One-dimensional Search methods: Golden search method, Fibonacci method, Newton's Method.

(12 Hours)

Unit III: Unconstrained Multivariable optimization: Introduction, Necessary and sufficient conditions for existence of extreme point. Conditions for local minimization. Direct search methods: unidirectional search, box evolutionary search method.

(12 Hours)

(12 Hours)

(14 Hours)

Text Book

1. Edwin K.P. Chong, Stanislaw H. Zak, “An Introduction to Optimization”, 2nd edition, Wiley, 2013.

Reference Books

1. Mokhtar S. Bazarrar, Hamit D Sherali, C.M. Shetty, “Nonlinear programming Theory and applications”, 2nd edition, Wiley , 2004.
2. Mohan C. Joshi and Kannan M. Moudgalya, Optimization: Theory and Practice, Narosa Publishing House, New Delhi, 2004 (Reference)
3. Kalyanmoy Deb, “Optimization for Engineering Design Algorithms and Examples”, Prentice Hall of India, New Delhi, 2004.
4. S.S. Rao, “Optimization Theory and Applications”, Second Edition, New Age International (P) Limited Publishers, 1995.
5. Bertsimas, Dimitris, and John Tsitsiklis. *Introduction to Linear Optimization*. Belmont, MA: Athena Scientific, 1997.

CO-PO Mapping

[illegible]

Course Outcomes	
CO1	Understand different data structures including factors, lists, data frames, and matrices. Also develop skills in importing, managing, and handling datasets from multiple data sources
CO2	Apply exploratory data analysis on real time datasets and implement data visualization techniques for creating meaningful and informative graphs using R.
CO3	To foster the ability to tackle real-world data problems and derive actionable insights using R based on statistical analysis.

Unit I

Overview of R software, Introduction to R Studio: R command Prompt, R script file, Handling Packages in R: Installing a R Package, Basic commands to get started and Special functions , Data Types, Vectors, Lists, Matrices, Arrays, Factors, String functions , Data Frame , Loading and handling Data in R, Writing into a CSV File and Reading from Excel file.

(24 Hrs)**Unit II**

Descriptive Statistics: Data Range, Frequencies, Mode, Mean and Median, variance, Standard Deviation, Data Visualization Using R- Pie Charts, R Histograms – Density Plot , Bar Charts, Line Chart, Scatterplot, Box Plot, drawing line, circle, rectangle and triangle .Classification and Tabulation of Data , Diagrammatic and Graphic representation of data, Measure of central tendency or averages, Measure of dispersion, Skewness and Kurtosis.

(18 Hrs)**Unit III**

Statistical Analysis Using R : Standard discrete distributions - Binomial, Poisson, Uniform, Geometric distributions, Standard continuous distributions - Uniform, Exponential and Normal distributions, Correlation and Regression . Case studies related logistic and supply chain management.

(18 Hrs)**Text books / Reference Books**

1. Norman Matloff : The Art of R Programming, Norman Matloff, Cengage Learning: Efficient R Programming:
A tool of statistical software design , First edition, No Starch Press, 2011.
2. Jared P. Lander , : R for Everyone: Advanced Analytics and Graphics, Second Edition, Pearson Education
3. Hadley Wickham and Garrett Gorlemund : R for Data Science, First edition, O'Reilly
4. Winston Chang : R Graphics Cookbook: Practical Recipes for Visualizing Data, Second Edition , Shroff/O'Reilly
5. Nina Zumel and John Mount : Practical Data Science with R, Dream tech Press/Manning Publications.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	2					1	1
CO2	3	3	3	2	3	2					1	1
CO3	3	3	3	2	2	2					1	1
CO4	3	2	2	1	2	1					1	1

26DLS506

Python Programming

3 0 2 4

Course Outcomes	
CO1	Understand the basic data types, operators, expressions, conditions and looping statements
CO2	Understand and apply data structure concepts and function calls in Python
CO3	Familiarise with functions, modules, packages and libraries in Python
CO4	Execute the Python programme for data cleaning and reading data from different file formats.
CO5	Understand and apply various Data Visualization plots

Unit – I: Introduction: History of Python, Need of Python Programming, Applications Basics of Python Programming, Running Python Scripts, Installing Python on Your Computer, Using the Terminal Command Prompt, IDLE, and Other IDEs, Variables, Assignment, Keywords, Input-Output, Indentation. Types, Operators and Expressions: Types - Integers, Strings, Booleans; Operators- Arithmetic Operators, Comparison (Relational) Operators, Assignment Operators, Logical Operators, Bitwise Operators, Membership Operators, Identity Operators, Expressions and order of evaluations Control Flow- if, if-elif-else, for, while, break, continue, pass .Case Study: An Investment Report and Approximating Square Roots. **(12 Hrs)**

Unit – II: Data Structures: Lists - Operations, Slicing, Methods; Tuples, Sets, Dictionaries, Sequences Comprehensions. Case Study: Nondirective Psychotherapy. **(12 Hrs)**

Unit – III: Functions: Defining Functions, Calling Functions, Passing Arguments, Keyword Arguments, Default Arguments, Variable-length arguments, Anonymous Functions, Fruitful Functions (Function Returning Values), Scope of the Variables in a Function - Global and Local Variables.

Modules: Creating modules, import statement, from. Import statement, name spacing. Python packages: Introduction to PIP, Installing Packages via PIP, Using Python Packages. Text Files: Text Files and Their Format, Writing Text to a File, Writing Numbers to a File, Reading Text from a File, Reading Numbers from a File, Accessing and Manipulating Files and Directories on Disk. Case Study: Gathering Information from a File System. **(12 Hrs)**

Unit – IV: Data Gathering and Cleaning: Cleaning Data, Checking for Missing Values, Handling the Missing Values, Reading and Cleaning CSV Data, Merging and Integrating Data, Reading Data from the JSON Format.

Regular expressions: Character matching in regular expressions, Extracting data using regular expressions, Combining searching and extracting and Escape character. Case Study: Detecting the e-mail addresses in a text file. **(12 Hrs)**

Unit – V: Popular Libraries for Data Visualization in Python: Matplotlib, Seaborn, Plotly, Geoplotlib, and Pandas. Data Visualization: Direct Plotting, Line Plot, Bar Plot, Pie Chart, Box Plot, Histogram Plot, Scatter Plot, Seaborn Plotting System, Strip Plot, Box Plot, Swarm Plot, Joint Plot, Matplotlib Plot, Line Plot Bar Chart, Histogram Plot, Scatter Plot, Stack Plot and Pie Chart. **(12 Hrs)**

Text Books/ Reference Books:

1. Chun, W. (2006) Core python programming. Prentice Hall Professional.
2. Embarak, O. (2018). Data Analysis and Visualization Using Python: Analyze Data to Create Visualizations for BI Systems. Apress.
3. Lambert, K. A. (2011). Fundamentals of Python: First Programs. Cengage Learning.
4. Severance, C. (2013). Python for informatics: Exploring information. Create Space.
5. <https://www.w3schools.com/python>
6. Learning Python, Mark Lutz, Orielly
7. Python Programming: A Modern Approach, Vamsi Kurama, Pearson
8. VanderPlas, J. (2016). Python data science handbook: Essential tools for working with data. " O' Reilly Media, Inc."

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	2	2	2	2					3	2
CO2	2	3	2	2	2	2	2					3	2
CO3	2	3	1	2	2	3	3					3	2
CO4	2	2	1	2	2	2	3					3	2
CO5	2	2	1	2	2	2	3					3	2

Introduction: Love is the substratum of life and spirituality. If love is absent life becomes meaningless. In the present world if love is used as the string to connect the beads of values, life becomes precious, rare and beautiful like a fragrant blossom. Values are not to be learned alone. They have to be imbibed into the inner spirit and put into practice. This should happen at the right time when you have vitality and strength, when your hearts are open.

The present course in value education is a humble experience-based effort to lead and metamorphosis the students through the process of transformation of their inner self towards achieving the best. Amma's nectarous words of wisdom and acts of love are our guiding principles. Amma's philosophy provides an insight into the vision of our optimistic future.

1. Invocation, Satsang and Question - Answers
2. Values - What are they? Definition, Guiding Principles with examples Sharing own experiences
3. Values - Key to meaningful life. Values in different contexts
4. Personality - Mind, Soul and Consciousness - Q and A. Body-Mind-Intellect and the Inner psyche Experience sharing
5. Psychological Significance of samskara (with e.g. From Epics)
6. Indian Heritage and Contribution and Q and A; Indian Ethos and Culture
7. Self-Discipline (Evolution and Practice) – Q and A
8. Human Development and Spiritual Growth - Q and A
9. Purpose of Life plus Q and A
10. Cultivating self-development
11. Self effort and Divine Grace - their roles – Q and A; - Vedanta and Creation – Understanding a spiritual Master
12. Dimensions of Spiritual Education; Need for change Lecture – 1; Need for Perfection Lecture - 2
13. How to help others who have achieved less - Man and Nature Q and A, Sharing of experiences

REFERENCES:

1. Swami Amritaswaroopananda Puri - Awaken Children (Volume VII and VIII)
2. Swami Amritaswaroopananda Puri - Amma's Heart
3. Swami Ramakrishnanda Puri - Rising Along the Razor's Edge
4. Deepak Chopra - Book 1: Quantum Healing; Book 2: Alpha and Omega of God; Book 3: Seven Spiritual Rules for Success
5. Dr. A. P. J. Abdul Kalam- 1. Ignited Minds 2. Talks (CD)
6. Swami RamakrishnandaPuri - Ultimate Success
7. Swami JnanamritanandaPuri - Upadesamritham (Trans: Malayalam)
8. Vedanta Kesari Publication - Values - Key to a meaningful life
9. Swami Ranganathananda - Eternal values for a changing society
10. David Megginson & Vivien Whitaker - Cultivating Self Development

11. Elizabeth B. Hurlock - Personality Development, Tata McGraw Hill
12. Swami Jagatatmananda - Learn to Live (Vol.1 and 2), RK Ashram, Mylapore

Semester – II

26DLS511

Supply Chain Management

3 0 2 4

CO	Course Outcomes
CO01	Understand various concepts, drivers and key metrics in the supply chain management framework
CO02	Evaluate single and multiple facility location problems, vehicle routing and scheduling models
CO03	Develop the appropriate supply chain through distribution requirement planning and strategic alliances
CO04	Evaluate packing, packaging, and transportation models and modes so as to reduce transportation, warehousing and supply chain costs as also address inefficiencies
CO05	Identify the issues in global supply chain management, procurement and outsourcing strategies

Unit I:

Introduction: Introduction to Supply Chain Management (SCM), Complexity and key issues in SCM, Location strategy, Facility location decisions, Single facility and multiple location models Supply Chain Integration: Supply chain integration, Distributed strategies, Push versus pull systems. Distribution Requirements Planning (DRP) and demand forecasting, DRP and master production scheduling, DRP techniques – time-phased order point, managing variations in DRP, Strategic alliances, Third party logistics, Distribution integration. **(20 Hrs)**

Unit II:

Basics of Transportation, Transportation Functionality and Principles, Multimodal Transport, Modal Characteristics, Modal Comparisons, Vehicle routing and scheduling models, Traveling salesman problems, Exact and heuristic methods, International Air Cargo Transport; Coastal and Ocean transportation, Characteristics of shipping transport, Types of Ships, Containerization Basics of Packing and Packaging: Packing for Storage, Product content Protection, Packaging Types: Primary, Secondary and Tertiary- Requirements of Consumer Packaging, Channel Member Packaging and Transport Packaging - Shrink packaging –Identification codes, Universal Product Code- GS1 Standards- package labels- Symbols used on packages and labels. **(20 Hrs)**

Unit III:

Issues in SCM: Procurement and outsourcing strategies, Framework of e-procurement, International issues in SCM, Regional differences in logistics, coordinated product and supply chain design, Customer value and SCM, Omnichannel supply chains **(20 Hrs)**

Text Book

1. Simchi-Levi,D., Kaminsky,P., Simchi-Levi, E., Shankar, R., ‘Designing and Managing the Supply Chain: Concepts, Strategies, and Cases’, Tata McGraw Hill, 2008.

Reference Books

2. Sunil Chopra, Peter Meindl, ‘Supply Chain Management’, Pearson Education, 2016
3. Martin Christopher, Logistics and Supply Chain Management, Prentice-Hall, 2011.
4. Donald J. Bowersox & David J. Closs: Logistical Management, Tata McGraw Hill Publishing Co. Ltd, New Delhi, 2004.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	2					1	1
CO2	3	3	3	2	2	2					1	1
CO3	3	3	3	2	3	2					1	1
CO4	3	3	3	2	2	2					1	1
CO5	2	3	3	1	2	2					1	1

26DLS512

Advanced Data Mining

3 0 2 4

Course Outcomes	
CO1	Understand the basic concepts of data mining and apply association rule mining to the real-life problems.
CO2	Gain and apply the knowledge to classify the data and apply them to datasets
CO3	Group the data using various clustering techniques
CO4	Gain knowledge on Link analysis , Graph mining, temporal mining
CO5	Knowledge on Text mining, web mining and social networks

Unit I

Data Mining : Steps in Data mining process, Data Mining Functionalities, Architecture of a Typical Data Mining Systems, Association rule mining, Various Kinds of Association Rules, Market Basket Analysis, Apriori Algorithm,, FP growth, ECLAT **(12 Hrs)**

Unit II

Classification Data mining :Classification and Prediction – Basic concepts– Bayesian classification, Rule– based classification, Ensemble learning, pattern classification, neural networks -metric learning
(12 Hrs)

Unit III

Clustering Data mining–Types of Data in Cluster Analysis–Categorization of Major Clustering Methods– Partitioning Methods, Hierarchical Methods– Density–Based Methods, Grid–Based Methods, Modelling based, clustering high dimensional data.
(12 Hrs)

Unit IV

Link Analysis: Page Rank, Efficient Computation of Page Rank, Topic Sensitive Page Rank, Link Spam, Hubs and Authorities. Graph mining - Graph representation learning, node embeddings, Graph Neural network, Knowledge graph mining Introduction to spatial mining – Construction of spatial data cubes , spatial classification and clustering, Temporal Data Mining , Temporal Association Rule
(12 Hrs)

Unit V

Text Data mining: TF-IDF, N-grams, Word embeddings, Transformer models, topic modelling, semantic mining , sentiment mining. Introduction to social network and web mining.
(12 Hrs)

TEXT BOOKS

1. By Richard J. Roiger "Data Mining A Tutorial-Based Primer", Second Edition, 2017 Hall/CRC.
2. Jiawei Han, Micheline Kamber and Jian Pei "Data Mining Concepts and Techniques", Third Edition, Elsevier, 2011.
3. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning-Data Mining, Inference, and Prediction, Second Edition, Springer Verlag, 2009
4. William L. Hamilton , "Graph Representation Learning", Synthesis Lectures on Artificial Intelligence and Machine Learning, Springer, 2020

REFERENCES

5. Dunham, Sridhar , Data Mining a: Introductory and Advanced topics, Pearson Education , India , 2002
6. Ponniah, Paulraj. *Data warehousing fundamentals: a comprehensive guide for IT professionals*. John Wiley & Sons, 2004.
7. G. K. Gupta "Introduction to Data Mining with Case Studies", Eastern Economy Edition, Prentice Hall of India, 2006.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	3	3						2
CO2	3	3	3	2	3	3						2
CO3	3	3	3	2	3	3						2
CO4	3	3	3	2	3	3						2
CO5	3	3	3	2	3	3						2

26DLS513

Machine Learning

3 0 2 4

Course Outcomes	
CO1	To be able to formulate machine learning problems corresponding to different applications.
CO2	Exploring and implementing supervised learning through regression and decision tree learning.
CO3	Understand the instance-based learning and classification methods.
CO4	Understand the Ensemble learning methods.
CO5	Exploring and implementing unsupervised learning algorithms.

Unit I

(12 Hrs)

Introduction: Well-Posed Learning Problems, designing a Learning System, A Concept Learning Task, Concept Learning as Search, Find-S: Finding a Maximally Specific Hypothesis, Version spaces and the Candidate-Elimination algorithm, Inductive Bias. Validation Metrics. Introduction to types of learning: Supervised learning, Semi-Supervised Learning, Unsupervised learning and Reinforcement Learning.

Unit II

(12 Hrs)

Classification and Regression: Learning a class from training, linear, Nonlinear, Multi Class and Multi Label classification. Regression: Simple Linear Regression, Multiple linear regression, Logistic Regression, Polynomial, and Ridge and Lasso Regression. Decision Tree learning: Introduction, Decision tree representation, Appropriate problems for decision tree learning, The

basic decision tree learning algorithm, Issues in decision tree learning, classification and regression Trees (CART), Random Forest. Validation Metrics for Classification and Regression.

Unit III

(12 Hrs)

Bayesian Learning: Naïve Bayes classifier. Instance-Based Learning: K-Nearest Neighbour Learning, Radial Basis Functions, Support Vector Machines: The Margin and Support Vectors, linear and Nonlinear Kernels.

Unit IV

(12 Hrs) Cross

Validation (CV) and resampling. Ensemble Learning: Ensemble Learning Model Combination Schemes, Maximum Voting, Averaging, Weighted Averaging, Bagging: Random Forest Trees, Boosting: Gradient Boosting, Adaptive Boosting, Extreme Gradient Boosting, XG Boosting and Adaboost, Stacking.

Unit V

(12 Hrs)

Unsupervised Learning: Clustering: K-means/Kernel K-means. Dimensionality Reduction: Principal Component Analysis (PCA) and kernel PCA. Matrix Factorization and Matrix Completion. Expectation Maximization, Gaussian Mixture Models, Case Study.

TEXT BOOKS

1. Tom M. Mitchell, Machine Learning, McGraw Hill, 1997.
2. Ethem Alpaydin, Introduction to Machine Learning, MIT Press, Prentice Hall of India, 3rd Edition, 2014.
3. Stephen Marsland, Machine Learning: An Algorithmic Perspective, Taylor & Francis (CRC), 2014.
4. Peter Flach, Machine Learning, Cambridge University Press, 2012.

REFERENCES

3. Haroon D, Python Machine Learning Case Studies, Apress, 2017.
4. Harrington, P, Machine learning in action, Manning Publications Co., 2012.
5. Richard O. Duda, Peter E. Hart and David G. Stork, Pattern classification, John Wiley & Sons, 2001.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	3					2	2
CO2	3	3	3	2	2	3					2	2
CO3	2	3	3	2	2	3					2	2
CO4	2	2	3	2	2	3					2	2

26DLS514

Information System Management

3 1 0 4

Course Outcomes	
CO1	Understand the basic concepts involved in information systems.
CO2	Understand the components of IT infrastructure including hardware, software, databases, telecommunications, and emerging technologies
CO3	Understand the concepts of Enterprise Business Systems.
CO4	Gain knowledge about e-commerce and decision support system
CO5	Gain knowledge about the role of security and ethical issues challenges of information system

Unit I

(12 Hrs)

Information Management System: Fundamental role of IS in business, Types of Information system, Information system Managing hardware and Software.

Computer Hardware: Types of Computer Systems, Input, Output, and Storage Technologies

Computer Software: Application Software, System Software.

Unit II

(12 Hrs)

Data resources Management:

Technical Foundations of Database- Fundamental Data Concepts- Database Structures- Management Managing Data Resources- Types of Databases- The Database Management Approach.

Telecommunication and Networks

Basic components in a telecommunication networks, Types of telecommunication networks – Wide area networks, Metropolitan area networks, local area networks, virtual private networks

client/server networks, peer to peer networks, digital and analog signals, wired technologies, wireless technologies, cellular and PCS systems, Telecommunication Processors.

Unit III

(12 Hrs)

Enterprise business system: Customer relationship management (CRM), Three phases of CRM, Trends, challenges and Failure of CRM, Enterprise Resource Planning (ERP), basic features, selection and implantation challenges and Failure of ERP, Supply Chain Management (SCM), challenges and Failure of SCM E-Commerce System and Decision support system

Unit IV

(12 Hrs)

Essential e- commerce processes, electronic payment process, Business to Consumer- e-commerce, Business to Business e- commerce, Decision support system (DSS) components and trends. Online Analytical Processing, Data mining for decision support. Domain of Artificial Intelligence, Components of expert system, Developing expert systems, Other Intelligence techniques: Neural networks, Fuzzy logic, Genetic algorithm .Virtual Reality and Intelligent agents.

Unit V

(12 Hrs)

Security and ethical challenges

Computer crime, Hacking and cracking- Examples , Cyber theft, Cyber terrorism, Software privacy, Computer viruses and worms Adware and Spyware, Privacy on the internet, Privacy laws and cyber law. Cryptography – keys, encryption, fire walls ,Denial of service attacks, virus defences, other security measures

TEXT BOOKS

1. James O'Brien and George Marakas (2019) – “Management Information Systems” – 11th Edition – MH Education
2. Kenneth C. Laudon, Jane P. Laudon, Jane P. Laudon (2020) – “Management Information Systems: Managing the Digital Firm” – 16th Edition – Pearson

REFERENCES

3. Efraim Turban, Carol Pollard, Gregory Wood (2018) - “Information Technology for Management: On-Demand Strategies for Performance, Growth and Sustainability” - 11th Edition - Wiley
4. Waman S Jawadekar (2017) – “Management Information Systems : A Global Digital Enterprise Perspective” – 5th Edition – Tata Mcgraw Hill Publishing Co Ltd
5. Ewa Ziemia (2017) – “Information Technology for Management: New Ideas and Real Solutions” – 1st Edition – Springer
6. A. R. Prathap Reddy (2017) – “Information Technology for Managers” – 1st Edition – Notion Express

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3	3					2	2
CO2	3	3	2	2	3	3					2	2
CO3	3	3	2	2	3	3					2	2
CO4	3	3	2	2	3	3					2	2
CO5	3	3	2	2	3	3					2	2

26DLS 515

Pricing and Revenue Management

3 -1- 0- 4

Course Outcomes	
CO1	Understanding about basics of PRO, Designing price function.
CO2	Able to do Price estimation, Optimal price computation
CO3	Knowledge of Price differentiation, pricing with supply constraints.
CO4	Knowledge of Revenue Management and deep RM Techniques.

Unit I

(18Hrs)

Introduction to pricing and revenue optimization: The Challenges of Pricing, Traditional Approaches to Pricing, The Scope of Pricing and Revenue Optimization, The Pricing and Revenue Optimization Process, Models of Demand function: The Price-Response Function, Measures of Price Sensitivity, Common Price-Response Functions; Estimation of price response and price optimization: Data Sources for Price-Response Estimation, Price-Response Estimation Using Historical Data, The Estimation Process, Challenges in Estimation;

Unit II: :

(18Hrs)

Optimization: Elements of Contribution, The Basic Price Optimization Problem, Existence and Uniqueness of Optimal Prices, Optimization with Multiple Prices, A Data-Driven Approach to Price Optimization, Competitive Response and Optimization, Optimization with Multiple Objective Functions Price differentiation: The Economics of Price Differentiation, Limits to Price Differentiation, Tactics for Price Differentiation, Calculating Differentiated Prices, Price Differentiation and Consumer Welfare, Nonlinear Pricing; Pricing with Constrained supply: The Nature of Supply Constraints, Optimal Pricing with a Supply Constraint, Opportunity Cost, Market Segmentation and Supply Constraints.

Unit III

(20Hrs)

Revenue Management: History, Levels of Revenue Management, Revenue Management Strategy, The System Context, Booking Control, Tactical Revenue Management, Revenue Management Metrics, Capacity Allocation: The Two-Class Problems, Capacity Allocation with Multiple Fare Classes; Network Management. When Is Network Management Applicable? A Linear Programming Approach. Overbooking: Background, Approaches to Overbooking.

Text / Reference Books:

1. Pricing and Revenue Optimization. By Robert L. Phillips. First edition published by Stanford University Press, 2005.
2. Data Analysis for Managers by Christian Albright, Wayne Winston and Christopher J. Zappe. Second edition by Duxbury, 2004

REFERENCES

6. The Theory and Practice of Revenue Management by Kalyan T. Talluri and Garrett J. van Ryzin. First edition published by Kluwer Academic Publishers, 2004.
7. Revenue Management and Pricing: Case Studies and Applications by I. Yeoman and U. McMohan-Beattie.

CO-PO Mapping

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
CO 1	3	2	2		3			2				
CO 2	3	2	3		3	1		2				
CO 3	3	2	3	2	3	1		2				
CO 4	3	2	3	3	3	1		2				

26DLS516

Warehouse and Production Management

3-1-0-4

Course Outcomes	
CO1	Gain knowledge about warehouse management, modern warehousing methods and procurement management
CO2	Apply and analyse the various methods related to assembly line production and forecasting to real life problems
CO3	Implementation of project scheduling methods and work study techniques to real life scenarios
CO4	Understand the concepts involved in inventory management and quality control . Also apply and analyse the control charts and capability indices to real life problems.

Unit I

Warehouse Management : Introduction to Warehousing Concepts -Role of warehouse types of warehouse- Need for warehousing- Warehouse functions– warehouse Structure, Warehouse Operations – Types of Warehouses – Functions , Warehouse process – e-commerce warehouse. Methods of warehousing – Types of warehousing based on structure and shelving methods, Material Handling equipment and Systems.

Modern Warehousing Methods : Modern Warehousing – Automated Storage & Retrieval Systems & their operations – Bar Coding Technology & Applications in Logistics Industry – RFID Technology & Applications .Health and Safety Perspective, Health and Safety at Work, Health and Safety Risks at the Warehouse

Procurement Management : Objectives of Procurement System, Principles of procurement, History of procurement function, Procurement Cycle. Principles of Right purchasing, Centralised V/S. Decentralised purchasing, Purchase Procedures. **(20 Hrs)**

Unit II

Production Management – Definition – Scope – Functions of Production Manager –production systems – Job order – Intermittent and continuous Flow Line production – Assembly line production – Automation, Line balancing and Capacity planning, Plant Location & Plant Layout :Factors affecting plant location- Location selection techniques, Types of plant layout-Advantages and disadvantages of layouts,

Production Planning and Control (PPC) : Definition, Framework & History, Functions of PPC-Routing, Scheduling, Dispatching.

Demand Management and Work Study - Importance of demand management in production, Forecasting methods- Moving average, method of least square , seasonal variation, smoothing methods. Method study and work measurement – Flow Process chart – Two handed process chart – Micromotion Study – Time Study Procedure and Techniques – Application of work study techniques.

Project Management : Project life cycle – Project selection – Types of project selection models . Project Planning and Scheduling, Structuring Projects, Work Breakdown Structure, Network PERT/CPM problems, Project Monitoring, Performance Monitoring Technique

(20Hrs)

Unit III

Inventory Management : Inventory control techniques, Need for Inventory – Just in Time , inventory classification, Economic Order Quantity (EOQ) and reorder point calculation, Multi-Echelon Inventory Systems – Distribution Requirement Planning – Bull Whip Effect , Using WMS for Managing Warehousing Operations Receiving inventory, Picking inventory, Organising inventory, Despatching inventory, ABC analysis , XYZ analysis, VED analysis.

Quality Management - Definition of Quality, Dimensions of Quality, Contribution of Deming , Shewhart, Juran, Taguchi and Ishikawa to quality management. Tools and techniques for quality improvement: check sheet, cause and effect diagram, Pareto chart. Quality control vs quality assurance, Acceptance sampling, Statistical process control – construction of control charts for attributes and variables -X bar , R chart, np chart , p chart and U chart . Process capability indices- Cp and Cpk, Quality Control Tools. **(20Hrs)**

Reference Books

1. James A. Tompkins, Warehouse Management Handbook, Tompkins Press, 1998.
2. David Mulcahy, Warehouse Distribution and Operations Handbook, McGraw Hill, 1993
3. William.Stevenson, Operations Management, Twelfth Edition, McGraw Hill Education (India) Pvt. Ltd., 2017
4. Jay Heizer, Barry Render (2014), Operations Management, 11th Edition, Pearson Education.

5. Chary S.N., Production and Operations Management, Tata McGraw Hill Publishing Co., Ltd., New Delhi.
6. Adam E.E., Jr and Ebert R.J. 1997, Production and Operations Management: Concepts, Models and Behaviour, 5th Ed. Prentice Hall of India
7. Collier, Evans, Ganguly(2016), OM-Operations Management , Cengage Learning.
8. R. Panneerselvam, (2013), Production and Operations Management, 3rd edition, PHI

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	3		2					2
CO2	3	3	3	3	3		1					2
CO3	3	3	3	3	3		1					2
CO4	3	3	3	3	3		1					2

Amrita Values Program

1 0 0 1

Amrita University's Amrita Values Program (AVP) is a new initiative to give exposure to students to the richness and beauty of the Indian way of life. India is a country where history, culture, art, aesthetics, cuisine, and nature exhibit more diversity than anywhere else in the world. Amrita Values Programs emphasize making students familiar with the rich tapestry of Indian life, culture, arts, science, and heritage which has historically drawn people from all over the world. Post-graduate students shall have to register for any one of the following courses, in the second semester, which may be offered by the respective school.

Courses offered under the framework of the Amrita Values Program:

22AVP501 Message of Śrī Mātā Amritanandamayī Devi

1 0 0 1

Amma's messages can be put into action in our life through pragmatism and attuning of our thought process in a positive and creative manner. Every single word Amma speaks, and the guidance received in matters which we consider trivial are rich in content and touches the very inner being of our personality. Life gets enriched by Amma's guidance, and She teaches us the art of exemplary life skills where we become witness to all the happenings around us keeping the balance of the mind.

1 0 0 1

1 0 0 1

1 0 0 1

1 0 0 1

1 0 0 1

1 0 0 1

1 0 0 1

The aim of this course is to present the rich literature, culture of ancient India, and help students appreciate their deep influence on Indian life, Vedic culture, the primary source of Indian culture, brief introduction, and appreciation of a few of the art forms of India, arts, music, dance, theatre, paintings, sculpture and architecture, the wonder language, Sanskrit, and ancient Indian Literature.

22AVP509**Yoga and Meditation****1 0 0 1**

The objective of the course is to provide practical training in YOGA ASANAS with a sound theoretical base and theory classes on selected verses of Patanjali's Yoga Sutra and Ashtanga Yoga. The coverage also includes the effect of yoga on integrated personality development.

22AVP510**Appreciation of Kerala's Mural Art Forms****1 0 0 1**

A mural is any piece of artwork painted or applied directly on a wall, ceiling, or another large permanent surface. In the contemporary scenario, Mural painting is not restricted to permanent structures and is being done even on canvas. A distinguishing characteristic of mural painting is that the architectural elements of the given space are harmoniously incorporated into the picture. Kerala mural paintings are frescos depicting mythology and legends, which are drawn on the walls of temples and churches in South India, principally in Kerala. Ancient temples, churches, and places in Kerala, South India, display an abounding tradition of mural paintings mostly dating back to the 9th to 12th centuries CE when this form of art enjoyed Royal patronage. Learning Mural painting through the theory and practice workshop is the objective of this course.

22AVP512**Ancient Indian Science and Technology****1 0 0 1**

Science and technology in ancient and medieval India covered all the major branches of human knowledge and activities, including mathematics, astronomy, physics, chemistry, medical science and surgery, fine arts, mechanical, civil engineering, architecture, shipbuilding, and navigation. Ancient India was a land of sages, saints, and seers as well as a land of scholars and scientists. The course gives awareness of India's contribution to science and technology.

25AVP501**Mastery Over Mind (MAOM)****1-0-2 2**

Course Outcomes (CO)

CO1: Relate to the causes of stress in one's life.

CO2: Experiment with a range of relaxation techniques **CO3:** Model a meditative approach to work, study, and life.

CO4: Develop appropriate practice of MA-OM technique that is effective in one's life **CO5:** Inculcate a higher level of awareness and focus.

CO6: Evaluate the impact of a meditation technique

Unit 1 (4 hours)

Causes of Stress: The problem of not being relaxed. Need for meditation -basics of stress management at home and workplace. Traditions and Culture. Principles of meditation– promote a sense of control and autonomy in the Universal Human Value System. Different stages of Meditation. Various Meditation Models. Various practices of Meditation techniques in different schools of philosophy and Indian Knowledge System.

Unit 2 (4 hours)

Improving work and study performance. Meditation in daily life. Cultivating compassion and good mental health with an attitude of openness and acceptance. Research and Science of Meditation: Significance of practising meditation and perspectives from diverse fields like science, medicine, technology, philosophy, culture, arts, management, sports, economics, healthcare, environment etc. The

role of meditation for stress and anxiety reduction in one's life with insights based on recent cutting-edge technology. The effect of practicing meditation for the wholesome wellbeing of an individual.

Unit 3 (4 hours)

Communications: principles of conscious communication. Relationships and empathy: meditative approach in managing and maintaining better relationships in life during the interactions in the world, role of MAOM in developing compassion, empathy and responsibility, instilling interest, and orientation to humanitarian projects as a key to harness intelligence and compassion in youth. Methodologies to evaluate effective awareness and relaxation gained from meditation. Evaluating the global transformation through meditation by instilling human values which leads to service learning and compassion driven research.

Text Books /References Books:

1. Mata Amritanandamayi Devi, "Cultivating Strength and vitality," published by Mata Amritanandamayi Math, Dec 2019
2. Swami Amritaswarupananda Puri, "The Color of Rainbow" published by MAM, Amritapuri.
3. Craig Groeschel, "Winning the War in Your Mind: Change Your Thinking, Change Your Life" Zondervan Publishers, February 2019
4. R Nagarathna et al, "New Perspectives in Stress Management" Swami Vivekananda Yoga Prakashana publications, Jan 1986
5. Swami Amritaswarupananda Puri "Awaken Children Vol 1, 5 and 7 - Dialogues with Amma on Meditation", August 2019
6. Swami Amritaswarupananda Puri "From Amma's Heart - Amma's answer to questions raised during world tours" March 2018
7. Secret of Inner Peace- Swami Ramakrishnananda Puri, Amrita Books, Jan 2018.
8. Mata Amritanandamayi Devi "Compassion :The only way to Peace:Paris Speech", MA Center, April 2016.
9. Mata Amritanandamayi Devi "Understanding and collaboration between Religions", MA Center, April 2016.
10. Mata Amritanandamayi Devi "Awakening of Universal Motherhood: Geneva Speech" M A center, April 2016.

CO – PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2			2	3		3		3
CO2	3	3	3	2	2		2	3	3	3		3
CO3	3	3	2	2	2	2	2	3	3	3		3
CO4	3	3	3	2		2	3	3	3	3		3
CO5	3	2	2	2		2		3	2	2		2
	3	2	2	2	3	2		3	2	2		2

Semester -III

26DLS601

Inventory and Marketing Management

3 1 0 4

Course Outcomes	
CO1	Understanding inventory management, dependent demand, independent demands models and its costs
CO2	Exploring different types of deterministic and stochastic inventory models.
CO3	Understanding joint replenishment inventory problem, BoM, MRP and Supply chain management
CO4	To gain knowledge on sales strategies and management

Unit I: The Basic Concepts of inventory management. Independent and dependent demands. Different inventory systems. Inventory costs, Service level and safety stock Inventory policy, order quantity and reorder point. (20Hrs)

Unit II: Inventory Models: Deterministic demand model, EOQ with price break, Multi-Item Inventory Models, ABC Analysis, Stochastic demand model, Newsvendor model, S-S Policy, Optimal solution and approximations. Joint replenishment inventory problem, Supply chain management: Series, Assembly, Tree and general production network systems, Optimal solution, heuristics and approximation, (20Hrs)

Unit III: Understanding Marketing Management, Marketing environmental analysis, Strategic marketing planning, Marketing strategy, Product life cycle Strategy, Branding and Packing, Integrated marketing communication, Advertising and sales promotion and sales management. Case studies related to supply chain management (20Hrs)

Text / Reference Books:

1. Toomey, J. W., Inventory Management: Principles, Concepts and Techniques. Kluwer Academic Publishers, 2000.
2. Zipkin, Paul H., Foundations of Inventory Management. The McGraw-Hill Company, 2000.
3. Silver, E. A., Pyke, D. F. and Peterson, R., Inventory Management and Production Planning and Scheduling. 3rd Edition, Wiley, 1999.
4. Philip Kotler, Marketing Management – Analysis, Planning and Control , 12th edition , Prentice Hall of India, New Delhi,2007.
5. Gert H.N Laursen and Jesper Thorlund :Business analytics for managers taking business intelligence beyond reporting, second edition 2016.
6. Schiffman, Kanuk, Kumar, Consumer Behaviour, Pearson, Tenth Edition,2010
7. Still, R., Richard, Sales Management, Pearson Prentice Hall, Delhi,2017

CO – PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2						2	2
CO2	3	3	3	2	2						2	2
CO3	3	3	3	2	2						2	2
CO4	3	3	3	2	2						2	2
CO5												

26DLS602**Deep Learning****3 0 2 4**

Course Outcomes	
CO1	To understand the theoretical foundations, algorithms, and methodologies of Neural Networks.
CO2	To design, implement, and evaluate deep learning models for real-world applications.
CO3	To analyze model performance and apply appropriate optimization and regularization techniques.
CO4	To explore modern deep learning architectures including CNNs, RNNs, Transformers, and Generative Models.
CO5	To explore sequence modelling algorithms are BPTT, LSTM, GRU and application in NLP.

Unit I -Foundations of Deep Learning

Introduction to Machine Learning vs Deep Learning; Biological Neuron vs Artificial Neuron; Perceptron and Multilayer Perceptron (MLP); Representation Learning; Width vs Depth of Neural Networks; Activation Functions: Sigmoid, Tanh, ReLU, Leaky ReLU, ELU, Softmax; Loss Functions: MSE, Cross-Entropy; Backpropagation Algorithm; Binary and Multiclass Classification; Weight Initialization Techniques; Overfitting and Underfitting; Regularization Techniques (L1, L2, Dropout). **(15Hrs)**

Unit II – Convolutional Neural Networks

Motivation for CNN; Convolution Operation and Feature Maps; Filters, Stride, Padding; Pooling Layers; Parameter Sharing; Batch Normalization; Regularization in CNN; Optimization Techniques: Gradient Descent, Stochastic Gradient Descent, Mini-batch SGD, Momentum,

Nesterov Accelerated Gradient, Adagrad, Adadelata, RMSProp, Adam and AdamW; Popular CNN Architectures: AlexNet, VGGNet, ResNet, DenseNet; Applications in Image Classification and Object Detection
(15Hrs)

Unit III – Transfer Learning and Advanced CNNs

Concept of Transfer Learning; Feature Extraction vs Fine-Tuning; Pre-trained Models; Large-scale Datasets (ImageNet); Advanced Architectures: Inception, MobileNet; Vision Transformers (ViT) – Basic Concepts; Applications in Medical Imaging, Face Recognition, and Industrial AI.
(10 Hrs)

Unit IV- Generative Models

Autoencoders: Undercomplete, Sparse, Denoising, Contractive; Variational Autoencoder (VAE); Generative Adversarial Networks (GAN): Architecture, Minimax Optimization, DCGAN, Conditional GAN; Applications in Image Generation and Data Augmentation.

(10 Hrs)

Unit V – Sequence Modelling and Transformers

Recurrent Neural Networks (RNN); Vanishing and Exploding Gradient Problem; Backpropagation Through Time (BPTT); Long Short-Term Memory (LSTM); Gated Recurrent Unit (GRU); Bidirectional RNN; Encoder–Decoder Architecture; Attention Mechanism; Introduction to Transformers; Applications in NLP, Time Series Forecasting, and Speech Recognition.
(10 Hrs)

Text Books:

1. Ian Goodfellow, YoshuaBengio and Aaron Courville, *Deep Learning*, MIT Press, 2017.
2. Josh Patterson, Adam Gibson, *Deep Learning: A Practitioner's Approach*, O'Reilly Media, 2017
3. Umberto Michelucci, *Applied Deep Learning. A Case-based Approach to Understanding Deep Neural Networks*, Apress, 2018.
4. Kevin P. Murphy, *Machine Learning: A Probabilistic Perspective*, The MIT Press, 2012.
5. EthemAlpaydin, *Introduction to Machine Learning*, MIT Press, Prentice Hall of India, ThirdEdition 2014.
6. Giancarlo Zaccone, Md. RezaulKarim, Ahmed Menshawy *Deep Learning with TensorFlow: Explore neural networks with Python*, Packt Publisher, 2017.
7. Antonio Gulli, Sujit Pal, *Deep Learning with Keras*, Packt Publishers, 2017.
8. Francois Chollet, *Deep Learning with Python*, Manning Publications, 2017.

CO – PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	2					3	1
CO2	3	2	2	2	2	2					3	1
CO3	3	2	2	2	2	3					3	1
CO4	3	2	1	2	2	2					3	1
CO5	3	2	2	2	2	2					3	1

Elective Courses

26DLS631

Pattern Recognition

3 0 0 3

Pattern recognition systems – the design cycle – learning and adaptation – Bayesian decision theory – continuous features – Minimum error rate classification – discriminant functions and decision surfaces – the normal density based discriminant functions. Bayesian parameter estimation – Gaussian case and general theory – problems of dimensionality – components analysis and discriminants- Nonparametric techniques – density estimation – Parzen windows – nearest neighborhood estimation – rules and metrics - decision trees – CART methods – algorithm-independent machine learning – bias and variance for regression and classification – resampling or estimating statistics- Unsupervised learning and clustering – mixture densities and identifiability – maximum likelihood estimates – application to normal mixtures – unsupervised Bayesian learning – data description and clustering – criterion functions for clustering – hierarchical clustering – k-means clustering.

Text Reference Book:

1. Richard O. Duda, Peter E. Hart and David G. Stork, “*Pattern Classification*”, Second Edition, 2003, John wily & sons.
2. Earl Gose, Richard Johnsonbaugh and Steve Jost, “*Pattern Recognition and Image Analysis*”, 2002, Prentice Hall of India.

26DLS632

Stochastic Process

3 0 0 3

Random processes: General concepts and definitions - stationarity in random processes - strict sense and wide sense stationary processes - autocorrelation and properties- special processes – Poisson points, Poisson and Gaussian processes and properties , spectrum estimation , ergodicity, mean ergodicity, correlation ergodicity, Power spectrum density functions – properties, Markov process and Markov chain, transition probabilities, Chapman Kolmogorov theorem, limiting distributions classification of states.

Text Books:

1. J. Ravichandran, “*Probability and Random Processes for Engineers*”, First Edition, IK International, 2015
2. Douglas C. Montgomery and George C. Runger, *Applied Statistics and Probability for Engineers*, (2005) John Wiley and Sons Inc.

Reference Books:

1. A. Papoulis, and Unnikrishna Pillai, “*Probability, Random Variables and Stochastic Processes*”, Fourth Edition, McGraw Hill, 2002.
2. Scott L. Miller, Donald G. Childers, “*Probability and Random Processes*”, Academic press, 2012.

Queuing Models: Basic characteristics of a Queueing Model – Role of Poisson and Exponential distributions, Stochastic Processes, Markov chains, Poisson Processes, Poisson Queuing Models with single server: Descriptions of the model, Assumptions, Probability distributions for number of Units (steady state), waiting time distribution, simple numerical problems on (M/M/1): (/FIFO) and (M/M/1): (N/FIFO) Models.

Poisson Queuing Models with multiple server: Descriptions of the model, Assumptions, Probability distributions for number of Units (steady state), waiting time distribution, simple numerical problems on (M/M/C): (/FIFO), (M/M/C): (N/FIFO) and (M/M/C): (C/FIFO) Models, M/M/G Models.

Text Books

1. Donald Gross & Carl M Harris (1998): Fundamentals of Queuing theory, John Wiley & Sons, Inc
2. Hamdy A. Taha (2006): Operations Research – An Introduction, 8/e, Prentice Hall of India Private Ltd., New Delhi

Reference Books

1. S.D. Sharma (2003) Operations Research, Kedar Nath Ram Nath & Co, Meerut, India
2. Kanthi Swarup, P.K. Gupta and Man Mohan (2004), Operations Research, Sultan Chand & Sons, New Delhi

Survival Analysis: Functions of survival times, survival distributions and their applications Censoring Schemes: Type I, Type II and progressive or random censoring with biological examples. Estimation of mean survival time and variance of the estimator for Type I and Type II censored data with numerical examples.

Non-parametric methods: Actuarial and Kaplan-Meier methods for estimating survival function and variance of the Estimator.

Competing Risk Theory: Indices for measurement of probability of death under competing risks and their inter-relations. Estimation of probabilities of death using maximum likelihood principle and modified minimum Chi-square methods.

References

1. Miller, R.G. *Survival analysis*, John Wiley, 1981
2. Collet, D. *Statistical analysis of life time data*, 1984
3. Cox, D.R. and Oakes, D.: *Analysis of survival data*, Chapman & Hall, New York, 1984
4. Gross, A.J. and Clark, V.A.: *Survival distribution: Reliability applications in the Biomedical sciences*, John Wiley and Sons, 1975
5. Elandt-Johnson, R.E. Johnson, N.L. : *Survival models and data analysis*, John Wiley & sons.

Preliminary concepts – schedules and questionnaires, pilot survey, non-sampling errors, use of random numbers. Simple random sampling with and without replacements, random number generation – estimates of population mean and population proportion and their standard errors, Probability proportional to size sampling, estimates of these standard errors. Stratified random sampling – estimates of sample statistic and estimates of their standard errors. Allocation of sample size in stratified random sampling. Linear and circular systematic sampling. Cluster sampling : Two stage sampling (equal first stage units). Ideas of ratio and regression estimators – only estimates of sample mean.

References

1. Cochran, W.G. : *Sampling Techniques*, 3rd Ed., Wiley Eastern. 1984
2. Murthy, M.N. : *Sampling Theory & Statistical Methods*, Statistical Pub. Society, Calcutta, 1977
3. Des Raj and Chandhok P. : *Sample Survey Theory*, Narosa Publishing House, 1988.

Demographic data – Sources, Coverage and Content errors in demographic data. Measures of fertility period and cohort measures. Use of birth order Statistics and child - Woman ratio. Brass technique to estimate current-fertility levels Estimation of TFR age pattern of fertility. Measures of mortality - standard death rates, neo-natal, perinatal death rates, maternal and infant mortality rates standardization of mortality rates.

Life table: Basic definitions, probabilities, construction of life tables, life expectancy, Life annuities: calculating annuity premium, interest and survivorship discount function, guaranteed payments, deferred annuities.

Life insurance: Introduction, calculation of life insurance premiums, types of life insurance, combined benefits, insurances viewed as annuities, Insurance and annuity reserves: General pattern reserves, recursion, detailed analysis of an insurance.

Contingent Functions: Contingent probabilities, assurances. Decrement tables. Pension funds: Capital sums on retirement and death, widow's pensions, benefits dependent on marriage.

Text Books:

1. Ramkumar. R : *Technical Demography*, Wiley eastern Ltd, New Delhi, 1986.
2. Rogers. A : *Introduction to Mathematical Demography*, John Wiley, New York, 1975
3. Biswas. S. : *Stochastic processes in Demography and applications*, Wiley eastern limited, 1988
4. Atkinson, M.E. and Dickson, D.C.M.: *An Introduction to Actuarial Studies*, Elgar Publishing, 2000
5. Philip, M. et. al : *Modern Actuarial Theory and Practice*, Chapman and Hall, 1999.

Introduction to Indian Statistical systems- Role, function and activities of Central Statistical organization and State Agencies. Role of National Sample Survey Organization. General and special data dissemination systems. Scope and Contents of population census of India. statistics, their reliability and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), Registered General Office and National Statistical Commission.

Population growth in developed and developing countries, Evaluation of performance of family welfare programmes. Statistics related to Industries, foreign trade, balance of payment, cost of living, inflation, educational and other social statistics.

Economic development: Growth in per capita income and distributive justice indices of development, human development index. National income estimation- Product approach, income approach and expenditure approach. Measuring inequality in income: Gini Coefficient, Theil's measure; Poverty measurements: Different issues, measures of incidence and intensity; Combined Measures: Indices due to Kakwani, Sen etc. **Text Books:**

1. Guide to Official Statistics (CSO) 1999.
2. Principles and Accommodation of National Population Census, UNEDCO
3. CSO (1989)a: National Accounts Statistics- Sources and Methods.
4. Guide to current Indian Official Statistics, Central Statistical Office, GOI, and New Delhi. <http://mospi.nic.in/>

26DLS638

Reinforcement Learning

3 0 0 3

Introduction: Reinforcement Learning, Elements of Reinforcement Learning, Limitations and Scope, An Extended Example- Tic-Tac-Toe. Multi-armed Bandits: A k-armed Bandit Problem, Action-value Methods, The 10-armed Testbed, Incremental Implementation, Tracking a Nonstationary Problem, Optimistic Initial Values, Upper-Confidence-Bound Action Selection, Gradient Bandit Algorithms.

Finite Markov Decision Processes: The Agent-Environment Interface, Goals and Rewards, Returns and Episodes, Unified Notation for Episodic and Continuing Tasks, Policies and Value Functions, Optimal Policies and Optimal Value Functions, Optimality and Approximation.

Review of Markov process and Dynamic Programming.

Temporal-Difference Learning: TD Prediction, Advantages of TD Prediction Methods, Optimality of TD, Sarsa: On-policy TD Control, Q-learning: Policy TD Control. Expected Sarsa. Maximization Bias and Double Learning.

Text/ References Book:

1. Richard S. Sutton and Andrew G. Barto, *Reinforcement Learning: An Introduction*, MIT Press, 2018.
2. Sudharsan Ravichandiran, *Hand-on Reinforcement Learning with Python*, Packt Publications, 2018.
3. Sayon Dutta, *Reinforcement Learning with Tensor Flow: A beginner's guide*, Packt Publications, 2018.

26DLS639

Social Network Analytics

3 0 0 3

An Introduction to social network data analytics: research Issues, statistical properties of social networks, random walks in social networks and their applications: survey, applications, community discovery in social networks, node classification in social networks, evolution in social networks - survey, survey of models and algorithms for social influence analysis, survey of algorithms and systems for expert location in social networks, survey of link prediction in social networks, data mining in social media, text mining in social networks **Text and Reference**

1. Charu C. Aggarwal : *Social Network Data Analytics*, Springer, 2011.
2. Cioffi-Revilla, Claudio. *Introduction to Computational Social Science*, Springer, 2014.
2. Matthew A. Russell. *Mining the Social Web: Data Mining Facebook, Twitter, LinkedIn, Google+, Github, and More*, 2nd Edition, O'Reilly Media, 2013.

3. Robert Hanneman and Mark Riddle. Introduction to social network methods. Online Text Book, 2005.

26DLS640

Mining of Massive Datasets

3 0 0 3

Basics of Data Mining - computational approaches - statistical limits on data mining MapReduce - Distributed File Systems . MapReduce . Algorithms using MapReduce . Extensions to MapReduce. Mining Data Streams: The Stream Data Model - Sampling Data in a Stream - Filtering Streams. Link analysis, Frequentitemsets, Clustering, Advertising on web, Recommendation system, Mining Social-Network Graphs, Dimensionality Reduction, Large-Scale Machine Learning.

Text / References Book

1. Jure Leskovec ,AnandRajaraman, Jeffrey David Ullman, Mining of Massive Datasets, Cambridge University Press, 2014.
2. Tom White, Hadoop: The Definitive Guide: Storage and Analysis at Internet Scale O'Reilly Media; 4 edition , 2015.

26DLS641

Parallel and Distributed Systems

3 0 0 3

Introduction – parallelism and goals, parallel computing models – RAM, PRAM , CTA. Reasoning about Performance – Introduction -Basic Concepts - Performance Loss - Parallel Structure - Measuring Performance. Shared memory architecture.

Parallel Programming: Task and Data Parallelism with examples –Comparison Programming with Threads - POSIX Threads- Thread Creation and Destruction. Mutual Exclusion- Synchronization - Safety and Performance Issues – Reduction – threads Inter process communication – internet protocols – multicast communication – MPI. Remote invocation: Remote procedure call – remote method invocation -

System models : physical models, architecture models, operating system support. Distributed file systems – introduction- time and global states – synchronization of physical clocks – coordination and agreements: Mutual exclusion, election, consensus.

Text Books

1. George Coulouris , Jean Dollimore , Tim Kindberg , Gordon Blair: *Distributed Aystems : Concepts and Design* , Fifth Edition , Addison Wiley, 2012.
2. Calvin Lin ,Larry Snyder : *Principles of Parallel Programming*, Pearson, 2009

References

1. Bertil Schmidt,Jorge Gonzalez-Dominguez, Christian Hundt , Moritz Schlarb, *Parallel Programming: Concepts and Practice* First Edition, Morgan Kaufmann, 2017.
2. Ajay D. Kshemkalyani,MukeshSinghal , *Distributed Computing: Principles, Algorithms, and Systems*, Cambridge University Press, First edition, 2008.

26DLS642

Taguchi Techniques

3 0 0 3

Taguchi loss functions –mean square error loss function, average loss function, higher the better and lower the better loss functions –two-way analysis of variance with interactions –factorial experiments with two and three-level factors – orthogonal array experiments with two and three-level factors – methods of interpretation of experimental results - parameter and tolerance design experiments – signal-to-noise ratios – inner and outer array experiments.

Text/Reference Books

1. Taguchi Techniques for Quality Engineering
2. Taguchi G, (1991). Introduction to Quality Engineering: Designing Quality into Products and Processes. Asian Productivity Organization Second Edition,. Wiley

26DLS643

Special Distribution Functions

3 0 0 3

Inverted Beta Distribution, Noncentral Beta Distribution, Beta Binomial Distribution, Cauchy Distribution, Noncentral Chi-Squared Distribution, Dirichlet Distribution, Empirical Distribution Function, Erlang Distribution, Error Distribution, Generalized Exponential Distributions, Noncentral F-distribution, Inverted Gamma Distribution, Normal Gamma Distribution, Generalized Gamma Distribution, Inverse Gaussian (Wald) Distribution, Lognormal Distribution, Pareto Distribution, Power Function Distribution, Power Series (Discrete) Distribution, Wishart (Central) Distribution.

Text/Reference books

Catherine Forbes, Merran Evens, Nicholas Hastings and Brian Peacock. (2010). *Statistical Distributions*, Fourth Edition, Wiley & Sons Publication, USA.
Karl Bury (1999) :Statistical distributions in Engineering , Cambridge University Press. **Thomopoulos**, Nick T(2017): Statistical Distributions:Applications and Parameter Estimates, Springer.