Modern Education Society's

Nowrosjee Wadia College (AUTONOMOUS)

NAAC Accredited A+ with CGPA 3.51

Affiliated to the

Savitribai Phule Pune University

(Formerly University of Pune)

Two Year M. Sc. Degree Program in Data Science

(Faculty of Science & Technology)

M. Sc. (Data Science)

Choice Based Credit System Syllabus under NEP

To be implemented from Academic Year 2024-2025

1. Preamble of the Syllabus

Data science combines the knowledge of mathematics, statistics and computer science to solve exciting data-intensive problems in industry and in many fields of science. In today's tech-driven world, access to vast amounts of information and ways to interpret it have taken priority than ever before. Real time processing of this huge data is also a major requirement in every walk of life. It also means we need more people who can organize and analyze that information - people who can use data to make change and help businesses. Data science employs a variety of instruments, scientific procedures, methods, and algorithms to glean insights from both structured and unstructured data. This Data Science program integrates scientific methods from statistics, computer science and data-based business management to extract knowledge from data and drive decision making. Our curriculum provides students with a rigorous course of study in big data technologies, applications and practices a pathway for student internships and full-time employment. Students are prepared to meet the challenges at the intersection between big data, business analytics, and other emerging fields. In compliance with the directives from the University Grants Commission, under the autonomous status of the college, the syllabus for Data Science at the post graduate level is designed as per the National Educational Policy (NEP 2020) curriculum framework. The present syllabus is prepared by the Board of Studies in Mathematics, Nowrosjee Wadia College, taking into consideration the present relevance and application of data science. While preparing this syllabus the U.G.C. model curriculum (LOCF) and existing syllabus given by Savitribai Phule Pune University is followed.

2. Objectives

- To equip students with statistical, mathematical reasoning, machine learning, knowledge discovery, problem solving, and visualization skills.
- To provide technology-oriented students specialized in data science stream with the capability in various areas of data science and business domains.
- Familiarize the students with suitable tools of mathematical and statisical analysis to handle issues and problems in data sciences.
- Enhance the ability of learners to apply the knowledge and skills acquired by them during the programme to solve specific theoretical and applied problems in data Science.
- Develops attitude and interest along with necessary skills among the students to encourage them to do research and work in industry.
- Encourage the students to develop a range of generic skills helpful in employment, internships and social activities.

3. Programme Outcomes

PO1**:** To apply ethical practices in everyday business activities and make well-reasoned ethical business and data management decisions.

PO2: To demonstrate knowledge of statistical data analysis techniques utilized in businessdecision making.

PO3: To apply principles of Data Science to the analysis of business problems.

PO4: To use data mining software to solve real-world problems.

PO5: To employ cutting edge tools and technologies to analyze Big Data.

PO6: To apply algorithms to build machine intelligence.
PO7: To demonstrate use of team work, leadership skills, decision making and organizationtheory.
PO8: To enhance research culture and uphold scientific integrity and objectivity.

Programme Specific Outcome:
PSO1: Abstract thinking: Ability to understand the abstract concepts that lead to various data science theories in Mathematics, Statistics and Computer science.
PSO2: Problem Analysis and Design Ability to identify analyze and design solutions for data science problems using fundamental principles of mathematics, Statistics, computing sciences, and relevant domain disciplines.
PSO3: Modern software tool usage: Acquire the skills in handling data science programming tools towards problem solving and solution analysis for domain specific problems.
PSO4: Innovation And Entrepreneurship: Produce innovative IT solutions and services based on global needs and trends.
PSO5: Societal And Environmental Concern: Utilize the data science theories for societal and environmental concerns.
PSO6: Professional Ethics: Understand and commit to professional ethics and cyber regulations, responsibilities, and norms of professional computing practices.
PSO7: Conduct Investigations of complex computing problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PSO8: Individual and Team work: Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary environments.
PSO9: Applications in Multi disciplinary domains: Understand the role of statistical approaches and apply the same to solve the real life problems in the fields of data science.
PS10: Project Management: Apply the research-based knowledge to analyse and solve advanced problems in data science.

4. Eligibility

Graduate degree in Mathematics/ Statistics / Computer Science / Computer Application/ Engineering / Technology or any other discipline with a minimum of two years of learning mathematics or statistics from a recognized university / institution with an equivalent qualification.

5. Duration of the Course:

The duration of the M.Sc. Data Science Program shall extend over 4 semesters (two academic years) of 15 weeks or more, each with a maximum of 90 actual working days of instruction in each semester.

6. Medium of instruction:

The medium of instruction shall be English.

7. Teaching Scheme:

- The course is a 2 year, 3 semesters full time under graduate course.
- The course follows the NEP (National Educational Policy 2020) pattern as per
- Government of Maharashtra G.R(s) as follows:

सांकेतांक २०२३०४२०१९२५२६६९०८

शासन निर्णय क्रमांक: एनईपी-२०२२/प्र.क्र.०९/विशि-३ शिकाना, दिनांक २० एप्रिल, २०२३

4 credit theory course = 60 hours (60 lectures)

2 credit theory courses = 30 hours (30 lectures)

2 credit practical course = **60 hours (4 hours/ week/ batch)**

8. Abbreviations

OE: Open Elective

AEC: Ability Enhancement Course

VEC: Value Education Courses

CC: Co-Curricular Courses

IKS: Indian Knowledge System

OJT: On Job Training

FP: Field Project

VS: Vocational Skill Courses

CEP: Community Engagement Project

T: Theory

P: Practical

CE: Continuous Evaluation

SEE: Semester End Examination

F.Y.: First Year

S.Y.: Second Year

T.Y.: Third Year

M. Sc. (Data Science) Proposed Structure as per NEP 2020

YEAR	Level	Sem	Mandatory	Credit	Elective(select one)	RM	OJT/FP	RP	Cum Cr	Degree
I	6	Sem I	Statistics for Data Science-I	**4**	Database Technologies (2T+2P)	4	—	—	20-22	PG Diploma (after 3 yr degree)
			Mathematics for Data Science	4						
			Python Programming for Data Science	2	R-Programming for Data Science (2T+2P)					
			LAB on Mathematics and Statistics for Data Scienc	2						
			LAB on Python Programming	2						
		Sem II	Statistics for Data Science-II	4	Data Mining and Data Ware housing (2T + 2P)		(Mini project) - 4 credit	—	20-22	
			AI & Machine Learning	4						
			Fundamental of Data Science	2	Optimization Techniques (2T + 2P)					
			LAB on Statistics for Data Science-II	2						
			LAB on AI and Machine Learning using Python	2						
Cum . Cr. For PG Diploma			24-28		8	4	4		40-44	
Exit Option: PG Diploma (40-44 credits) after three year UG Degree										
II	6.5	Sem III	AI and Big data Mining	4			—		20-22	PG Degree

			Data Visualization and Analytics	4	Predictive Analysis and Generative AI			4 credit (mini project)		(after 3 yr degree) Or PG Degree (after 4 yr degree)
			Deep Learning	2	Design and Analysis of Algorithms					
			LAB on Deep Learning	2						
			LAB on Big data and data Visualisation	2						
		Sem IV	Emerging Trends in Data Science	4			—	12 credit	20-22	
			Data Science Case Studies	4						
			Business Informatics	2						
Cum. Cr. for 1 Yr PG Degree			22-26		8			10	40-44	
Cum. Cr. for 2 Yr PG Degree			46-54		16	4	4	10	80-88	

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	Masters of Science with Major in Data Science	
Major (Theory) Subject SEMESTER – I		
Year – I	**Paper No-**	**Credits 4**
Semester-I	**Name of Paper-** Statistics for Data Science-I	**Hours 60**

Course Specific Outcomes: On completion of the course, the students will

CO1: Describe basic features of the data.

CO2: Summarize the sample using different quantitative measures.

CO3: Apply and compare various counting techniques to analyse a particularproblem.

CO4: Identify different forms of probability distribution for discrete andcontinuous data.

CO5: Build predictive models for the sample data.

COURSE CONTENTS/ SYLLABUS	**Lectures**
Unit 1: Descriptive Statistics: 1.1 Measures of Central Tendency: Mean, Median, Mode 1.2 Partition Values: Quartiles, Percentiles, Box Plot 1.3 Measures of Dispersion: Variance, Standard Deviation, Coefficient of variation 1.4 Skewness: Concept of skewness, measures of skewness 1.5 Kurtosis: Concept of Kurtosis, Measures of Kurtosis (All topics to be covered for raw data using R software. Manual calculationsare not expected.)	**11**
Unit 2: Introduction to Probability: 2.1 Probability - classical definition, probability models, axioms of probability, probability of an event. 2.2 Concepts and definitions of conditional probability, multiplication theorem P(A∩B) =P(A). P(B|A) 2.3 Bayes' theorem (without proof) 2.4 Concept of Posterior probability, problems on posterior probability. 2.5 Definition of sensitivity of a procedure, specificity of a procedure. Application of Bayes' theorem to design a procedure for false positive and false negative. 2.6 Concept and definition of independence of two events.	**9**

2.7 Numerical problems related to real life situations.	
Unit 3: Introduction to Random Variables 3.1 Definition of discrete random and continuous random variable. 3.2 Concept of Discrete and Continuous probability distributions. (p.m.f. and p.d.f.) 3.3 Distribution function 3.4 Expectation and variance 3.5 Numerical problems related to real life situations	**10**
Unit 4: Special Distributions 4.1 Binomial Distribution 4.2 Uniform Distribution 4.3 Poisson Distribution 4.4 Negative Binomial Distribution 4.5 Geometric Distribution 4.6 Continuous Uniform Distribution 4.7 Exponential Distribution 4.8 Normal Distribution 4.9 Log Normal Distribution 4.10 Gamma Distribution 4.11 Weibull Distribution 4.12 Pareto Distribution (For all the probability distributions its pmf/pdf, p-p plot, q-q plot, generation of probabilities and random samples using R software isexpected. **)**	**8**
Unit 5: Correlation and Linear Regression 5.1 Bivariate data, Scatter diagram. 5.2 Correlation, Positive Correlation, Negative correlation, Zero Correlation 5.3 Karl Pearson's coefficient of correlation (r), limits of r ($-1 \leq r \leq 1$), interpretation of r, Coefficient of determination (r^2) 5.4 Meaning of regression, difference between correlation and regression. 5.5 Fitting of line $Y = a+bX$ 5.6 Concept of residual plot and mean residual sum of squares. 5.7 Multiple correlation coefficient, concept, definition, computation and interpretation. 5.8 Partial correlation coefficient, concept, definition, computation and interpretation. 5.9 Multiple regression plane. 5.10 Identification and solution to Multicollinearity 5.11 Evaluation of the Model using R square and Adjusted R square All topics to be covered for raw data using R software. Manual calculations are not expected.	**7**
References:	1. Fundamentals of Applied Statistics (3rd Edition), Gupta and Kapoor, S.Chand andSons, New Delhi, 1987. 2. An Introductory Statistics, Kennedy and Gentle. 3. Statistical Methods, G.W. Snedecor, W.G. Cochran, John Wiley & sons,

	1989. 4. Introduction to Linear Regression Analysis, Douglas C. Montgomery, Elizabeth A.Peck, G. Geoffrey Vining, Wiley 5. Modern Elementary Statistics, Freund J.E., Pearson Publication, 2005. 6. Probability, Statistics, Design of Experiments and Queuing theory with applicationsComputer Science, Trivedi K.S., Prentice Hall of India, New Delhi,2001. 7. A First course in Probability 6th Edition, Ross, Pearson Publication, 2006. 8. Introduction to Discrete Probability and Probability Distributions, Kulkarni M.B.,Ghatpande S.B., SIPF Academy, 2007. 9. A Beginners Guide to R, Alain Zuur, Elena Leno, Erik Meesters, Springer, 2009 10. Statistics Using R, Sudha Purohit, S.D.Gore, Shailaja Deshmukh, Narosa, PublishingCompany
Learning Outcomes	LO1: LO2:

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Major (Theory) Subject SEMESTER – I		
Year – I	**Paper No-**	**Credits 4**
Semester-I	**Name of Paper-** Mathematics for Data Science	**Hours 60**

Course Specific Outcomes: On completion of the course, the students will

CO1: able to effectively use matrix algebra tools to analyse and solve systemsof linear equations.
CO2: Students will be able to use some numerical methods to solve linear systems of equations
CO3: Students will be able to work on vector maps
CO4: understand the application of mathematics in data science

COURSE CONTENTS/ SYLLABUS	**Lectures**
Unit 1: INTRODUCTION TO VECTOR SPACES Vector Spaces: Null spaces, R^n and C^n, lists, F^n and digression on Fields, Definition of Vector spaces, Subspaces, sums of Subspaces, Direct Sums, Span and Linear Independence, Bases-Coordinate systems-The dimension of a vector space-Rank-Change of Basis.	**12**
Unit 2: EIGENVALUES, EIGENVECTORS, AND INNER PRODUCT SPACES Eigen values and Eigen vectors – Eigen vectors and Upper Triangular matrices – Eigen spaces andDiagonal Matrices - Inner Products and Norms - Linear functionals on Inner Product spaces.	**10**
Unit 3: LINEAR MAPS Definition of Linear Maps –Algebraic Operations on L(V,W) - Null spaces and Injectivity-Rangeand Surjectivity- Fundamental Theorems of Linear Maps-Representing a Linear Map by a Matrix-Invertible Linear Maps – Isomorphic Vectors paces-Linear Map as Matrix Multiplication - Operators - Products of Vector Spaces - Product of Direct Sum - Quotients of Vector spaces	**12**

Unit 4: BASIC MATRIX METHODS FOR APPLICATIONS Linear Equations in Linear Algebra - Systems of linear equations-Row reduction and Echelon forms-Vector Equations-Matrix equations Ax=b-Solution set of linear systems-Applications of linear systems-Linear Independence Introduction to linear transformations-The matrix of linear transformation Matrix Norms – The inverse of a matrix-Characterizations of Invertible Matrices-Partitioned Matrices-Matrix factorizations-Subspaces of R^n -Dimension and Rank, Least square problem - Singular value decomposition- Householder Transformation and QR decomposition- Non Negative Matrix Factorization – bidiagonalization, Inner product, length and orthogonality-Orthogonal sets-Orthogonal projections-The Gram-Schmidt Process	**18**
Unit 5: MATHEMATICS APPLIED TO DATA SCIENCE Handwritten digits recognition using simple algorithm - Classification of handwritten digits usingSVD bases and Tangent distance - Text Mining using Latent semantic index, Clustering, Non- negative Matrix Factorization and LGK bidiagonalization.	**8**
References:	1. Kenneth H. Rosen, Discrete Mathematics and its Applications, Tata McGraw Hill, 7th Ed.,2011 2. K Hoffman and R Kunze, Linear Algebra, Pearson Education, 2nd Edition, 2005
Learning Outcomes	LO1: LO2:

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	Masters of Science with Major in Data Science	
Major (Theory) Subject SEMESTER – I		
Year – I	**Paper No-**	**Credits 2**
Semester-I	**Name of Paper- Python Programming for Data Science**	**Hours 30**

Course Specific Outcomes: On completion of the course, the students will

CO1: use lists, tuples, and dictionaries in Python programs.

CO2: use indexing and slicing to access data in Python programs.

CO3: build and package Python modules for reusability.

CO4: To acquire Object Oriented Skills in Python.

CO5: Learn to understand data science Library- NumPy,Matplotlib,Pandas

COURSE CONTENTS/ SYLLABUS	**Lectures**
Unit 1: Introduction To Python 1.1 History of Python 1.2 Features of Python 1.3 Python Identifiers, variables, Keywords and Indentation 1.4 Comments and document interlude in Python 1.5 Command line arguments 1.6 Getting User Input 1.7 Python Data Types-List, tuple,Dictionary,set 1.8 Python Core objects and Functions	**06**
Unit 2: Control Flow and Functions, 2.1Control Flow 2.2Conditional blocks using if else and elif 2.3Simple for and while loops in python, For loop using ranges, string, list and dictionaries, Loop manipulation using pass, continue, break and else Functions, Arguments, 2.4Lambda Expressions, Function Annotations Modules	**6**
Unit 3: . Python Modules, Working with files, Exception handling 3.1. Modules: Importing module, Creating & exploring modules, Math module, Random module, Time module 3.2. Packages: Importing package, creating package,examples	**06**

3.3. Working with files: Creating files and Operations on files(open, close, read, write), File object attributes, file positions, Listing Files in a Directory, Testing File Types,Removing files and directories, copying and renaming files, splitting pathnames, creating and moving directories Exception Handling: Built-in Exceptions, Handling Exceptions, Exception with Arguments, User-definedExceptions	
Unit 4: Working with NUMPY with Jupyter 4.1. Installing and launching jupyter 4.2. Installing numpy 4.3. Numpy introduction 4.4. NumPy Datatypes 4.5. NumPy Array 4.6. Numpy Arithmatic operations, binary operators 4.7. Numpy String functions, mathematical functions, statistical 4.8. Functions -Numpy sort, search and counting functions	**6**
Unit 5: Working with Pandas with Spyder 5.1. Installing Spyder and Pandas 5.2. Introduction to Pandas 5.3. Pandas Dataframe object 5.4. Importing data (.csv,.xlsx,.txt fromat) into spyder [if this part in included in ML course we can exclude from here] 5.5. Attributes of data, creating copy of original data 5.6. Data Preprocessing: indexing and selection, Handling missing data, Missing data in pandas, Operations on null values 5.7. Frequency tables 5.8. Two way tables : Joint Probability, Marginal Probability, Conditional Probability 5.9. Aggregation and Grouping Planets Data Simple Aggregation in Pandas GroupBy: Split, Apply,Combine	**6**
References:	1. Programming Python, O`Reilly by Mark Lutz 2. Python Data Science Handbook O'Reilly, Jake Vander Plas 3. Python Programming: An introduction to computer, John Zelle,3rd Edition 4. An Introduction to Computer Science using Python 3 by Jason Montojo, JenniferCampbell, Paul Gries, The pragmatic bookshelf-2013 5. James Payne, "Beginning Python: Using Python and Python 3.1,Wrox Publication
Learning Outcomes	On completion of the course, student will be able to 1. manipulate and process dataset 2. perform data analysis to find hidden pattern form data sets

	3. visualize dataset in term of different charts 4. Determine the methods to create and develop Python programs by utilizing the datastructures like lists, dictionaries, tuples and sets. 5. To develop python programs and create a small application project

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	Masters of Science with Major in Data Science	
Major (Theory) Subject SEMESTER – I		
Year – I	**Paper No-**	**Credits 2**
Semester-I	**Name of Paper-** LAB on Mathematics and Statistics for Data Scienc	**Hours 60**

Course Specific Outcomes: On completion of the course, the students will

CO1:

CO2:

COURSE CONTENTS/ SYLLABUS	**Lectures**
Lab Based on Mathematics:- 1) Practical based on application of vector spaces 2) Practical based on Unit 2 3) Practical based on Unit 3 4) Practical based on Unit 4 5) A Mini case based on Unit 5 (2 practical's) **Statistics Practical:** **1.** Introduction to R-studio, mathematical and logical operators in R,Data types and data structures, simple operations and programs, matrix operations. **2.** Data frames, string operations, factors, handling categorical data, listsand list **3.** Operations Loops and conditional statements, switch and breakfunction. **4.** Apply functions, Statistical problem solving in R, **5.** Visualizations in R – 1 **6.** Visualizations in R – 2 **7.** Spatial Data Representation and Graph Analysis **8.** Hands-on data manipulations1: cleaning, sub-setting, sampling, datatransformations and allied data operations **9.** Hands-on data manipulations2: cleaning, sub-setting, sampling, datatransformations and allied data operations	**11**

Learning Outcomes	LO1: LO2:

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	Masters of Science with Major in Data Science	
Major (Theory) Subject SEMESTER – I		
Year – I	**Paper No-**	**Credits 2**
Semester-I	**Name of Paper-** LAB on Python Programming	**Hours 60**
Course Specific Outcomes: On completion of the course, the students will CO1: CO2:		
COURSE CONTENTS/ SYLLABUS		**Lectures**
1. Basic Practical on List. Dictionary. 2. Basic Practical on List. Dictionary-II. 3. Practical on control statements. 4. Pracrical on NumPy 5. Practical on Pandas 6. Practical on IDE-spyder, **7.** Practical on Matplotlib		**11**
Learning Outcomes	LO1: LO2:	

	MODERN EDUCATION SOCIETY'S **Nowrosjee Wadia College, Pune (Autonomous)**	**Academic Year 2024-2025**
	Masters of Science with Major in Data Science	
Major-Elective (Theory) Subject SEMESTER – I		
Year – I	**Paper No-**	**Credits 4**
Semester-I	**Name of Paper-** Database Technologies (2T+2P)	**Hours 30+ 60**

Course Specific Outcomes: After successful completion of course students will be able to:

1) Differentiate between RDBMS and NOSQL technologies.
2) Understand various NOSQL technologies, their needs, and applications.
3) Learn new concepts of data modelling, clustering, polyglot persistence,version stamps, mapreduce, schema migrations.
4) Make a choice of database technologies based on their needs and applications.

COURSE CONTENTS/ SYLLABUS	**Lectures**
Unit 1: Introduction to Database technology Database Systems Review SQL Overview- DDL commands (create, alter. drop, rename, desc) with examples DML commands(insert, delete, update, select) DCL commands(commit, rollback, grant, revoke)Basic structure of SQL query(Using BETWEEN,IN,OR, Like ,ORDER BY, GROUP BY and HAVING Clause, Distinct) Transaction ConceptsACID Properties, Database recovery techniques, DB Failure	**05**
Unit 2: Introduction to NOSQL (Core concepts) Why NoSQL, Aggregate Data Models, Data modeling details, Distribution Models Consistency Version stamps, Map-Reduce. Implementation with NOSQL databases Document Databases (Mongodb) Graph databases (Neo4j)	**15**
Unit 3: Schema Migrations, Polyglot Persistence (Multi model types)	**8**
Unit 4: Choosing your database	**2**

References:	
	1. NoSQL for Dummies By Pramod Sadalge,Martin Fowler Pearson. 2. https://www.udemy.com/topic/nosql/

LAB/ Practicals On Database Technology:	1. Database Practical's - Data Query Language(DQL)Statements Data Query Language(DQL) Statements: (Select statementwith operations like Where clause, Order by,Logical operators, Scalar functions and Aggregate functions) Using Virtual Lab IIT Bombayhttp://vlabs.iitb.ac.in/vlabs-dev/labs/dblab/labs/index.php 2. Assignment 2: Model the following hospital database as document databaseConsider the hospitals in and around pune. Each hospital may have one or more specializations like pediatric, gynac, ortho.A person can recommendor provide review for a hospital. One doctor can be associated with more than one hospital. Queries: 3. List the names of the hospitals withspecialization 4. List the names of doctors visiting to birlahospital onmonday 5. List the multispeciality hospitals 6. List the names of hospitals having rating >=4 7. List the doctors who are specialized in ortho 8. List the persons who have given ratings toSahyadri hospital. Neo4j Practical Assignment 3: Song Database Consider a Song database, with labels as Artists,Song, Recording_company, Recoding_studio, song author etc.Relationships can be as follows Artist → [Performs] → Song →[Written by] →Song_author. Song → [Recorded in] → Recording Studio →[managedby] → recordingCompany RecordingCompany → [Finances] → Song You may add more labels and relationship and their properties, as perassumptions. 1 List the names of songs written by ":….." 2 List the names of the songs recorded in"..." 3 List the names of record companies who havefinanced for the song "…." 4 List the names of artist performing the song"….." 5 Name the songs recorded by the studio " ……." 6 List the names of artists who have sungonly songswritten by " " 7 List the names of artists who have sung the maximumnumber of songs recorded by"……" studio Assignment 4: Employee database Consider an employee database, with a minimal setof labelsas follows Employee: denotes a person as an employee of the organization Department: denotes the different departments, in which employees work. Skillset: A list of skills acquired by an employee

Learning Outcomes	LO1: LO2:

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	Masters of Science with Major in Data Science	
Major (Theory) Subject SEMESTER – I		
Year – I	**Paper No-**	**Credits 4**
Semester-I	**Name of Paper-** R-Programming for Data Science	**Hours (30T+60P)**
Course Specific Outcomes: On completion of the course, the students will CO1: CO2: CO3: CO4: CO5:		
COURSE CONTENTS/ SYLLABUS		**Lectures**
Unit 1:		
Unit 2:		
Unit 3:		
Unit 4:		
Unit 5:		
References:		
Learning Outcomes	LO1: LO2:	

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	Masters of Science with Major in Data Science	
Major (Theory) Subject SEMESTER – I		
Year – I	**Paper No-**	**Credits 4**
Semester-II	**Name of Paper-** Statistics for Data Science-II	**Hours 60**

Course Specific Outcomes: On completion of the course, the students will

CO1: Identify sampling methods from the pattern of the observed data.

CO2: Predict the future behaviour of the time series data.

CO3: Predict different models of forecasting of time series data.

CO4: Analyze sample data and identify the parameters and their probabilitydistributions.

CO5: Hypothesize and test an assumption regarding population parameters usingsample data.

COURSE CONTENTS/ SYLLABUS	**Lectures**
Unit 1: Sampling 1.1 Introduction to Sampling 1.2 Simple random Sampling 1.3 Stratified Random Sampling 1.4 Cluster Sampling. 1.5 Concept of Sampling Error	
Unit 2: Sampling Distributions 2.1 Introduction to Sampling distributions 2.2 Student's t distribution 2.3 Chi square distribution 2.4 Snedecor's F distribution 2.5 Interrelations among t, chi-square and F distributions 2.6 Central Limit Theorem (Various Versions) and its applications.	
Unit 3: Testing of hypothesis 3.1 Definitions: population, statistic, parameter, standard error ofestimator. 3.2 Concept of null hypothesis and alternative hypothesis, critical region, level of significance, type I and type II error, one sided and two-sided tests, p-value. 3.3 Large Sample Tests	

Tests based on t, Chi-square and F-distribution **All tests to be taught using R software. Manual calculations are not expected**	
Unit 4: Analysis of Variance 4.1 One Way ANOVA 4.2 Two Way ANOVA 4.3 Application of ANNOVA to test the overall significance ofRegression. **All topics to be covered using R software. Manual calculations are not expected**.	
Unit 5: Time Series 5.1 Meaning and Utility. 5.2 Components of Time Series. 5.3 Additive and Multiplicative models. 5.4 Methods of estimating trend: moving average method, least squaresmethod and exponential smoothing method. (single, double and triple) 5.5 Elimination of trend using additive and multiplicative models. 5.6 Simple time series models: AR (1), AR (2). 5.7 Introduction to ARIMA Modelling.	

References:	1. Fundamentals of Applied Statistics (3rd Edition), Gupta and Kapoor, S.Chand andSons, New Delhi, 1987. 2. Time Series Methods, Brockell and Devis, Springer, 2006. 3. Time Series Analysis,4th Edition, Box and Jenkin, Wiley, 2008. 4. Modern Elementary Statistics, Freund J.E., Pearson Publication, 2005. 5. Probability, Statistics, Design of Experiments and Queuing theory with applicationsComputer Science, Trivedi K.S., Prentice Hall of India, New Delhi,2001. 6. Common Statistical Tests, Kulkarni M.B., Ghatpande S.B., Gore S.D., SatyajeetPrakashan,Pune, 1999.
Learning Outcomes	LO1: LO2:

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	Masters of Science with Major in Data Science	
Major (Theory) Subject SEMESTER – II		
Year – I	**Paper No-**	**Credits 4**
Semester-II	**Name of Paper-** AI & Machine Learning	**Hours :60**

Course Specific Outcomes: On completion of the course, the students will

Course Outcome:

CO1: Learn the basics of learning problems with hypothesis and version spaces.

CO2: Understand the features of machine learning to apply on real world problems

CO3: Characterize the machine learning algorithms as supervised learning and unsupervised learning and apply and analyze the various algorithms of supervisedand unsupervised learning.

CO4: Learn the concepts in Bayesian analysis from probability models and methods

COURSE CONTENTS/ SYLLABUS	**Lectures**
Unit 1: Introduction to Artificial Intelligence And Intelligent system What is Artificial Intelligence? Forms/types of AI, Purpose of AI , Applications of AI Artificial Intelligence in Data Science Role of Artificial Intelligence in Data Science Comparison of AI and Data Science What is an Intelligent Agent in AI? Types of Intelligent Agent. Structure of Intelligent Agent Properties of Intelligent Agent Examples of Intelligent Agents AI Problems(State Space search)(any 2) Water jug problem, 8 puzzle problem, Travellin gsalesman problem, Tower of Hanoi Problem	**10**
Unit 2: Search algorithm in AI: Search algorithm in AI: Problem solving agent Search algorithm Terminologies Properties of Search Algorithm Types of Search Algorithm(any 2/3)	**08**

Uninformed/Blind Search- BFS(Breadth First Search), DFS(Depth First Search), DLS(Depth Limited Search), IDDFS(Iterative Deepening DFS), UCS(Uniform Cost Search), BS(Bi-Directional Search). Informed Search- Best First Search Algorithm(Greedy Search)A* Search Algorithm. AO* Search Algorithm	
Unit 3: Introduction to Machine Learning: What is Machine Learning?, Application of ML Machine learning basics:Key terminology, Steps in developinga machine learning application. How we split data in Machine, Types Of ML algorithms.	**3**
Unit 4: Advance ML **Supervised Learning** Naïve Base Classifier, Classifying with k-Nearest Neighbour classifier, Decision Tree classifier, Naive Bayes classifier. **Introduction to reinforcement learning**	**13**
Unit 5: Unsupervised Learning - Grouping unlabelled items using k-means clustering, Distance measures. Different clustering methods (Distance,Density,Hierarchical). Unsupervised Learning Model- Association RuleAssociation Rules- The applications of Association Rule Mining :Market Basket, Recommendation Engines, etc. A mathematical model for association analysis; Large item sets; Association Rules Apriori Algorithm, Eclat Algorithm, FP-trees	**14**
Unit 6: Forecasting and Learning Theory : Non-linear regression, Logistic regression, Random forest, Baysian Belief networks, Bias/variance trade off, Tuning Model Complexity, Model Selection Dilemma. Support Vector Machine (SVM), SVM- Algorithm Kernel Machines & Ensemble Methods:	**12**

Introduction,	
References:	

Sr. No.	Title of the Book	Author/s	Publication
1	Artificial Intelligence: A New Synthesis	Nilsson	Elsevier Publication
2	Artificial Intelligence with Python	Prateek Joshi	Packt Publishing Ltd
3	Rogers, Simon, and Mark Girolami. A first course in machine learning. CRC Press, 2015		
4	Machine learning course material by Andrew Ng, Stanford University		
6	Introduction to Machine	Ethem Alpaydin	PHI 2nd Edition

Learning Outcomes	LO1: LO2:

	MODERN EDUCATION SOCIETY'S **Nowrosjee Wadia College, Pune (Autonomous)**	**Academic Year 2024-2025**
	Masters of Science with Major in Data Science	
Major (Theory) Subject SEMESTER – II		
Year – I	**Paper No-**	**Credits 2**
Semester-II	**Name of Paper- Fundamental of data science**	**Hours :30**

CO1: Understand basic concepts of Data science

CO2: Perform Exploratory Data Analysis

CO3: Obtain, clean/process, and transform data.

CO4: Detect and diagnose common data issues, such as missing values, special values, outliers,inconsistencies, and localization.

CO5: Present results using data visualization techniques.

CO6: Prepare data for use with a variety of statistical methods and models and recognize howthe quality of the data and the means of data collection may affect conclusions.

COURSE CONTENTS/ SYLLABUS	**Lectures**
Unit 1: Introduction to Data Science Introduction to data science, The 3 V's: Volume, Velocity, VarietyWhy learn Data Science? Applications of Data ScienceThe Data Science Lifecycle Data Scientist's Toolbox Types of Data Structured, semi-structured, Unstructured Data, Problems with unstructured data Data sources Open Data, Social Media Data, MultimodalData, standard datasets All Data Formats	**6**

Unit 2: Statistical Data Analysis Role of statistics in data science Descriptive statistics Measuring the Frequency Measuring the Central Tendency- Mean, Median, and Mode Measuring the Dispersion: Range, Standard deviation, Variance, Interquartile Range. Inferential statistics Hypothesis testing, Multiple hypothesis testing, Parameter Estimation methods Measuring Data Similarity and Dissimilarity- Data Matrix versus Dissimilarity Matrix, Proximity Measuresfor Nominal Attributes, Proximity Measures for Binary Attributes, Dissimilarity of Numeric Data: Euclidean, Manhattan, and Minkowski distances, Proximity Measures forOrdinal Attributes Concept of Outlier, types of outliers, outlier detectionmethods	**10**
Unit 3: Data Preprocessing Data Objects and Attribute Types: What Is an Attribute?, Nominal , Binary, Ordinal Attributes, Numeric Attributes,Discrete versus Continuous Attributes Data Quality: Why Preprocess the Data?Data munging/wrangling operations. Cleaning Data - Missing Values, Noisy Data (Duplicate Entries, Multiple Entries for a Single Entity, Missing Entries, NULLs, Huge Outliers, Out-of- Date Data, Artificial Entries, Irregular Spacings, Formatting Issues - Irregular between Different Tables/Columns, Extra Whitespace, Irregular Capitalization, Inconsistent Delimiters, Irregular NULL Format, Invalid Characters, Incompatible Datetimes) Data Transformation – Rescaling, Normalizing, Binarizing, Standardizing, Label and One Hot Encoding	**10**
Unit 4: Data Visualization Introduction to Exploratory Data AnalysisData visualization and visual encoding Data visualization libraries Basic data visualization tools: Histograms, Bar charts/graphs, Scatter plots, Line charts, Area plots, Pie charts, Donut charts. Specialized data visualization tools Boxplots, Bubble plots, Heat map, Dendrogram, Venn diagram, Tree map, 3D scatter plots.	**4**

References:

Sr. No.	Title of the Book	Author/s	Publication
1	Data Science Fundamentals and Practical Approaches	Gypsy Nandi, Rupam Sharma,	BPB Publications, 2020

		2	The Data Science Handbook	Field Cady, John Wiley & Sons	Inc, 2017
		3	Data Mining Concepts and Techniques, Third Edition	Jiawei Han, Micheline Kamber, Jian Pei, Morgan Kaufmann	2012
Learning Outcomes	LO1: LO2:				

	MODERN EDUCATION SOCIETY'S **Nowrosjee Wadia College, Pune (Autonomous)**	**Academic Year 2024-2025**
	Masters of Science with Major in Data Science	
Major (Theory) Subject SEMESTER – II		
Year – I	**Paper No-**	**Credits 2**
Semester-II	**Name of Paper-** LAB on Statistics for Data Science-II	**Hours :30**

Course Outcomes: At the end of the course students are expected to be able

i. To use various graphical and diagrammatic techniques and interpret using pythonprogramming
ii. To compute various measures of central tendency, dispersion, Skewness andkurtosis.(using Python Programming)
iii. To study Theory of Probability.
iv. To Study correlation & Regression analysis.
v. To apply statistical testing Procedures.
vi. To study free statistical software and use them for data analysis in project.
vii. To develop the ability to build and assess data-based models
viii. To execute statistical analyses with professional statistical software

COURSE CONTENTS/ SYLLABUS	**Lectures**

Practical List: 1. Diagrammatic Representation and Descriptive Statistics for raw data (examples barchart, line chart, pie chart etc.) 2. Looking at the data: Data Summaries: Measures of Central Tendency, Measures ofDispersion, Measures of skewness and kurtosis 3. Implementation of Correlation and Linear Regression 4. Problems on simple probability, conditional probability, Baye's theorem and independence of events–Applications 5. Implementation of logistic regression 6. Implementation of Hypothesis Testing– t-test, Chi-square, ANOVA, F-test 7. Case study (Using real world dataset (for ex. Kaggle dataset - https://www.kaggle.com),students are supposed to perform all above experiments for statistical analysis of data.	**6**

	MODERN EDUCATION SOCIETY'S **Nowrosjee Wadia College, Pune (Autonomous)**	**Academic Year 2024-2025**
	Masters of Science with Major in Data Science	
Major (Theory) Subject SEMESTER – I		
Year – I	**Paper No-**	**Credits 2**
Semester-I	**Name of Paper-** LAB on AI and Machine Learning	**Hours :30**

COURSE CONTENTS/ SYLLABUS	**Lectures**
Write a program to implement Breadth First Search Traversal. Write a program to implement Depth First Search Traversal. Write a program to implement Water Jug Problem. Write a program to implement Simple Chatbot. Write a program to implement Breadth First Search Traversal. Write a program to implement Depth First Search Traversal.	**6** **10**

1. Implementation of Logistic Regression for iris using sklearn
2. Implementation of naive bayes classifier algorithm
3. Write a program to implement k-nearest Neighbor algorithm to classify the iris data set. Print both correct and wrong prediction.
4. Implementation of SVM classification.

	MODERN EDUCATION SOCIETY'S **Nowrosjee Wadia College, Pune (Autonomous)**	**Academic Year 2024-2025**
	Masters of Science with Major in Data Science	
Major Elective-A (Theory) Subject SEMESTER – II		
Year – I	**Paper No-**	**Credits 4**
Semester-II	**Name of Paper-** Data Mining and Data Ware housing (2T + 2P)	**Hours :30+ 60**

Course Outcomes:

CO1- Describe Data warehouse system and perform business analysis with OLAP tools.
CO2- Explain suitable data pre-processing techniques and weka tools for data analysis

CO3- Use frequent pattern and association rule mining techniques

CO4- Understand appropriate classification and clustering techniques for data analysis

COURSE CONTENTS/ SYLLABUS	**Lectures**
Unit 1: Introduction to Data Warehousing 1.1 Data Warehousing and Business Analysis, 1.2 Data warehousing Components 1.3 Building a Data warehouse 1.4 Data Warehouse Architecture 1.5 DBMS Schemas for Decision Support 1.6 Data Extraction, Cleanup, and Transformation Tools 1.7 Metadata 1.8 reporting 1.9 Query tools and Applications 1.10 Online Analytical Processing (OLAP) 1.11 OLAP and Multidimensional Data Analysis	**04**
Unit 2: Introduction to Data Mining Systems 2.1 Knowledge Discovery Process 2.2 Data Mining Techniques, Issues and applications 2.3 Data Objects and attribute types 2.4 Statistical description of data 2.5 Data Preprocessing **2.6** Cleaning, Integration, Reduction, Transformation and discretization, Data Visualization, Data similarity and dissimilarity measures.	**06**
Unit 3: Data Mining Tasks 3.1 Mining Association Rules in Large Databases, 3.2 Association Rule Mining, 3.3 Market Basket Analysis: Mining A Road Map, 3.4 The Apriori Algorithm: Finding Frequent Item sets UsingCandidate	**10**

Generation, 3.5 Generating Association Rules from Frequent Item sets, 3.6 Improving the Efficiently of Apriori, 3.7 Mining Frequent Item sets without CandidateGeneration, 3.8 Multilevel Association Rules, 3.9 Approaches to Mining Multilevel Association Rules, 3.10 Mining Multidimensional Association Rules forRelational Database and Data Warehouses 3.11 Multidimensional Association Rules, 3.12 Mining Quantitative Association Rules, 3.13 Mining Distance-Based Association Rules, From Association Mining to Correlation Analysis	
Unit 4: Classification & Clustering 4.1 Problem definition 4.2 General Approaches to solving a classification problem, 4.3 Evaluation of Classifiers, Classification techniques, 4.4 Decision trees-Decision Tree Construction, 4.5 Methods for expressing attribute test conditions, 4.6 Measures for Selecting the Best split, 4.7 Algorithm for Decision tree Induction, 4.8 Naïve-Bayes Classifier, 4.9 Bayesian Belief Networks; 4.10 K-nearest neighbor classification-Algorithm andcharacteristics. 4.11 Clustering overview, 4.12 Evaluation of clustering algorithms, 4.13 Partitioning clustering 4.14 K-Means Algorithm K-Means Additional Issues,	**10**
Practical Assignments: 1. Write a python program to Prepare Scatter Plot (Use Forge Dataset / Iris Dataset) 2. Write a python program to find all null values in a given data set and remove them. 3. Write a python program the Categorical values in numeric format for a given dataset. 4. Write a python program to Implement Naïve Bayes. 5. Write a python program to Implement Decision Tree whether or not to play tennis. 6. Write a python program to find Decision boundary by using a neural network with unitson two moons dataset 7. Write a python program to implement k-nearest Neighbours ML algorithm to buildPrediction model	

	(Use Forge Dataset) 8. Write a python program to implement k-means algorithm on a synthetic dataset. 9. Write a python program to implement Agglomerative clustering on a synthetic dataset	
References:	References Books: 1. Data Mining: Concepts and Techniques, Han, Elsevier ISBN:9789380931913/9788131205358 2. Margaret H. Dunham, S. Sridhar, Data Mining – Introductory and Advanced Topics,Pearson Education 3. Tom Mitchell, —Machine Learning‖, McGraw-Hill, 1997 4. Christopher M. Bishop, —Pattern Recognition and Machine Learning‖, Springer 2006 5. Raghu Ramkrishnan, Johannes Gehrke, Database Management Systems, SecondEdition, McGraw Hill International 6. Ian H. Witten, Eibe Frank Data Mining: Practical Machine Learning Tools andTechniques	

	MODERN EDUCATION SOCIETY'S **Nowrosjee Wadia College, Pune (Autonomous)**	**Academic Year 2024-2025**
	Masters of Science with Major in Data Science	
Major (Theory) Subject SEMESTER – II		
Year – I	**Paper No-**	**Credits 4**
Semester-II	**Name of Paper- Optimization Technique** (2T + 2P)	**Hours :30 +60**
COURSE CONTENTS/ SYLLABUS		**Lectures**
Unit 1:		**6**

Unit 2:	**10**
Unit 3:	**10**
Unit 4:	**4**
References:	
Learning Outcomes	LO1: LO2:

The Examination pattern for all Undergraduate (UG) courses.

EVALUATION PATTERN : For Two Credit Courses

(i) Each course shall be evaluated with Continuous Evaluation (CE) and End Semester Examination (EE).

(ii) Continuous Evaluation shall be of 15 marks and End Semester Examination (EE) shall be of 35 marks

(iii) To pass a course of 2credits, a student has to earn minimum 20 marks, provided that he/she should earn minimum 6 marks in Continuous Evaluation and minimum 14 marks in End-Semester Examination. That is passing criterion is minimum 40% marks in the examination.

(iv) For Internal evaluation (out of 15 marks), There has to be one written test of 10 marks (Mid-Semester Examination). For remaining 5 marks shall be based on the continuous evaluation consisting of tutorial, viva, seminars, home-assignments, mini project, survey, group discussion etc.(on approval of Head of the Department)

(v) There shall be revaluation of the answer scripts of End-Semester Examination (out of 35 marks) of theory papers only, but not of internal assessment papers as per Ordinance No. **134 A and B.**

ATKT RULES

(i) Minimum number of credits required to take admission to Second year of B. Sc. course is 31 (70%) (As same as SPPU).

(ii) Minimum number of credits required to take admission to Third year of B. Sc. course is 44 (100%) to be completed from First year of B. Sc. and pass in physical education examination in first year of B. Sc. and 22 credits from second year of B. Sc (As same as SPPU).

AWARD OF GRADES AND GRADE POINTS

The mapping of percentage to letter grade and grade point is given in the following Table 1

CGPA will be calculated as follows:

Table No. 1

Sr. No.	Grade Letter	Grade Point	Marks
1.	O (Outstanding)	10	90 ≤ Marks ≤ 100
2.	A+ (Excellent	9	80≤ Marks ≤ 89
3.	A (Very Good)	8	70 ≤ Marks ≤ 79
4.	B+ (Good)	7	55 ≤ Marks ≤ 69
5.	B (Above Average)	6	50 ≤ Marks ≤ 54
6.	C (Average)	5	45 ≤ Marks ≤ 49
7.	D (Pass)	4	40 ≤ Marks ≤ 44
8.	F (Fail)	0	Marks < 40
9.	Ab (Absent)	0	

PERFORMANCE INDICES:

The performance of a student in a Semester is indicated by a number called the Semester Grade Point Average (SGPA). Similarly, the performance of a student in the Course is indicated by a number called the Course Grade Point Average (CGPA).

The End-Semester results and final result of the courses will contain SGPAand CGPA, respectively.

(1) **SGPA**:The SGPA is the weighted average of the grade points obtained by a students in all the courses during the Semester. That is

$$SGPA = \frac{\sum_{i=1}^{p} C_i G_i}{\sum_{i=1}^{p} C_i}$$

For example, suppose in a Semester, student has registered for five courses having credits C1, C2, C3, C4 and C5 and suppose his/her grade points are G1, G2, G3, G4 and G5, respectively. The SGPA is calculated as

$$SGPA = \frac{C_1G_1 + C_2G_2 + C_3G_3 + C_4G_4 + C_5G_5}{C_1 + C_2 + C_3 + C_4 + C_5}$$

SGPA is calculated correct up to two decimal places by rounding off.

(2) **CGPA**:The CGPA is the weighted average of the grade points obtained in all courses (theory and Practicals) by students in all the courses in 6 semesters. It is calculated in the same manner as the SGPA.

RESULTS :

Based on the performance of the student in the Semester Examinations, Nowrosjee Wadia College will declare the results and issue the Semester Grade sheets. Also, the College will declare the results and issue the Grade sheets at the end of the course.

The class will be awarded to a student on the basis of CGPA. The award of the class shall be as per Table 2 and corresponding percentage calculation for the CGPA is given in Table No. 3

Table 2

Sr. No.	CGPA	Class of the degree awarded
1	9.50 or more than 9.50	OUTSTANDING (O)
2	8.50 or more but less than 9.50	EXCELLENT (A+)
3	7.50 or more but less than 8.50	VERY GOOD (A)
4	6.25 or more but less than 7.50	GOOD (B+)
5	5.25 or more but less than 6.25	ABOVE AVERAGE (B)
6	4.75 or more but less than 5.25	AVERAGE (C)
7	4.00 or more but less than 4.75	PASS (D)

Percentage of marks corresponding to CGPA is calculated by the formulae which are given in the following Table 3.

Table 3

GRADE	Formula for the percentage of marks
O	$20 \times \text{CGPA} - 100$
A+	$10 \times \text{CGPA} - 5$
A	$10 \times \text{CGPA} - 5$
B+	$12 \times \text{CGPA} - 20$
B	$5 \times \text{CGPA} + 23.75$
C	$10 \times \text{CGPA} - 2.50$
D	$6.6 \times \text{CGPA} + 13.6$

The above percentage calculations are illustrated in the following Table 4

Table 4

Some examples of CGPA to Percentage calculations

CGPA obtained	Formula	Percentage (%)	Grade
10	$20 \times 10 - 100 = 100$	100	O
9.75	$20 \times 9.75 - 100 = 95$	95	O
9.5	$20 \times 9.5 - 100 = 90$	90	O
9.0	$10 \times 9 - 5 = 85$	85	A+
8.0	$10 \times 8.0 - 5 = 75$	75	A
7.0	$12 \times 7.0 - 20 = 64$	64	B+
6.67	$12 \times 6.67 - 20 = 60.04$	60.04	B+
6.25	$12 \times 6.25 - 20 = 55$	55	B+
5.25	$5 \times 5.25 + 23.75 = 50$	50	B
4.75	$10 \times 4.75 - 2.50 = 45$	45	C
4.0	$6.6 \times 4.0 + 13.6 = 40$	40	D

While declaring the results, the existing ordinances are applicable. There is also a provision for verification and revaluation. In case of verification, the existing rules will be applicable. The revaluation result will be adopted if there is a change of at least 10% marks and in the grade of the course.

PATTERN OF THE QUESTION PAPER: Two Credits

(1) **Internal Examination:**
(Mid-Semester Examination of 10 marks, Duration: 30 Mins)

Question No.	Total Marks	No. Of questions	Remarks
Q. 1.	5	Attempt any 5 out of 7	Definitions/Counter examples/Short answer / objective type of questions/True or False. (Each question carries 1 mark.)
Q. 2.	5	Solve any 1 out of 2 questions	Descriptive type questions (Each question carries 5 marks)

(2) **End Semester Examination(EE):**
Shall be of 35 marks, 2 hours duration. The pattern of the question paper shall be as follows:

Question No.	Total Marks	No. Of questions	Remarks
Q. 1.	5	Solve any 5 out of 7	Definitions/Counter examples/Short answer / objective type of questions/True or False. (Each question carries 1 mark.)
Q. 2.	10	Solve any 5 out of 7 OR Solve any 2 out of 3	Descriptive type questions (Each question carries 5 marks)
Q. 3.	10	Solve any 2 out of 3	Descriptive type questions (Each question carries 5 marks)
Q. 4.	10	Solve any 2 out of 3 OR Solve any 1 out of 2	Descriptive type questions

EVALUATION PATTERN : For Four Credit Courses

(i) Each course shall be evaluated with Continuous Evaluation (CE) and End Semester Examination (EE).
(ii) Continuous Evaluation shall be of 30 marks and End Semester Examination (EE) shall be of 70 marks

(iii) To pass a course of 4credits, a student has to earn minimum 40 marks, provided that he/she should earn minimum 12 marks in Continuous Evaluation and minimum 28 marks in End-Semester Examination. That is passing criterion is minimum 40% marks in the examination.

(iv) For Internal evaluation (out of 30 marks), There has to be one written test of 20 marks (Mid-Semester Examination). For remaining 10 marks shall be based on the continuous evaluation consisting of tutorial, viva, seminars, home-assignments, mini project, survey, group discussion etc. (on approval of Head of the Department)

(v) There shall be revaluation of the answer scripts of End-Semester Examination (out of 70 marks) of theory papers only, but not of internal assessment papers as per Ordinance No. **134 A and B.**

PATTERN OF THE QUESTION PAPER: Four Credits

(1) **Internal Examination:**
(Mid-Semester Examination of 10 marks, Duration: 30 Mins)

Question No.	Total Marks	No. Of questions	Remarks
Q. 1.	10	Attempt any 5 out of 7	Definitions/Counter examples/Short answer / objective type of questions/True or False. (Each question carries 2 marks)
Q. 2.	10	Solve any 1 out of 2 questions	Descriptive type questions (Each question carries 10 marks)

(2) **End Semester Examination (EE):**
Shall be of 70 marks, 2 hours and 30 Minutes duration. The pattern of the question paper shall be as follows:

Question No.	Total Marks	No. Of Questions	Remarks
Q. 1.	10	Solve any 5 out of 7	Definitions/ Counter examples/ Short answer / Objective type of questions/ True or False. (Each question carries 2 marks)
Q. 2.	20	Solve any 5 out of 7 OR Solve any 2 out of 3	Descriptive type questions
Q. 3.	20	Solve any 2 out of 3	Descriptive type questions (Each question carries 5 marks)
Q. 4.	20	Solve any 2 out of 3 OR Solve any 1 out of 2	Descriptive type questions