Academic Council Meeting No. and Date: 9 / July 02, 2024

Agenda Number: 3 Resolution Number: 41, 42 / 3.19 and 3.39

Vidya Prasarak Mandal's

B. N. Bandodkar College of Science (Autonomous), Thane

Syllabus for

Programme Code : BPDS

Programme: Master of Science

Specific Programme: Data Science

[M.Sc.(Semester III and IV)]

Level 6.5

CHOICE BASED GRADING SYSTEM

Revised under NEP 2020

From academic year 2024-25

Year (2 Yrs)	LEVEL	SEMESTER	Major				Research Methodo-logy	On Job Training / Field project	Research project	Cum Credits	Degrees
			Mandatory		Electives anyone						
I	6.0	SEM-I	3*4 + 2 = 14		Credits 4		Credits 4	NA	NA	22	PG Diploma in Data Science (After 3 Yrs. degree UG)
			Course 1	Credits 4	Course 1= Credits 4						
			Course 2	Credits 4	**OR**						
			Course 3	Credits 4	Course 2 = Credits 4						
			Course 4	Credits 2	**OR**						
		SEM-II	Course 1	Credits 4	Course 1 = Credits 4		NA	Credits 4	NA	**22**	
			Course 2	Credits 4	**OR**						
			Course 3	Credits 4	Course 2 = Credits 4						
			Course 4	Credits 2	**OR**						
Cum Cr.for 1 Yr. PG Diploma			**28**		8		4	4		44	
II	6.5	SEM-III	Course 1	Credits 4	Course 1	Credits 4	NA	NA	Credits 4	22	Master Program in Data Science (After 3 Yrs. degree UG)
			Course 2	Credits 4	**OR**						
			Course 3	Credits 4	Course 2	Credits 4					
			Course 4	Credits 2	**OR**						
		SEM IV	Course 1	Credits 4	Course 1	Credits 4	NA	NA	Credits 6	**22**	
			Course 2	Credits 4	**OR**						
			Course 3	Credits 4	Course 2	Credits 4					
					OR						
Cum Cr. for integrated 1 Yr. PG Degree			**26**		**8**				**10**	**44**	
Cum Cr. for 2 Yr. PG Degree			**44**		**16**		**4**	**4**	**10**	**88**	

B. N. Bandodkar College of Science (Autonomous), Thane

Master of Science
Data Science

(To be implemented from the academic year 2024-2025)

SEMESTER III and SEMESTER IV

Sr. No.	Heading	Particulars
1.	Title of the Course	M.Sc. (Data Science)
2.	Eligibility for Admission	Students who have Completed B.Sc. with Data Science, Information Technology, Computer Science, Physics, Mathematics, Statistics from recognized University / Board / Institutions. Candidate should have programming background / concepts learned.
3.	Passing Marks	40%
4.	Ordinances / Regulations (if, any)	Existing ordinances and regulations.
5.	Number of years / Semesters	Two years – Four Semesters
6.	Level	PG
7.	Pattern	Semester
8.	To be implemented from Academic year	2024 – 2025
9.	Mode of conduct	Offline / Online Lectures / Practicals

Preamble

Data Science is considered one of the trendiest courses in the world. It leads to the right skills and knowledge required to become a successful Data Analyst or Scientist. Data science is a “concept to unify statistics, data analysis, machine learning and their related methods” in order to “understand and analyze actual phenomena” with data. It’s study of the flow of information from structured and unstructured data available with an organization. It involves obtaining the meaningful insights from the data which is processed through analytical study. One needs to understand the language of data through analytical skill. Hence, it is absolutely necessary nowadays, to develop manpower with a skill to perform data analysis to get meaningful information from the data of different domains such as banking and finance, insurance, agriculture, healthcare, retail, education, social media, manufacturing, transportation, entertainment and so on.

Abhijeet A. Kale
BOS Chairperson

PROGRAMME OUTCOMES (POs) OF MASTERS IN SCIENCE (M.Sc.)

The Postgraduate Programmes of Science are intended to cater quality education and attain holistic development of learners through the following programme outcomes:

PO1 – Domain Knowledge

Comprehend and demonstrate domain knowledge in specialized branch of science. Instil ability to apply it in upgrading professional, social and personal life.

PO2 – Development of Research Competence

Imbibe skills related to identification of research problem, formulating hypothesis, execution of research process, analysing data, interpreting the data, drawing conclusion and presenting research work. Encourage learners for doctoral studies.

PO3 - Digital Literacy

Enhance ability to access, select and use a variety of relevant information e-resources for creating new knowledge resources.

PO4 - Sensitization towards Environment

Build cohesive bond with nature by respecting natural resources, encouraging eco-friendly practices and creating awareness about sustainable development.

PO5 - Individuality and Team work

Encourage learner to work independently or in collaboration for achieving effective results through practical experiments, project work and research activities.

PO6 – Competence for Employment

Promote field work, internships, industrial training, research projects, research paper presentations and publications to develop competence for adapting towards dynamic socio-economic changes and make learner employable.

Program Specific Outcome: On completion of the M.Sc. (Information Technology) degree the learners will be able to

1. Explain and apply fundamental concepts of Statistics, Information Technology, and Computer Science essential for problem solving in Data Science. (Level 2)
2. Apply appropriate data visualization and interpretation techniques to analyze datasets and support effective decision-making. (Level 3)
3. Design and develop data-driven solutions demonstrating professional skills required of a Data Scientist in industry, academia, or government sectors.. (Level 6)
4. Formulate and conduct independent research or investigations to solve real-world and practical problems using data science methodologies. (Level 6)
5. Use domain-specific software tools for data storage, processing, analysis, and visualization in data science applications. (Level 3)
6. Integrate qualitative analysis, technical expertise, and professional practices to work effectively in industry and research organizations.. (Level 6)

Credit Distribution Structure for Two Years/ One Year PG / M.Sc. (Data Science)

<table>
<tr><th rowspan="2">Year</th><th rowspan="2">Level</th><th rowspan="2">Sem</th><th colspan="3">Major</th><th rowspan="2">RM</th><th rowspan="2">OJT/FP</th><th rowspan="2">RP</th><th rowspan="2">Cum. Cr.</th><th rowspan="2">Degree</th></tr>
<tr><th colspan="2">Mandatory</th><th>Electives</th></tr>
<tr><td rowspan="6">1</td><td rowspan="6">6.5</td><td rowspan="4">Sem III</td><td colspan="2">3*4+1*2</td><td>4</td><td>-</td><td rowspan="4">-</td><td rowspan="4">Research Project</td><td rowspan="4">22</td><td rowspan="11">PG
(after 2 Years Degree)</td></tr>
<tr><td>Artificial Intelligence
Introduction to Machine Learning
Soft Computing</td><td>TH
TH
TH</td><td>4
4
4</td><td rowspan="3">Deep Learning
(TH) and (PR)
(OR)
Cloud Application Development
(TH) and (PR)</td><td rowspan="3">-</td></tr>
<tr><td>Practical Based on 24BPDS3T01 and 24BPDS3T02</td><td>PR</td><td>2</td></tr>
<tr><td rowspan="4">Sem IV</td><td colspan="2">3*4+1*2</td><td>4</td><td rowspan="3">-</td><td rowspan="3">-</td><td rowspan="3">Research Project</td><td rowspan="3">22</td></tr>
<tr><td>Business Communication
Introduction to Management</td><td>TH
TH</td><td>4
4</td><td rowspan="2">Cyber Security
(TH) and (PR)
(OR)
Natural Language Processing
(TH) and (PR)</td></tr>
<tr><td>Predictive Analytics Development</td><td>TH</td><td>4</td></tr>
<tr><td colspan="3">Cum. Cr. For PG Diploma</td><td colspan="2">26</td><td>8</td><td>-</td><td>-</td><td>10</td><td>44</td></tr>
<tr><td colspan="11">Exit Option: PG Diploma (44 credits) after Three Year UG Degree</td></tr>
</table>

SEMESTER III

VPM's B. N. Bandodkar College of Science (Autonomous), Thane
M.Sc. Data Science
Structure of Programme

SEMESTER III

Course Code	Course Title	No. of Lectures	Credits
MANDATORY PAPERS			
24BPDS3T01	Artificial Intelligence	60	4
24BPDS3T02	Introduction to Machine Learning	60	4
24BPDS3T03	Soft Computing	60	4
24BPDS3P01	Practical based on 24BPDS3T01 & 24BPDS3T02	60	2
ELECTIVE PAPERS			
24BPDS3T04	Deep Learning	30	2
24BPDS3P02	Practicals Based on 24BPDS3T04	60	2
OR			
24BPDS3T05	Cloud Application Development	30	2
24BPDS3P03	Practicals Based on 24BPDS3T05	60	2
RESEARCH PROJECT (RP)			
24BPDS3RP7	Research Project – I based on Data Science	120	4
	Total Credits		22

Course Code	Course Title	Credits	No. of lectures
24BPDS3T01	**Artificial Intelligence**	04	60

CO1	Describe the fundamental concepts of Artificial Intelligence, including its historical evolution, foundations, intelligent agents, and the current state-of-the-art AI systems.	L1
CO2	Explain problem-solving techniques in AI, including agent-based problem formulation, uninformed and informed search strategies, and the role of heuristic functions.	L2
CO3	Analyze and compare different machine learning approaches such as decision trees, linear models, neural networks, support vector machines, ensemble methods, and probabilistic learning models to determine their suitability for specific problems.	L4
CO4	Evaluate and design AI-based solutions using reinforcement learning and probabilistic models by selecting appropriate learning strategies, policies, and algorithms for real-world applications.	L5

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	-	-	1
CO2	3	2	1	-	1	2
CO3	3	3	2	-	2	3
CO4	3	3	2	1	2	3

Unit I	**Introduction:** What is Artificial Intelligence? Foundations of AI, history, the state of art AI today. **Intelligent Agents:** agents and environment, good behavior, nature of environment, the structure of agents.	15 [CO1, CO2]
Unit II	**Problem Solving by searching:** Problem-Solving Agents, Example Problems, Searching for Solutions, Uninformed Search Strategies, Informed (Heuristic) Search Strategies, Heuristic Functions.	15 [CO2]
Unit III	**Learning from Examples:** Forms of Learning, Supervised Learning, Learning Decision Trees, Evaluating and Choosing the Best Hypothesis, Theory of Learning, Regression and Classification with Linear Models, Artificial Neural Networks, Nonparametric Models, Support Vector Machines, Ensemble Learning, Practical Machine Learning	15 [CO3, CO4]
Unit IV	**Learning probabilistic models:** Statistical Learning, Learning with Complete Data, Learning with Hidden Variables: The EM Algorithm. Reinforcement learning: Passive Reinforcement Learning, Active Reinforcement Learning, Generalization in Reinforcement Learning, Policy Search, Applications of Reinforcement Learning.	15 [CO3, CO4]

References:

1) Artificial Intelligence: A Modern Approach, Stuart Russell and Peter Norvig,3rd Edition, Pearson, 2010.
2) Artificial Intelligence: Foundations of Computational Agents, David L Poole,Alan K. Mackworth, 2nd Edition, Cambridge University Press ,2017.
3) Artificial Intelligence, Kevin Knight and Elaine Rich, 3rd Edition, 2017
4) The Elements of Statistical Learning, Trevor Hastie, Robert Tibshirani and Jerome Friedman, Springer, 2013

Course Code	Course Title	Credits	No. of lectures
24BPDS3T02	**Introduction to Machine learning**	04	60

CO1	Identify and describe fundamental concepts of Machine Learning, including learning paradigms, types of machine learning tasks, model representations, feature types, and evaluation metrics.	L1
CO2	Apply appropriate machine learning models such as linear models, classification and regression techniques, distance-based models, and tree-based models to solve real-world predictive and descriptive problems.	L3
CO3	Evaluate and compare machine learning algorithms using performance measures, generalization theory, regularization techniques, over fitting analysis to select suitable model for a given dataset.	L5
CO4	Design and implement end-to-end machine learning solutions by integrating feature engineering, model selection, probabilistic reasoning, and advanced learning techniques such as ensemble methods, deep learning, and reinforcement learning.	L6

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	-	-	1
CO2	3	2	2	-	2	3
CO3	3	3	2	-	1	3
CO4	3	3	3	1	2	3

Unit I	Introduction: Machine learning, Examples of Machine Learning Problems, Structure of Learning, learning versus Designing, Training versus Testing, Characteristics of Machine learning tasks, Predictive and descriptive tasks, Machine learning Models: Geometric Models, Logical Models, Probabilistic Models. Features: Feature types, Feature Construction and Transformation, Feature Selection.	15 [CO1, CO2]
Unit II	Classification and Regression: Classification: Binary Classification- Assessing Classification performance, Class probability Estimation Assessing class probability Estimates, Multiclass Classification. Regression: Assessing performance of Regression- Error measures, Overfitting- Catalysts for Overfitting, Case study of Polynomial Regression. Theory of Generalization: Effective number of hypothesis, Bounding the Growth function, VC Dimensions, Regularization theory.	15 [CO2, CO3]
Unit III	Linear Models: Least Squares method, Multivariate Linear Regression, Regularized Regression, Using Least Square regression for Classification. Perceptron, Support Vector Machines, Soft Margin SVM, Obtaining probabilities from Linear classifiers, Kernel methods for non-Linearity. Logic Based and Algebraic Model: Distance Based Models: Neighbors and Examples, Nearest Neighbors Classification, Distance based clustering-K means Algorithm, Hierarchical clustering, Rule Based Models: Rule learning for subgroup discovery, Association rule mining. Tree Based Models: Decision Trees, Ranking and Probability estimation Trees, Regression trees, Clustering Trees.	15 [CO1, CO3]
Unit IV	Probabilistic Model: Normal Distribution, its Geometric Interpretations, Naïve Bayes Classifier, Discriminative learning with Maximum likelihood, Probabilistic Models with Hidden variables: Estimation-Maximization Methods, Gaussian Mixtures, and Compression based Models. Trends In Machine Learning: Model and Symbols Bagging and Boosting, Multitask learning, Online learning and Sequence Prediction, Data Streams and Active Learning, Deep Learning, Reinforcement Learning.	15 [CO3, CO4]

References: 1. Machine Learning: The Art and Science of Algorithms that Make Sense of Data, Peter Flach, Cambridge University Press, 2012
2. Introduction to Statistical Machine Learning with Applications in R, Hastie, Tibshirani, Friedman, Springer 2nd Edition, 2012
3. Introduction to Machine Learning, EthemAlpaydin, PHI, 2nd Edition, 2013

Course Code	Course Title	Credits	No. of lectures
24BPDS3T03	Soft computing	04	60

CO1	Identify and list fundamental concepts, terminology, and components of soft computing, including neural networks, fuzzy logic systems, genetic algorithms, and hybrid soft computing techniques.	L1
CO2	Explain working principles and learning mechanisms of supervised, unsupervised, associative, and advanced neural network models, along with fuzzy set operations and genetic algorithm processes.	L2
CO3	Analyze differentiate various soft computing models like neural networks, fuzzy inference systems, evolutionary algorithms with respect to learning capability, convergence behavior, application suitability.	L4
CO4	Evaluate and justify the selection of appropriate soft computing and hybrid techniques (neuro-fuzzy, genetic-fuzzy, neuro-genetic) for solving complex real-world optimization, control, and decision-making problems.	L5

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	-	-	1
CO2	3	2	2	-	1	2
CO3	3	3	2	-	2	3
CO4	3	3	2	1	2	3

Unit I	Introduction of soft computing, soft computing vs. hard computing, various types of soft computing techniques, Fuzzy Computing, Neural Computing, Genetic Algorithms, Associative Memory, Adaptive Resonance Theory, Classification, Clustering, Bayesian Networks, Probabilistic reasoning, applications of soft computing. Artificial Neural Network: Fundamental concept, Evolution of Neural Networks, Basic Models, McCulloh-Pitts Neuron, Linear Separability, Hebb Network. Supervised Learning Network: Perceptron Networks, Adaptive Linear Neuron, Multiple Adaptive Linear Neurons, Backpropagation Network, Radial Basis Function, Time Delay Network, Functional Link Networks, Tree Neural Network. Associative Memory Networks: Training algorithm for pattern Association, Autoassociative memory network, hetroassociative memory network, bi-directional associative memory, Hopfield networks, iterative autoassociative memory networks, temporal associative memory networks.	15 [CO1, CO2]
Unit II	UnSupervised Learning Networks: Fixed weight competitive nets, Kohonen self-organizing feature maps, learning vectors quantization, counter propogation networks, adaptive resonance theory networks. Special Networks: Simulated annealing, Boltzman machine, Gaussian Machine, Cauchy Machine, Probabilistic neural net, cascade correlation network, cognition network, neo-cognition network, cellular neural network, optical neural network Third Generation	15 [CO1, CO2, CO3]
Unit III	Neural Networks: Spiking Neural networks, convolutional neural networks, deep learning neural networks, extreme learning machine model. Introduction to Fuzzy Logic, Classical Sets and Fuzzy sets: Classical sets, Fuzzy sets. Classical Relations and Fuzzy Relations: Cartesian Product of relation, classical relation, fuzzy relations, tolerance and equivalence relations, non-iterative fuzzy sets Membership Function: features of the membership functions, fuzzification, methods of membership value assignments. Defuzzification: Lambda-cuts for fuzzy sets,	15 [CO2, CO3, CO4]

	Lambda-cuts for fuzzy relations, Defuzzification methods. Fuzzy Arithmetic and Fuzzy measures: fuzzy arithmetic, fuzzy measures, measures of fuzziness, fuzzy integrals.	
Unit IV	Fuzzy Rule base and Approximate reasoning: Fuzzy proportion, formation of rules, decomposition of rules, aggregation of fuzzy rules, fuzzy reasoning, fuzzy inference systems, Fuzzy logic control systems, control system design, architecture and operation of FLC system, FLC system models and applications of FLC System. Genetic Algorithm: Biological Background, Traditional optimization and search techniques, genetic algorithm and search space, genetic algorithm vs. traditional algorithms, basic terminologies, simple genetic algorithm, general genetic algorithm, operators in genetic algorithm, stopping condition for genetic algorithm flow, constraints in genetic algorithm, problem solving using genetic algorithm, the schema theorem, classification of genetic algorithm, Holland classifier systems, genetic programming, advantages and limitations and applications of genetic algorithm. Differential Evolution Algorithm, Hybrid soft computing techniques – neuro – fuzzy hybrid, genetic neuro-hybrid systems, genetic fuzzy hybrid and fuzzy genetic hybrid systems.	15 [CO2, CO3, CO4]

References:

1. Artificial Intelligence and Soft Computing, Anandita Das Battacharya, SPD, 3rd Edition, 2018
2. Principles of Soft computing, S.N.Sivanandam, S.N.Deepa, Wiley, 3rd Edition, 2019
3. Neuro-Fuzzy Computing and Soft J.S.R.Jang, C.T.Sun and E.Mizutani, Prentice Hall of India, 2004
4. Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis & Applications, S.Rajasekaran, G. A., Vijayalakshami, Prentice Hall of India, 2004
5. Fuzzy Logic with Engineering Applications, Timothy J.Ross, McGrawHill, 1997

Course Code 25BPDS3P01	Course Title Practicals Based upon 25BPDSBT01 and 25BPDSBT02	Credits 02	No. of lectures 60

CO1	Recall and describe fundamental concepts of search algorithms, machine learning paradigms, hypothesis learning, regression models, dataset types, and basic Python libraries used in artificial intelligence and machine learning.	L1
CO2	Apply uninformed and informed search techniques such as Breadth First Search, Depth First Search, Hill Climbing, and A algorithms, and implement basic machine learning algorithms including Find-S, Candidate Elimination, and simple linear regression using Python	L2
CO3	Apply Python libraries such as NumPy, SciPy, Pandas, Matplotlib, and Seaborn to create, load, preprocess datasets, handle missing values and outliers, compute statistical measures, and visualize data through univariate and bivariate plots.	L3
CO4	Analyze datasets and machine learning models by interpreting regression coefficients, evaluating model performance using metrics such as R-squared and MSE, exploring feature relationships, and addressing issues such as feature selection and multicollinearity.	L3

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	-	-	-
CO2	3	3	2	-	2	-
CO3	2	3	3	1	1	-
CO4	2	3	2	-	1	2

Practical 1	Write a Program to Implement Breadth First Search.
Practical 2	Write a Program to Implement Depth First Search
Practical 3	Write a program to implement Hill Climbing Algorithm
Practical 4	Write a program to implement A* Algorithm
Practical 5	Write a program to implement Tic-Tac-Toe game
Practical 6	Implementation of Python basic Libraries such as Math, Numpy and Scipy
Practical 7	Implementation of Python Libraries for ML application such as Pandas andMatplotlib
Practical 8	Creation AND Loading different datasets in Python.
Practical 9	Write a python program to compute Mean, Median, Mode, Variance and Standard Deviation using Datasets
Practical 10	Implementation of Find S Algorithm
Practical 11	Implementation of Candidate elimination Algorithm
Practical 12	Write a program to implement simple Linear Regression and Plot the graph
Practical 13	Load a CSV dataset. Handle missing values, inconsistent formatting, and outliers
Practical 14	Load a dataset, calculate descriptive summary statistics, create visualizations using different graphs, and identify potential features and target variables Note: ExploreUnivariate and Bivariate graphs (Matplotlib) and Seaborn for visualization.
Practical 15	Create or Explore datasets to use all pre-processing routines like label encoding, scaling, and binarization.
Practical 16	Implement and demonstrate the FIND-S algorithm for finding the most specific hypothesis based on a given set of training data samples. Read the training data from CSV file and generate the final specific hypothesis. (Create your dataset)
Practical 17	Fit a linear regression model on a dataset. Interpret coefficients, make predictions, and evaluate performance using metrics like R-squared and MSE
Practical 18	Extend linear regression to multiple features. Handle feature selection and potential Multicollinearity

Course Code	Course Title	Credits	No. of lectures
24BPDS3T04	Deep Learning	02	30

CO1	Identify fundamental mathematical concepts and numerical computation principles, including linear algebra structures, matrix operations, eigen decomposition, and numerical stability issues.	L1
CO2	Apply linear algebra techniques and gradient-based optimization methods to formulate and solve machine learning and deep learning problems.	L3
CO3	Evaluate and justify the selection of optimization strategies, regularization techniques, and deep network architectures for improving model performance and generalization.	L5
CO4	Design and implement deep learning models such as feed-forward networks, convolutional neural networks, and sequence models to address real-world applications.	L6

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	-	-	1
CO2	3	2	2	-	1	3
CO3	3	3	2	-	1	3
CO4	3	3	3	1	2	3

Unit I	Applied Math and Machine Learning Basics: Linear Algebra: Scalars, Vectors, Matrices and Tensors , Multiplying Matrices and Vectors , Identity and Inverse Matrices, Linear Dependence and Span , norms, special matrices and vectors, eigen decompositions. Numerical Computation: Overflow and under flow, poor conditioning, Gradient Based Optimization, Constraint optimization	15 [CO1, CO2]
Unit II	Deep Networks: Deep feed forward network , regularization for deep learning, Optimization for Training deep models, Convolution Networks, SequenceModeling, Applications	15 CO3, CO4]

References:

1. Deep Learning, Ian Goodfellow,YoshuaBengio,AaronCourvile, An MIT Press book, 1st Edition, 2016
2. Fundamentals of Deep Learning, Nikhil Buduma, O'Reilly, 1st Edition, 2017
3. Deep Learning: Methods and Applications, Deng & Yu, Now Publishers, 1st Edition, 2013
4. Deep Learning CookBook, DouweOsinga, O'Reilly, 1st Edition, 2017

Course Code	Course Title	Credits	No. of lectures
24BPDS3P02	**Practicals Based on 24BPDS3T04**	**02**	**30**

CO1	Identify fundamental concepts of linear algebra & deep learning required for practical implementation, including matrix operations, eigen values, neural network components, learning paradigms.	L1
CO2	Analyze the behavior and performance of deep feed-forward and recurrent neural networks by interpreting outputs from classification, regression, and sequence modeling experiments.	L4
CO3	Evaluate deep learning models using appropriate performance metrics by comparing classification accuracy, probability estimates, regression errors, and sequence prediction results.	L5
CO4	Design and implement deep learning solutions using TensorFlow to solve problems such as XOR classification, multi-class classification, regression, and stock price sequence analysis.	L6

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	-	-	1
CO2	3	2	2	-	1	2
CO3	3	3	2	-	1	3
CO4	3	3	3	1	2	3

Practical 1	Performing matrix multiplication and finding eigen vectors and eigen values using TensorFlow.
Practical 2	Solving XOR problem using deep feed forward network.
Practical 3	Implementing deep neural network for performing classification task.
Practical 4	Using deep feed forward network with two hidden layers for performing classification and predicting the class.
Practical 5	Using a deep field forward network with two hidden layers for performing classification and predicting the probability of class.
Practical 6	Using a deep field forward network with two hidden layers for performing linear regression and predicting values.
Practical 7	Demonstrate recurrent neural network that learns to perform sequence analysis for stock price.

Course Code	Course Title	Credits	No. of lectures
24BPDS3T05	Cloud Application Development	02	30

CO1	Identify and list fundamental concepts, components, and architectures of microservices, Azure Service Fabric, Azure Kubernetes Service (AKS), and DevOps environments.	L1
CO2	Explain microservices communication mechanisms, security models, monitoring strategies, and database design approaches in cloud-based and on-premises Azure environments.	L2
CO3	Apply Azure and DevOps tools to deploy, monitor, and secure microservices applications using Service Fabric, AKS, API gateways, and Azure monitoring services.	L3
CO4	Analyze microservices architectures and DevOps workflows to evaluate scalability, security, reliability, and performance trade-offs in enterprise cloud and hybrid deployments.	L4

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	-	-	1
CO2	3	2	2	-	1	2
CO3	3	2	3	-	2	3
CO4	3	3	2	1	2	3

Unit I	**Implementing Microservices:** Client to microservices communication, Interservice communication, data considerations, security, monitoring, microservices hosting platform options. **Azure Service Fabric:** Introduction, core concepts, supported programming models, service fabric clusters, develop and deploy applications of service fabric. **Monitoring Azure Service Fabric Clusters:** Azure application, resource manager template, Adding Application Monitoring to a Stateless Service Using Application Insights, Cluster monitoring, Infrastructure monitoring. **Azure Kubernetes Service (AKS):** Introduction to kubernetes and AKS, AKS development tools, Deploy applications on AKS. **Monitoring AKS:** Monitoring, Azure monitor and analytics, monitoring AKS clusters, native kubernetesdashboard, Prometheus and Grafana.	15 [CO1, CO2]
Unit II	**Securing Microservices:** Authentication in microservices, Implenting security using API gateway pattern, Creating application using Ocrlot and securing APIs with Azure AD. **Database Design for Microservices:** Data stores, monolithic approach, Microservices approach, harnessing cloud computing, dataase options on MS Azure, overcoming application development challenges. **Building Microservices on Azure Stack:** Azure stack, Offering IaaS, PaaS on-premises simplified, SaaS on Azure stack..**NET DevOps for Azure:** DevOps introduction, Problem and solution. **Professional Grade DevOps Environment:** The state of DevOps,professional grade DevOps vision, DevOps architecture, tools for professional DevOps environment, DevOps centered application.	15 [CO3, CO4]

References:

1. Applications on Microsoft Azure- Designing, Developing, Deploying, and Monitoring , by Harsh Chawla, Hemant Kathuria , Apress , 2019
2. .NET DevOps for Azure A Developer's Guide to DevOps Architecture the Right Way by Jeffrey Palermo ,Apress , 2019
3. Practical API Architecture and Development with Azure and AWS - Design and Implementation of APIs for the Cloud byThurupathan Vijayakumar , Apress , 2018

Course Code	Course Title	Credits	No. of lectures
24BPDS3P03	Practicals Based on 24BPDS3T05	02	60

CO1	Identify core concepts, tools, technologies used in microservices development including ASP.NET Core, Spring Boot, Azure Kubernetes Service (AKS), API gateways, and cloud monitoring services.	L1
CO2	Explain the workflow of building, securing, monitoring, and deploying microservices applications on Azure using Kubernetes, Dev Spaces, API gateways, and cloud-based databases.	L2
CO3	Develop stateless web applications and microservices APIs using ASP.NET Core, Spring Boot, Node.js, and Azure Kubernetes Service with appropriate monitoring and security configurations.	L3
CO4	Analyze microservices deployment architectures and configurations by examining scalability, security, database design, and performance of applications deployed on AKS.	L4

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	-	-	1
CO2	3	2	2	-	1	2
CO3	3	2	3	-	1	2
CO4	3	3	4	1	2	2

Practical 1	Develop an ASP.NET Core MVC based Stateless Web App.
Practical 2	Develop a Spring Boot API.
Practical 3	Create an ASP.NET Core Web API and configure monitoring.
Practical 4	a. Create an Azure Kubernetes Service Cluster b. Enable Azure Dev Spaces on an AKS Cluster
Practical 5	Configure Visual Studio to Work with an Azure Kubernetes Service Cluster
Practical 6	Configure Visual Studio Code to Work with an Azure Kubernetes Service Cluster
Practical 7	Deploy Application on AKS i. Core Web API ii. Node.js API
Practical 8	Create an AKS cluster a. from the portal b. with Azure CLI
Practical 9	Create an Application Gateway Using Ocelot and Securing APIs with Azure AD.
Practical 10	Create a database design for Microservices an application using the database.

Course Code	Course Title	Credits	No. of Hours
24BPIT3RP7	Research Project in Data Science – I	04	120

CO1	Identifying problems, designing experiments, and executing research independently.	L4
CO2	Applying advanced concepts, interpreting complex data, and developing creative solutions.	L3
CO3	Demonstrate research clearly through papers, posters, or oral presentations to diverse audiences.	L3
CO4	Understand IPR, ethical issues, and responsible conduct in research.	L2

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	1	3	3
CO2	3	3	3	1	2	3
CO3	2	3	3	1	3	3
CO4	2	3	2	1	2	2

For details of Research Project Guidelines refer following link
https://drive.google.com/file/d/1l9hsRma6hrq6DxJ6yi-bnN9iZJNkGm-6/view?usp=sharing

SEMESTER IV

SEMESTER IV

Course Code	Course Title	No. of Lectures	Credits
MANDATORY PAPERS			
24BPDS4T01	Business Communication	**60**	**4**
24BPDS4T02	Introduction to Management	**60**	**4**
24BPDS4T03	Predictive Analytics and Development	**60**	**4**
ELECTIVE PAPERS			
24BPDS4T04	Cyber Security	**30**	**2**
24BPDS4P01	Practicals Based on 24BPDS3T04	**60**	**2**
OR			
24BPDS4T05	Natural Language Processing	**30**	**2**
24BPDS4P02	Practicals Based on 24BPDS3T05	**60**	**2**
RESEARCH PROJECT (RP)			
24BPDS4RP7	Research Project – II based on Data Science	**180**	**6**
	Total Credits		**22**
	Total Semester III & Semester IV Credits		**44**

Course Code	Course Title	Credits	No. of lectures
24BPDS4T01	**Business Communication**	04	60

CO1	Explain the principles, processes, and barriers of effective business communication, including verbal, non-verbal, cross-cultural, and technology-enabled communication.	L2
CO2	Analyze business communication scenarios to identify communication barriers, cultural influences, ethical concerns, and appropriate communication strategies.	L4
CO3	Evaluate written, oral business communication practice such as business correspondence, resumes, interviews, group discussions, listening skills to determine their effectiveness and professionalism.	L5
CO4	Design deliver professional business communication outputs, including resumes, business letters, interview responses, group discussion contributions, and ethical digital communication content.	L6

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	-	1	2
CO2	3	2	2	1	2	2
CO3	3	2	2	1	2	3
CO4	3	1	3	1	3	3

Unit I	Nature and Scope of Communication: Business Communication, Communication Basics, Informal Communication, Communication Barriers, Effective managerial Communication Non-verbal Communication: Significance and Forms of Non-verbal Communication, Types of Non-verbal Communication	15 [CO1, CO2]
Unit II	Cross Cultural Communication: Concept, Cultural variables and Communication, Strategies Technology Enabled Business Communication: Tools, Positive and Negative impact, Effectiveness in Technology Based Communication Business Writing: Importance of Written Business Communication, Business Correspondence: Common Components, Kinds of Business Letters	15 [CO1, CO3]
Unit III	Careers and Resumes: Career Building, Resume Formats, Sending resumes, Follow-up Effective Listening: Types of Listening, Barriers to effective listening	15 [CO2, CO4]
Unit IV	Interviews: General preparation for an interview, Success in Interview, Types of Interviewing Questions, Types of Interviews Group Discussion: Benefits of GD, Improiving GD Performance, Steps in GD Ethics in Business Communication: Ethical Communication, Ethical Code in communication, Ethical Communication on Internet	15 [CO3, CO4]

References:

1. Business Communication, A Practice Oriented Approch, Shalini Kalia, Shailaja Agarwal, Wiley, 2016
2. Business Communication, Volume I, Dr.Rishipal, Dr.JyotiSheoran, SPD, 2015
3. Soft Skills, An Integrated Approch to maximize personality, Gajendra Singh Chauhan, Sangeeta Sharma, Wiley, 1st Edition 2016

Course Code	Course Title	Credits	No. of lectures
24BPDS4T02	Management for I.T.	04	60

CO1	Identify and recall fundamental concepts, functions, roles, levels, skills, and historical approaches of management.	L2
CO2	Analyze organizational structures, departmentalization, span of management, delegation, empowerment, and decision-making processes to evaluate effectiveness and efficiency in managerial practice.	L4
CO3	Evaluate leadership styles, motivation theories, and control mechanisms to determine their suitability and impact on organizational performance.	L5
CO4	Design and formulate effective management strategies, organizational structures, planning processes, and control systems to address real-world business challenges.	L6

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	-	1	2
CO2	3	2	1	-	2	3
CO3	3	2	1	-	2	3
CO4	3	2	2	1	2	3

Unit I	Introduction to Management: Definition, Nature and Scope, Functions, Managerial Roles, Levels of Management, Managerial Skills, Challenges of Management; Evolution of Management- Classical Approach- Scientific and Administrative Management; The Behavioral approach; The Quantitative approach; The Systems Approach; Contingency Approach.	15 [CO1, CO2]
Unit II	Planning and Decision Making: Concept of Planning - Planning Process, Types of Plans, Management by Objectives; Approaches to Planning, Barriers to Effective Planning. Decision making - Meaning, types of Decisions, Decision Making Process; Bounded Rationality and Approaches of Decision Making.	15 [CO2, CO3]
Unit III	Organizing: Concept, Pros of Organization, Principles of Organizing, Formal and Informal Organization, Design of Organizational Structures; Departmentalization, Span of Management, Forms of Organization Structure: Delegation; Empowerment, Centralization, Decentralization; Organizational Culture; Organizational Climate and Organizational Change.	15 [CO2, CO4]
Unit IV	Leading, Motivation and controlling: Leadership – Concept & Types, Leadership Styles, Leadership Theories. Motivation – Concept & Meaning, Theories of Motivation Controlling: Concept, Nature and Importance, Steps in Controlling Process, Types of Control, Management by Exception, Design of Effective control system.	15 [CO3, CO4]

References:

1. Prasad L.M., "Principles and Practice of Management", 10e, Sultan Chand & Sons, 2020
2. Stephen Robbins, Timothy Judge, Neharika Vohra, Organizational Behaviour, Pearson Education, 18e, 2018

Course Code	Course Title	Credits	No. of lectures
24BPDS4T03	**Predictive Analytics and Development**	04	60

CO1	Explain the concepts of business intelligence, decision support systems, types of analytics, and their role in effective and ethical business decision-making.	L2
CO2	Apply descriptive, diagnostic, predictive, and prescriptive analytics techniques, including time-series forecasting and optimization models, to solve real-world business problems.	L3
CO3	Evaluate effectiveness of business intelligence tools, marketing models, and logistics/production optimization methods to improve decision-making and organizational performance.	L5
CO4	Design and develop business intelligence and analytics solutions using appropriate models and techniques for marketing, sales, supply chain, and revenue management applications	L6

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	-	1	2
CO2	3	2	3	-	2	3
CO3	3	2	2	-	2	3
CO4	3	3	3	1	2	3

Unit I	Business intelligence: Effective and timely decisions, Data, information and knowledge, The role of mathematical models, Business intelligence architectures, Ethics and business intelligence	15 [CO1]
Unit II	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 Data analytics in business?, Who needs data Analytics?	15 [CO1, CO2]
Unit III	Types of analytics : Descriptive Analytics -advantages and Disadvantages, Importance, Applications. Diagnostic Analytics-advantages and Disadvantages, Importance, Applications. Predictive Analytics-advantages and Disadvantages, Importance, Applications. Prescriptive Analytics- Methodology, advantages and Disadvantages, Importance, Applications.	15 [CO2, CO3, CO4]
Unit IV	Nature of Time-Series Data, Time Series Forecasting Techniques, other Time Series techniques that boost accuracy. Marketing models: Relational marketing, Sales force management, Logistic and production models: Supply chain optimization, Optimization models for logistics planning, Revenue management systems.	15 [CO3, CO4]

References:

1. Business Intelligence: Data Mining and Optimization for Decision Making, Carlo Vercellis, Wiley, First Edition, 2009
2. Decision support and Business Intelligence Systems, Efraim Turban, Ramesh Sharda, Dursun Delen, Pearson, Ninth Edition, 2011
3. Fundamental of Business Intelligence, Grossmann W, Rinderle-Ma, Springer, First Edition, 2015

Course Code	Course Title	Credits	No. of lectures
24BPDS4T04	Cyber Security	02	30

CO1	Identify fundamental concepts, procedures, and tools in computer, network, mobile, internet, email, and browser forensics, including data recovery, disk imaging, and automated search techniques.	L1
CO2	Explain standard procedures for incident verification, system identification, network traffic analysis, mobile device acquisition, and reconstruction of digital evidence.	L2
CO3	Analyze forensic evidence from various digital sources—computers, networks, mobile devices, internet activities, emails, and browsers—to detect, interpret, and reconstruct cyber incidents.	L4
CO4	Evaluate digital forensic investigation strategies in compliance with legal frameworks, IT laws, and cybercrime regulations to produce credible evidence for case studies and judicial proceedings.	L5

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	-	1	2
CO2	3	2	3	-	2	2
CO3	3	3	3	-	2	3
CO4	3	3	3	-	2	3

Unit I	**Computer Forensics :** Introduction to Computer Forensics and standard procedure, Incident Verification and System Identification ,Recovery of Erased and damaged data, Disk Imaging and Preservation, Data Encryption and Compression, Automated Search Techniques, Forensics Software **Network Forensic :** Introduction to Network Forensics and tracking network traffic, Reviewing Network Logs, Network Forensics Tools, Performing Live Acquisitions, Order of Volatility, Standard Procedure **Cell Phone and Mobile Device Forensics:** Overview, Acquisition Procedures for Cell Phones and Mobile Devices	
Unit II	**Internet Forensic :** **Introduction** to Internet Forensics, World Wide Web Threats, Hacking and Illegal access, Obscene and Incident transmission, Domain Name Ownership Investigation, Reconstructing past internet activities and events **E-mail Forensics :**e-mail analysis, e-mail headers and spoofing, Laws against e-mail Crime, **Browser Forensics:** Cookie Storage and Analysis, Analyzing Cache and temporary internet files, Web browsing activity reconstruction **Introduction to Legal aspects of Digital Forensics:** Laws & regulations, Information Technology Act, Giving Evidence in court, Case Study – Cyber Crime cases, Case Study – Cyber Crime cases	

References:

1. Guide to computer forensics and investigations, Bill Nelson, Amelia Philips and Christopher Steuart, course technology,5th Edition,2015
2. Incident Response and computer forensics, Kevin Mandia, Chris Prosise, Tata McGrawHill,2nd Edition,2003

Course Code	Course Title	Credits	No. of lectures
24BPDS4P01	Practicals Based on 24BPDS4T04	02	30

CO1	Identify and recall fundamental concepts, tools, and procedures in digital forensics, including forensic imaging, data acquisition, network monitoring, email, and web browser forensics.	L1
CO2	Explain the methodology and steps involved in creating forensic images, analyzing network packets, and performing process, memory, and email forensics.	L2
CO3	Analyze digital evidence from forensic images, network captures, emails, and browser artifacts to detect, interpret, and reconstruct potential security incidents or cybercrime activities.	L4
CO4	Design and execute comprehensive forensic investigations using appropriate tools (FTK/Encase Imager, Autopsy, Wireshark, Sysinternals) to provide conclusive reports for case studies and real-world digital forensic scenarios.	L6

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	-	1	2
CO2	3	2	3	-	2	2
CO3	3	3	3	-	2	3
CO4	3	3	3	-	2	3

Practical 1	Creating a Forensic Image using FTK Imager/Encase Imager : - Creating Forensic Image - Check Integrity of Data - Analyze Forensic Image
Practical 2	Data Acquisition: - Perform data acquisition using: - USB Write Blocker + Encase Imager - SATA Write Blocker + Encase Imager - Falcon Imaging Device
Practical 3	Forensics Case Study: - Solve the Case study (image file) provide in lab using Encase Investigator or Autopsy
Practical 4	Capturing and analyzing network packets using Wireshark (Fundamentals) : - Identification the live network - Capture Packets
Practical 5	Using Sysinternals tools for Network Tracking and Process Monitoring : - Check Sysinternals tools - Monitor Live Processes - Capture RAM - Capture TCP/UDP packets - Monitor Hard Disk - Monitor Virtual Memory - Monitor Cache Memory
Practical 6	Email Forensics - Mail Service Providers - Email protocols - Recovering emails - Analyzing email header
Practical 7	Web Browser Forensics - Web Browser working - Forensics activities on browser - Cache / Cookies analysis - Last Internet activity

Course Code	Course Title	Credits	No. of lectures
24BPDS4T05	Natural Language Processing	02	30

CO1	Identify and recall fundamental concepts, history, applications, and challenges of NLP, including speech-to-text, text-to-speech, machine translation, text summarization, and sentiment analysis.	L1
CO2	Explain the characteristics of natural language, NLP abstraction levels, natural language computing approaches, and tasks such as segmentation, chunking, tagging, parsing, and word sense disambiguation.	L2
CO3	Analyze text processing challenges, language scripts, corpus dependencies, and morphological structures to determine appropriate processing techniques for English and Indian languages.	L4
CO4	Evaluate and design rule-based, paradigm-based, and machine learning approaches for morphological parsing, tokenization, stemming (e.g., Porter Stemmer), and text processing pipelines for NLP applications.	L5

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	-	1	2
CO2	3	2	2	-	1	2
CO3	3	2	2	-	2	3
CO4	3	3	3	-	2	3

Unit I	Introduction to NLP, brief history, NLP applications: Speech to Text(STT), Text to Speech(TTS), Story Understanding, NL Generation, QA system, Machine Translation, Text Summarization, Text classification, Sentiment Analysis, Grammar/Spell Checkers etc., challenges/Open Problems, NLP abstraction levels, Natural Language (NL) Characteristics and NL computing approaches/techniques and steps, NL tasks: Segmentation, Chunking, tagging, NER, Parsing, Word Sense Disambiguation, NL Generation, Web 2.0 Applications : Sentiment Analysis; Text Entailment; Cross Lingual Information Retrieval (CLIR).	15 [CO1, CO3]
Unit II	Text Processing Challenges, Overview of Language Scripts and their representation on Machines using Character Sets, Language, Corpus and Application Dependence issues, Segmentation: word level (Tokenization), Sentence level. Regular Expression and Automata Morphology, Types, Survey of English and Indian Languages Morphology, Morphological parsing FSA and FST, Porter stemmer, Rule based and Paradigm based Morphology, Human Morphological Processing, Machine Learning approaches.	15 [CO2, CO3, CO4]

References:

1. Handbook of Natural Language Processing, Indurkhya, N., &Damerau, F. J., CRC Press Taylor and Francis Group, 2nd Edition, 2010
2. Speech and Language Processing, Martin, J. H., &urafsky, D., Pearson Education India, 2nd Edition, 2013
3. Foundations of Statistical Natural Language Processing, Manning, Christopher and Heinrich, Schutze, MIT Press, 1st Edition, 1997
4. Natural Language Processing With Python, Steven Bird,EdwardLoper, O'Reilly Media, 2nd Edition, 2016
5. Video Link: http://www.nptelvideos.in/2012/11/natural-language-processing.html

Course Code	Course Title	Credits	No. of lectures
24BPDS4P02	Practicals Based on 24BPDS4T05	02	30

CO1	Identify and recall key NLP tools, libraries, and corpora in Python, including NLTK, WordNet, Brown, Reuters, and UDHR datasets.	L1
CO2	Explain the functionality of NLP techniques such as text-to-speech, speech-to-text, tagging, conditional frequency distributions, and dictionary-based word properties.	L2
CO3	Apply NLP methods using Python to process text and audio, including creating custom corpora, tagging words, mapping words to properties, and finding synonyms and antonyms with WordNet.	L3
CO4	Analyze textual data to extract linguistic patterns, compare word similarities, identify frequent tags, and evaluate results from various taggers and corpora for effective natural language understanding.	L4

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	-	1	2
CO2	3	2	3	-	2	2
CO3	3	2	3	-	2	3
CO4	3	3	3	-	2	3

Practical 1	a. Install NLTK b. Convert the given text to speech
Practical 2	Convert audio file Speech to Text.
Practical 3	Study of various Corpus – Brown, Inaugural, Reuters, udhr with various methods like fields, raw, words, sents, categories,
Practical 4	a. Create and use your own corpora(plaintext, categorical) b. Study Conditional frequency distributions
Practical 5	Study of tagged corpora with methods like tagged_sents, tagged_words.
Practical 6	Write a program to find the most frequent noun tags.
Practical 7	Map Words to Properties Using Python Dictionaries
Practical 8	Study DefaultTagger, Regular expression tagger, UnigramTagger
Practical 9	Find different words from a given plain text without any space by comparing this text with a given corpus of words. Also find the score of words.
Practical 10	Study of Wordnet Dictionary with methods as synsets, definitions, examples, antonyms.
Practical 11	Study lemmas, hyponyms, hypernyms, entailments,
Practical 12	a. Write a program using python to find synonym and antonym of word "active" using Wordnet b. Compare two nouns

Course Code	Course Title	Credits	No. of Hours
24BPIT4RP7	Research Project in Data Science - II	06	180

CO1	Identifying problems, designing experiments, and executing research independently.	L4
CO2	Applying advanced concepts, interpreting complex data, and developing creative solutions.	L3
CO3	Demonstrate research clearly through papers, posters, or oral presentations to diverse audiences.	L3
CO4	Understand IPR, ethical issues, and responsible conduct in research.	L2

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	1	3	3
CO2	3	3	3	1	2	3
CO3	2	3	3	1	3	3
CO4	2	3	2	1	2	2

For details of Research Project Guidelines refer following link
https://drive.google.com/file/d/1l9hsRma6hrq6DxJ6yi-bnN9iZJNkGm-6/view?usp=sharing

Evaluation and Examination Scheme

Evaluation Scheme 60:40

Internals Based on Unit 1 / Unit 2 / Unit 3/ Unit 4

Assignments/ Tutorials/Class Test	Seminar or any other activities	Active Participation &Leadership qualities	Total
30	05	05	40

Theory Examinations: For Paper 1, Paper 2, Paper 3and Elective

Suggested Format for Mandatory Question paper

Duration: 2 hr. 30 min **Total Marks: 60**

N.B.

1. **All questions are compulsory**
2. **Draw neat labeled diagram wherever necessary**
3. **All questions carry equal marks**

Q.1.	**(A)**		**Attempt any one**	**8**
		(I)		
		(II)		
Q.1.	**(B)**		**Attempt any one**	**7**
		(I)		
		(II)		
Q.2.	**(A)**		**Attempt any one**	**8**
		(I)		
		(II)		
Q.2.	**(B)**		**Attempt any one**	**7**
		(I)		
		(II)		
Q.3.	**(A)**		**Attempt any one**	**8**
		(I)		
		(II)		
Q.3.	**(B)**		**Attempt any one**	**7**
		(I)		
		(II)		
Q.4.	**(A)**		**Attempt any one**	**8**
		(I)		
		(II)		
Q.4.	**(B)**		**Attempt any one**	**7**
		(I)		
		(II)		
			**********	

Suggested Format for Elective Question paper:

23BPEV_T0_/0_/20_

Duration: 1 hr. 30 min **Total Marks: 30**

N.B.

1. **All questions are compulsory**
2. **Draw neat labeled diagram wherever necessary**
3. **All questions carry equal marks**

Q.1.	**(A)**		**Attempt any one**	**8**
		(I)		
		(II)		
Q.1.	**(B)**		**Attempt any one**	**7**
		(I)		
		(II)		
Q.2.	**(A)**		**Attempt any one**	**8**
		(I)		
		(II)		
Q.2.	**(B)**		**Attempt any one**	**7**
		(I)		
		(II)		

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Semester End Practical Examination:

Practical examination of each paper for 50 marks will be held for 4 hours.

Marks Distribution and Passing Criterion for Each Semester

Semester - III

Theory						Practical		
Course Code	**Internal**	**Min marks for passing**	**Theory Examination**	**Min marks for passing**	**Total**	**Course Code**	**Practical Examination**	**Min marks for passing**
24BPDS3T01	40	16	60	24	100			
24BPDS3T02	40	16	60	24	100	**24BPDS3P01**	**50**	**20**
24BPDS3T03	40	16	60	24	100			
E-I **24BPDS3T04**	40	16	60	24	100	**24BPDS3P02**	**50**	**20**
E-II **24BPDS3T05**	40	16	60	24	100	**24BPDS3P03**	**50**	**20**
24BPDS3RP7	Research Project – I based on Data Science					**100**		**40**

Semester - IV

Theory						Practical		
Course Code	**Internal**	**Min marks for passing**	**Theory Examination**	**Min marks for passing**	**Total**	**Course Code**	**Practical Examination**	**Min marks for passing**
24BPDS4T01	40	16	60	24	100			
24BPDS4T02	40	16	60	24	100	23BPDS2P01	**50**	**20**
24BPDS4T03	40	16	60	24	100			
E-I **24BPDS4T04**	40	16	60	24	100	**24BPDS4P01**	**50**	**20**
E-II **24BPDS4T05**	40	16	60	24	100	**24BPDS4P02**	**50**	**20**
24BPDS4RP7	Research Project – II based on Data Science					**150**		**60**

VPM's B. N. Bandodkar College of Science (Autonomous), Thane

Curriculum Structure for the Post Graduate Degree Programme M.Sc. Data Science

	SEMESTER–III	Course imparts Employability (EM), Entrepreneurship (EN), Skill Development (SD)			Course integrates with Professional Ethics (PE), Gender Equity (GE), Human Value (HV), Environmental Sustainability (ES)			
Course Code	**Mandatory Course Title**	**EM**	**EN**	**SD**	**PE**	**GE**	**HV**	**ES**
24BPDS3T01	Artificial Intelligence	✓	✓	✓	-	-	-	-
24BPDS3T02	Introduction to Machine Learning	✓	✓	✓	-	-	-	-
24BPDS3T03	Soft Computing	✓	-	✓	-	-	-	-
24BPDS3P01	Practical Based on 24BPDS3T01 and 24BPDS3T02	✓	✓	✓	-	-	-	-
	Elective Course Title							
24BPDS3T04	Deep Learning	✓	✓	✓	-	-	-	-
24BPDS3P02	Practicals Based on 24BPDS3T04	✓	✓	✓	-	-	-	-
	OR							
24BPDS3T05	Cloud Application Development	✓	✓	✓	-	-	-	-
24BPDS3P03	Practicals Based on 24BPDS3T05	✓	✓	✓	-	-	-	-
	Research Project (RP)							
24BPDS3RP7	Research Project – I based on Data Science	✓	✓	✓	✓	--	✓	✓

	SEMESTER–IV	Course imparts Employability (EM), Entrepreneurship (EN), Skill Development (SD)			Course integrates with Professional Ethics (PE), Gender Equity (GE), Human Value (HV), Environmental Sustainability (ES)			
Course Code	**Mandatory Course Title**	**EM**	**EN**	**SD**	**PE**	**GE**	**HV**	**ES**
24BPDS4T01	Business Communication	✓	✓	✓	-	-	-	-
24BPDS4T02	Introduction to Management	✓	✓	✓	-	-	-	-
24BPDS4T03	Predictive Analytics Development	✓	✓	✓	-	-	-	-
	Elective Course Title							
24BPDS4T04	Cyber Security	✓	✓	✓	-	-	-	-
24BPDS4P01	Practicals Based on 24BPDS4T04	✓	✓	✓	-	-	-	-
	OR							
24BPDS4T05	Natural Language Processing	✓	✓	✓	-	-	-	-
24BPDS4P02	Practicals Based on 24BPDS4T05	✓	✓	✓	-	-	-	-
	Research Project (RP)							
24BPDS4RP7	Research Project – II based on Data Science	✓	✓	✓	✓	--	--	--

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