Hindi Vidya Prachar Samiti's

RAMNIRANJAN JHUNJHUNWALA COLLEGE OF ARTS, SCIENCE & COMMERCE

(Autonomous)

University of Mumbai

Affiliated to

University of Mumbai

Refer to page no: 06
highlighting component
of Research Project/Internship

Syllabus for the M. Sc.

Program: M. Sc. In Statistics

Program Code: RJSPSTA

(Choice Based Credit System with effect from the academic year 2022 – 2023 for Part I and 2023 – 2024 for Part II)

Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of course	M.Sc. in Statistics
2	Eligibility for admission	A candidate for being eligible for admission to the M.Sc. degree course in Statistics must have passed The B.Sc. (Three Year Integrated course) degree examination of this University (or any other University recognized as equivalent there to) with at least Seven Units in Statistics (i.e. the minimum required for majoring in the subject). OR With Three Units in Statistics at T.Y.B.Sc. in combination with Three Units of Mathematics at the T.Y.B.Sc. students will be admitted to the M.Sc. degree course in Statistics on the basis of marks obtained at the T.Y.B.Sc. examination.
3	Passing Marks	40%
4	No. of Years, Semesters	2 Years, 4 Semesters
5	Level	Post Graduate
6	Pattern	Semester
7	Status	Introduced
8	To be implemented from Academic Year	Part I: 2022 – 2023, Part II: 2023 – 2024

Members of Board of Studies

Sr. No.	Name of BOS Member	Designation	Signature
1			
2			
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10			

Meeting of Board Studies:

Academic Council:

Program Educational Objectives

1. To enable graduates to excel professionally by adapting to the dynamic needs of the academia, industry and research in the field of Statistics and Data Science.
2. To enable student to excel in the field of Data Analytics, Data Mining, Machine Learning, Visualization Techniques, Predictive Analysis and Statistical modeling.
3. To practice the problems of analysis and decision making using big data.
4. To gain practical, hands-on experience with programming languages, data analysis tools and frameworks through coursework.

Program Outcomes

Students who have completed the M.Sc. in Statistics will be able to:

1. To apply statistical modeling and data analysis techniques to the solution of real-world business problems, effectively present results using data visualization techniques.
2. To test and train various machine learning algorithms for real world data and applications.
3. To create data warehouse and mine the data for analysis.
4. To analysis big data using various languages and tools.
5. To apply machine learning and deep learning algorithms to real-world problems.

Course Structure

Semester I

Course Code	Course Name	Group	Teaching Scheme (Hrs/Week)		Credits
			Lectures	Practical	
RJSPSTA101	Distribution Theory and Its Application	CC	4	-	4
RJSPSTA102	Estimation Theory	CC	4	-	4
RJSPSTA103	Sampling Theory	CC	4	-	4
RJSPSTA104	Linear models and Regression Analysis	CC	4		4
RJSPSTAPA101	Statistical Computing I (Practical based on Paper I and II in relevant software)	SC-1	-	6	3
RJSPSTAPA102	Statistical Computing II (Practical based on Paper III and IV in relevant software)	SC-2	-	6	3
RJSPSTA1I1	Organizational Behavior-I	OB-1	2	-	2
	Total		**18**	**12**	**24**

Semester II

Course Code	Course Name	Group	Teaching Scheme (Hrs/Week)		Credits
			Lectures	Practical	
RJSPSTA201	Multivariate Analysis and Its Application	CC	4	-	4
RJSPSTA202	Design of Experiments	CC	4	-	4
RJSPSTA203	Stochastic Processes	CC	4	-	4
RJSPSTA204	Testing of Hypothesis	CC	4		4
RJSPSTAPA201	Statistical Computing I (Practical based on Paper I and II in relevant software)	SC-1	-	6	3
RJSPSTAPA202	Statistical Computing II (Practical based on Paper III and IV in relevant software)	SC-2	-	6	3
RJSPSTA2I1	Organizational Behavior-II	OB-2	2	-	2
	Total		**18**	**12**	**24**

Semester III

Course Code	Course Name	Group	Teaching Scheme (Hrs/Week)		Credits
			Lectures	Practical	
RJSPSTA301	Machine Learning	CC	4	-	4
RJSPSTA302	Big Data Technology	CC	4	-	4
RJSPSTA303	Data Mining	CC	4	-	4
RJSPSTA304	Time Series Analysis	CC	4	-	4
RJSPSTAPA301	Statistical Computing I (Practical based on Paper I and II in relevant software)	SC-1	-	6	3
RJSPSTAPA302	Statistical Computing II (Practical based on Paper III and IV in relevant software)	SC-2	-	6	3
RJSPSTA3I1	Organizational Behavior-III	OB-3	2	-	2
	Total		**18**	**12**	**24**

Semester IV

Course Code	Course Name	Group	Teaching Scheme (Hrs/Week)		Credits
			Lectures	Practical	
RJSPSTA4INT	Industrial Internship	II	-	24	12
RJSPSTA4MP	Major Project	II	-	24	12
	Total		**-**	**48**	**24**

Note:

Students have to register for the courses as per the following guidelines:

Sr. No.	Category	Credits				Total Credits
		Semester I	Semester II	Semester III	Semester IV	
1	Core Courses (CC)	16 (4 Courses)	16 (4 Courses)	16 (4 Courses)	-	**48**
2	Statistical Computing-I	03 (1 course)	03 (1 course)	03 (1 course)	-	**09**
3	Statistical Computing-II	03 (1 course)	03 (1 course)	03 (1 course)	-	**09**
4	Organizational behaviour	02 (1 course)	02 (1 course)	02 (1 course)	-	**06**
5	Industrial Internship	-	-	-	-	**12**
6	Major Project	-	-	-	-	**12**
Total Credits		**24**	**24**	**24**	**24**	**96**

Semester I S I / P I

Course code	Course name	Group	Teaching Scheme (Hrs/Week)		credits
RJSPSTA101	**Distribution Theory and Its Application**	**CC**	**Lectures**	**Practical**	
			4	**-**	**4**

Course Objectives

1. To provide theoretical foundations for Statistical Distributions.
2. To expose students to Statistical Distributions, its theoretical aspects and applications.

Learning Outcomes

Upon completion of this course, the student should be able to understand probability **distributions** and its application.

Unit	Topic	Lectures
I	Concept of random variable, Expectation, moments, moment generating function, Distribution function, decomposition of distribution function (Jordan's decomposition), transformation, Mixture probability models, probability models of truncated random variable, Leibnitz's rule .	15
II	Bivariate random variable, joint and marginal probability distributions, joint distribution function, conditional distribution and independence, Bivariate transformation, variance and covariance matrix, conditional expectation and variance, Bivariate normal distribution. Multiple and partial correlation coefficient.	15
III	Convergence in distribution, convergence in probability, almost sure convergence. Chebyshev's inequality. Probability models of quadratic form. Law of large numbers: weak, strong. Central limit theorem: Lindberg's central limit theorem, Liapounov's central limit theorem.	15
IV	Some special statistical univariate discrete distributions: degenerate distribution, two-point distribution, discrete uniform distribution, hypergeometric distribution, negative hypergeometric distribution, negative binomial distribution. Special properties of binomial distribution, Poisson distribution, geometric distribution. Compound distributions. Some special statistical bivariate distributions: negative binomial distribution, hypergeometric distribution, Multinomial distribution. Some special statistical univariate continuous distributions: uniform distribution, Probability integral transform, gamma distribution, beta distribution, Cauchy distribution, Pareto distribution	15

References:

1. Cassela G. and Berger R .(2002) Statistical Inference (2nd edition), Duxbury Resource Centre.
2. Bhat B.R. (1999): Modern Probability Theory: An introductory test book 3rd edition. New Age International
3. Hogg, R. V., McKean, J. W. and Craig, T. T. (2012). Introduction to Mathematical Statistics, 7th Ed, Pearson Prentice Hall, New Jersey.
4. Rohatgi, V. K. and Saleh, A. K. M. E. (2008) Introduction to Probability and Statistics, paperback, Wiley, New York.

5. Wayne W. Daniel (1990) Applied Nonparametric statistics (2nd edition) Duxbury Thomas Learning.

S I / PII

Course code	Course name	Group	Teaching Scheme (Hrs/Week)		credits
RJSPSTA102	**Estimation Theory**	**CC**	**Lectures**	**Practical**	
			4	**-**	**4**

Course Objectives
1. To provide theoretical foundations for estimation theory.
2. To expose students to Bayesian inference and its application.

Learning Outcomes
Upon completion of this course, the student should be able to understand applicability of estimation theory in real life.

Unit	Topic	Lectures
I	Data reduction, sufficiency, sufficient partition, Neyman factorization theorem, minimal sufficiency, completeness, ancillarity and Basu's theorem One-parameter exponential family, multi-parameter exponential family and Pitman family of distributions, cannonical form, convexity property Unbiased estimator, estimability of parametric functions, uniformly minimum variance unbiased estimators, Rao-Blackwell and Lehmann-Scheffe theorems.	15
II	Methods of estimation: Method of moments, method of maximum Likelihood estimation (M.L.E.), properties of M.L.E, Scoring method, Large sample properties of MLE, Newton-Raphson method. Bounds for the variance: Cramer-Rao lower bound, Bhattacharya bound. EM algorithm and its applications: EM algorithm for incomplete data, EM algorithm for mixture models, EM algorithm for missing values. MCMC methods for missing values.	15
III	General decision problems, loss function, risk function, estimation and testing viewed as general decision problems, minimax decision, Bayes decision, least favourable prior, Bayes estimation under squared error loss, some simple illustrations based on binomial, Poisson, and normal distributions, procedure for obtaining minimax estimators from Bayes estimators.	15
IV	Bootstrap methods –parametric simulation, Non-parametric simulation, Simple confidence interval 's, Reducing Error, Statistical Issues. Jackknife estimator. Gibbs Sampling.	15

References:
1. Cassela G. and Berger R .(2002) Statistical Inference (2nd edition), Duxbury Resource Centre.

2. Ulhas Jayram Dixit (2016) Examples in parametric inference with R (1st edition), Springer.
3. A.C. Davison and D.V. Hinkley (2009) Bootstrap Methods and their application, Cambridge University Press.
4. Geoffrey J. McLachlan and Thriyambakam Krishnan (2008). The EM Algorithm and Extension, Wiley.
5. William M. Bolstad (2010). Understanding Computational Bayesian Statistics, Wiley.
6. Hogg, R. V., McKean, J. W. and Craig, T. T. (2012). Introduction to Mathematical Statistics, 7th Ed, Pearson Prentice Hall, New Jersey.
7. Lehmann, E. L. and Casella, G. (1998). Theory of Point Estimation, 2nd Ed, Springer, New York.
8. Rohatgi V.K. : Introduction to Probability and Statistics, paperback, Wiley, New York.

S I / P III

Course code	Course name	Group	Teaching Scheme (Hrs/Week)		credits
RJSPSTA103	**Sampling Theory**	**CC**	**Lectures**	**Practical**	
			4	**-**	**4**

Course Objectives

1. To provide theoretical foundations for sampling theory.
2. To expose students to sampling and its applications.

Learning Outcomes

Upon completion of this course, the student should be able to understand how sampling theory is applicable in different organizations.

Unit	Topic	Lectures
I	Systematic Sampling: Linear Systematic Sampling and Circular Systematic Sampling. Estimation of Population Mean, its Variance, Variance in terms of intra-sample correlation coefficient. Comparison with SRSWOR. Problem in Estimation of Variance using one systematic sample. Use of interpenetrating sub samples in estimation of variance. Other methods of estimation of variance.	15
II	Ratio and Regression Methods of Estimation and Two-phase Sampling Ratio and Regression Estimation of Population mean/total using SRSWOR. Comparison with Mean per Unit Estimator. Separate and combined ratio and regression estimators in stratified sampling. Mean Square error of Estimators. Unbiased type ratio estimator. Hartley-Ross Estimator. Two phase sampling in stratification.	15
III	Cluster Sampling, Two Stage Sampling and Adaptive Sampling Cluster sampling: For equal and unequal cluster sizes. Estimation of population mean/total, its variance and estimation of variance. Ratio to size estimator, Mean of Unit Means Estimator. Comparison with SRSWOR. Cluster Sampling for Proportions. Two Stage Sampling: With and Without Replacement at both the stages. Estimation of Population mean per second stage unit, its variance, estimation of variance. Optimum sampling.	15

	Adaptive Sampling: Adaptive Cluster Sampling, Systematic and strip adaptive cluster sampling. Stratified Adaptive Cluster Sampling.	
IV	Probability Proportional to size sampling and Network Sampling: Probability proportional to size sampling With Replacement (PPSWR): Hansen-Hurwitz Estimator of population total, its variance and estimator of the variance. Comparison with SRSWR. Cumulative Total Method and Lahiri's method of drawing PPSWR. PPSWOR: Horvitz-Thompson Estimator of Population Total, its variance and estimator of variance. Desraj ordered estimator, its expectation and variance, estimation of variance. Network Sampling: Multiplicity Estimators. Horvitz-Thompson Estimator. Stratification in Network Sampling. Non-sampling Errors: Response and Non-response Errors, Effect of Non-Response in simple random sampling.	15

References

1. Cochran W.G. (2007) sampling Techniques, 3rd Ed., Wiley.
2. P. Mukhopadhyay (2008) Theory and Methods of Survey Sampling, 2nd Ed.
3. Des Raj and Chandok P. (1998) Sampling Theory, Narosa Publication.
4. Singh D. and Chaudhary F.S. (1986) Theory and Analysis of Sample Survey Designs, New Age International Publishers.
5. Sukhatme P.V., Sukhatme B.V., Sukhatme S. and Ashok (1984) Sampling theory of Surveys with Applications, ICAR publication.
6. Bansal A, (2017): Survey Sampling, Narosa.

S I / P IV

Course code	**Course name**	**Group**	**Teaching Scheme (Hrs/Week)**		**Credits**
RJSPSTA104	**Linear models and Regression analysis**	**CC**	**Lectures**	**Practical**	
			4	**-**	**4**

Course Objectives

1. To provide theoretical foundations for linear models.
2. To expose students to matrix theory and linear model.

Learning Outcomes

Upon completion of this course, the student should be able to understand how regression is used in different corporate sectors.

Unit	Topic	Lectures
I	Linear Algebra - Matrix inverses and determinants, Solving systems of equations with matrices, Eigen values and eigenvectors, Orthogonal matrices, Positive definite matrices, Linear transformations, Linear dependence and independence. Linear parametric function and its estimability, Solving linear equations, generalized inverse. Gauss markoff theorem, Interval	15

	estimates and test of hypothesis, fundamental theorems on conditional error ss, Test of $\Lambda\beta = d$, generalized least squares.	
II	Analysis of variance, fixed effect models: i. One-way classification ii. Two-way classification model with and without interaction effect, one observation per cell. Tukey's test for non-additivity. Two-way classification model with and without interaction effect with unequal number of observations per cell.	15
III	Linear regression models, subset selection, Stepwise regression: Forward selection, backward elimination and stepwise. Orthogonal polynomials. Assumptions and box-cox transformations in the Analysis of Variance: q-q plot, use of skewness and kurtosis, Bartlett's test for equality of variances, Levene's test.	15
IV	Ridge regression: Eigen values and Eigen vectors of a matrix. Conditioned matrix, need of ridge regression, biased estimator and Mean square error. Bias and MSE of ridge estimator, ridge trace method. Logistic regression: Example, model, MLE of parameters, Iterative procedure to solve likelihood equations, multiple regressors. Multinomial, ordinal, Poisson Analysis of Categorical data: Log linear models, contingency tables.	15

References

1. Kshirsagar A.M.(1983) : A course in Linear Models, 1st edition.
2. Draper N.R & Smith H(1998) : Applied Regression Analysis, 3rd edition, John Wiley and Sons. INC.
3. Song GUI Wang and S.C Chow(1993): Advanced Linear Models, 1st edition, CRC Press.
4. Agresthi (2007): An introduction to categorical data analysis, second edition, John Wiley and Sons. INC.
5. Chattterjee and Haddi (1988): Sensitivity Analysis, , John Wiley and Sons. INC.
6. David W Hosmer and Stanley Lemeshow(2002): Applied Logistic regression, 2nd edition, John Wiley and Sons. INC.
7. Healy M. J. R. (2002): Matrices for Statistics, 2nd edition, Oxford university press .
8. Shantinarayan (2010) : Textbook of Matrices.
9. Cox, D. R. (1989): Analysis of binary data, 2nd edition, Chapman & Hall/CRC.
10. Chaterjee and Price (2012): Regression Analysis by example, 5th edition, John Wiley and Sons. INC.

Course code	Course name	Group	Teaching Scheme (Hrs/Week)		credits
RJSPSTAPA101	**Statistical Computing-I**	**CC**	**Lectures**	**Practical**	
			-	**6**	**3**

List of Practical's:
Practical 1: Standard Discrete Distributions
Practical 2: Standard Continuous Distribution
Practical 3: UMVUE
Practical 4: Maximum Likelihood Estimate and EM algorithm
Practical 5: Bootstrap sampling
Practical 6: Jackknife estimator
Practical 7: Bayesian estimation

Course code	Course name	Group	Teaching Scheme (Hrs/Week)		credits
RJSPSTAPA102	**Statistical computing-II**	**CC**	**Lecture**	**Practical**	
			-	**6**	**3**

List of Practical's:
Practical 1: Systematic Sampling
Practical 2: Two Phase Sampling
Practical 3: Cluster and Two Stage Sampling
Practical 4: Varying Probability Sampling
Practical 5: Matrix Theory-I(Determinant, Rank of Matrix , Inverse of matrix)
Practical 6: Linear Model
Practical 7: ANOVA
Practical 8: Ridge and Logistic Regression

SI/OGI

Course code	Course name	Group	Teaching Scheme (Hrs/Week)		Credits
RJSPSTA1I1	**Organizational Behaviour-I**	**CC**	**Lectures**	**Practical**	
			2	**-**	**2**

Course Objectives

1. To give students direct experience of the skills required in organization success.
2. To enhance understanding of organizational behaviour to influence students' success on the job.

Learning Outcomes

Upon completion of this course, the student should be able to understand purpose and importance of behavioural skills in organization life.

Unit	Topic	Lectures
1	Organisational Behaviour I • Introduction to Organizational Behaviour-Concept, definitions, Evolution of OB • Importance of Organizational Behaviour-Cross Cultural Dynamics, Creating Ethical Organizational Culture& Climate • Individual and Group Behaviour-OB models–Autocratic, Custodial, Supportive, Collegial & SOBC in context with Indian OB • Human Relations and Organizational Behaviour	7
2	Organisational Behaviour II • Managing Communication: Conflict management techniques. • Time management strategies. • Learning Organization and Organizational Design • Rewards and Punishments-Termination, layoffs, Attrition, Retrenchment, Separations, Downsizing	8
3	Human Resource Management-I • HRM-Meaning, objectives, scope and functions • HRP-Definition, objectives, importance, factors affecting HRP, Process of HRP, Strategies of HRM , Global HR Strategies • HRD-Concept ,meaning, objectives, HRD functions	7
4	Human Resource Management-II • Performance Appraisal: concept, process, methods and problems, KRA'S • Compensation-concept, components of Pay Structure, Wage and salary administration, Incentives and Employee benefits. • Career planning-concept of career Planning, Career stages and carrier planning	8

Text Books:

1. Robbins, Stephens (2007) – Organizational Behaviour (cd) 12e Paperback
2. Fred Luthans (2013) – Organizational Behaviour: An Evidence Based Approach, 13th Ed., McGraw Hill.

Semester-II S II / P I

Course code	Course name	Group	Teaching Scheme (Hrs/Week)		credits
RJSPSTA201	**Multivariate Analysis and Its Application**	**CC**	**Lectures**	**Practical**	
			4	**-**	**4**

Course Objectives

1. To provide theoretical foundations for multivariate analysis.

Learning Outcomes

Upon completion of this course, the student should be able to understand application of Principal Component Analysis, Factor Analysis and Cluster Analysis.

Unit	Topic	Lectures
I	Multivariate Distribution Random vector and its properties , Multivariate Normal Distribution and its properties , Distribution of Quadratic Form, Wishart Distribution and its properties, Hotelling's T^2- Distribution, Wilks $\wedge$- Distribution, Test For Mean Vector.	15
II	Principal Component Analysis_ Introduction, Method of Extraction of Principal Component, Graphical Representation of Principal Component , Properties of Principal Components, Decision Regarding Number of Principal Components, The Effect of Ignoring Some Components.	15
III	Factor Analysis- Introduction, The model for factor analysis, Estimation of Factor Loading, Estimation of Factor Loadings from correlation Matrix, Factor extraction, Interpretation of factors, Factor Score, Factor rotation. Canonical Correlation Analysis- Introduction, Population correlation analysis, Sample Canonical correlation Analysis, Interpretation from Canonical Correlation Analysis, Score and Prediction, Method of Test.	15
IV	Cluster Analysis- Introduction, Basic Steps of Cluster Analysis, Forming Clusters, and Test regarding Clustering. Discriminant Analysis- Scope of Discriminant analysis, Method of Discrimination, Probability of Misclassification, Test of Discriminant Function.	15

References

1. K.C. Bhuyan (2005): Multivariate Analysis and Its Application, New Central Book Agency Limited.
2. Johnson Richard A and Wicheren D.W. (1998): Applied Multivariate Statistical Analysis (4th Edition).
3. Giri Narayan C. (1995): Multivariate Statistical Analysis
4. Parimal Mukhopadhyay (2008): Multivariate Statistical Analysis, World Scientific Publishing Co Pte Ltd
5. Dillon William R & Goldstein Mathew (1984): Multivariate Analysis: Methods and Applications.

S II / P II

Course code	Course name	Group	Teaching Scheme (Hrs/Week)		credits
RJSPSTA202	**Design of Experiments**	**CC**	**Lectures**	**Practical**	
			4	**-**	**4**

Course Objectives

1. To provide theoretical foundations for design of experiments.
2. To expose students to understand application of different designs.

Learning Outcomes

Upon completion of this course, the student should be able to understand how different designs are used in agricultural and government organizations.

Unit	Topic	Lectures
I	Randomized Block design, Latin Square Design , Graeco-Latin Square Design, Balance Incomplete Block Design, C matrix , Statistical analysis of BIBD, Estimation of Parameters Model adequacy checking.	15
II	Factorial design – An example. The advantage of factorial designs. 2^2 factorial designs. General 2^k factorial experiment. Blocking, Confounding and partial confounding.	15
III	Experiments with Random Factors Random Effects Models, The Two-Factor Factorial with Random Factors, The Two-Factor Mixed Model. The Two-Stage Nested Design, The Split-Plot Design.	15
IV	Response Surface Methods: Introduction to Response Surface Methodology, The Method of Steepest Ascent, Analysis of a Second-Order Response Surface, Experimental Designs for Fitting Response Surfaces.	15

References:

1. Montgomery D. C. (2017). Design and analysis of experiments Wiley.
2. Das, M.N. and Giri N. C. (1986): Design and analysis of experiments, New Age International.
3. M.C. Chakrabarti (1963): Mathematica of Design and Analysis of Experiments, Asia Publishing House.
4. Cochran W. G. and Cox G.M. (1959): Experimental Design, Asia publishing House.
5. Fisher R. A. (1935): The Design of Experiments, Olive and Boyd.

S II / P III

Course code	Course name	Group	Teaching Scheme (Hrs/Week)		credits
RJSPSTA203	**Stochastic Processes**	**CC**	**Lectures**	**Practical**	
			4	**-**	**4**

Course Objectives

1. To provide theoretical foundations for stochastic Process.
2. To expose students to understand Markov chain.

Learning Outcomes

Upon completion of this course, the student should be able to understand how stochastic models are used in different model building.

Unit	Topic	Lectures
I	Introduction to stochastic processes (SPs): Classification of SPs according to state space and time domain. Countable state Markov chains (MC's), Chapman-Kolmogorov equations; calculation of n-step transition probability and its limit. Stationary distribution, classification of states; transient MC; random walk and gambler's ruin problem; Applications from social, biological and physical sciences.	15
II	Poisson process, Generalization of Poisson process. Renewal theory and its applications, Distribution of N(t), Limit theorems and their application, Renewal reward processes, Regenerative processes, Computing the renewal function, Applications to patterns and insurance.	15
III	Continuous-time Markov chains, Birth and Death Processes, The transition probability function Pij(t), Limiting probabilities, Time reversibility, The reversed chain, Computing the transition probabilities. Queuing theory, Queuing models and Network of queues, M/G/1 and its variations, G/M/1, Multi server queues.	15
IV	Brownian motion and stationary processes, White noise, Gaussian processes. Galton-Watson branching process, probability of ultimate extinction, distribution of population size. Martingale in discrete time.	15

Reference

1. Ross, S. M. (2014). Introduction to Probability Models, 11th Ed, Academic Press, New York.
2. Medhi, J. (2017). Stochastic Processes, Paperback, 4th Ed, New Age International.
3. Ross S. M. (2011). An elementary Introduction to Mathematical Finance, 3rd Ed, Cambridge University Press, London.
4. Bhat, B. R. (2000). Stochastic Models: Analysis and Applications, New Age International.
5. Cinlar, E. (2013). Introduction to Stochastic Processes, Paperback, Dover Publications Inc.
6. Hoel, P. G., Port, S. C. and Stone, C. J. (1986). Introduction to Stochastic Processes, Waveland Pr Inc.
7. Pinsky, M. A. and Karlin, S. (2010). An Introduction to Stochastic Modeling, 4th Ed, Academic Press.

S II / P IV

Course code	Course name	Group	Teaching Scheme (Hrs/Week)		credits
RJSPSTA204	**Testing of Hypothesis**	**CC**	**Lectures**	**Practical**	
			4	**-**	**4**

Course Objectives

1. To provide theoretical foundations for Time series
2. To expose students to understand different processes in Time Series.

Learning Outcomes

	Topic	Lectures
I	Introduction of hypothesis testing, test function, MP tests, Neyman-Pearson lemma, UMP tests, nonexistence of UMP tests.	15
II	Unbiased test, LMP test, α- similar test, Likelihood Ratio Test.	15
III	Goodness of fit tests: Chi-square goodness of fit test, The Kolmogorov-Smirnov one statistic test. Sign test, Wilcoxon Signed-rank test. Wald Wolfowitz run test, Kolmogorov-Smirnov two sample test, Mann-Whitney U-test, Wilcoxon Rank-Sum test.	15
IV	Test for equality of k independent samples, The Kruskal-Wallis Test, Friedman's test. Non-parametric regression.	15

References

1. Vijay K. Rohatgi, A. K. M. D. Ehsanes Saleh: An introduction to probability and statistics. John Wiley and Sons:- (2nd Edition)
2. J. D. Gibbons & S. Chakrabarti : Nonparametric Statistical Inference. (3rd Edition, Revised and Expanded).
3. Lehmann, E.L. & Romano Joseph P. (2005) : Testing Statistical Hypotheses (3rd Edition):- Springer Text

Course code	Course name	Group	Teaching Scheme (Hrs/Week)		credits
RJSPSTAPA201	**Statistical Computing-I**	**CC**	**Lectures**	**Practical**	
			-	**6**	**3**

List of Practical's:
Practical 1: Multivariate Distribution
Practical 2: Principal Component Analysis
Practical 3: Factor Analysis
Practical 4: Cluster Analysis
Practical 5: Design of Experiment -I
Practical 6: Design of Experiment - II
Practical 7: Response Surface Methodology

Course code	Course name	Group	Teaching scheme		credits
RJSPSTAPA202	**Statistical computing-II**	**CC**	**Lecture**	**Practical**	
			-	**6**	**3**

List of Practical's:
Practical 1: Markov Chain-I
Practical 2: Markov Chain-II
Practical 3: Poisson Process
Practical 4: Testing of Hypothesis-I
Practical 5: Testing of Hypothesis-II
Practical 6: Non- Parametric Test-I
Practical 7: Non- Parametric Test-II

SII/OGII

Course code	Course name	Group	Teaching Scheme (Hrs/Week)		Credits
RJSPSTA2I1	**Organizational Behaviour-II**	**CC**	**Lectures**	**Practical**	
			2	**-**	**2**

Course Objectives

1. To give students direct experience of the skills required in organization success.
2. To enhance understanding of organizational behaviour to influence students' success on the job.

Learning Outcomes

Upon completion of this course, the students will Aware about basics of an organization.

Unit	Topic	Lectures
1	Leadership Development Leadership–Basic definition, qualities of a leader. Trait theory and styles of leadership The orison Leadership Motivation strategies wrt motivation theories Emotional intelligence and its significance in the role of a leader Leadership and team building	7
2	Leadership skill and conflict management Creative leadership. Influence on the creative potential of work groups and teams; formation of innovative climate in organizations. Leadership in crisis	8
3	Leadership wrt managing a diverse work force, cross cultural dynamics, diverse team and change Creating a safe and healthy work environment Mentoring a tool towards leadership development Leadership in 21th century in terms of developing women leaders, developing policies for LGBTQ community, Green management by overcoming all challenges.	7
4	Case Study Assignment on analyzing successful leaders in terms of their leadership styles, skills and success stories.	8

Semester -III S III / P I

Course code	Course name	Group	Teaching Scheme (Hrs/Week)		credits
RJSPSTA301	Machine Learning	CC	Lectures	Practical	
			4	-	4

Course Objectives

1. To provide theoretical foundations for various statistical and machine learning concepts and methods.
2. To expose students to understand machine learning solutions to regression, classification and clustering problems.

Learning Outcomes

Upon completion of this course, the student should be able to Perform end-to-end process of investigating data through a machine learning lens.

	Topic	Lectures
I	Data pre-processing vectors, matrices and arrays, loading data, Data handling Handling numerical data and categorical data, Handling text, dates and time, Handling images. Statistical Learning What is statistical learning, assessing model accuracy.	15
II	Linear Regression, Multiple Linear Regression, Other Considerations in Regression Model, The Marketing Plan, Comparison of Linear Regression with K-Nearest.	15
III	Classification An overview of classification, why not linear regression, logistic regression, linear discriminant analysis, a comparison of classification methods.	15
IV	Unsupervised Learning The challenge of unsupervised learning, principal components analysis, clustering methods (density-based methods, hierarchical-based methods, portioning-based methods, grid-based methods), clustering algorithms (k-means, k-nearest neighbours).	15

References

1. "An Introduction to Statistical Learning With Application in R", By Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, Springer Texts in Statistics.
2. "Machine Learning", Mitchell Tom, McGraw Hill,1997.
3. "Pattern classification", 2nd edition, Richard O. Duda, Peter E. Hart, David G. Stork. Wiley, New York, 2001.
4. "Machine Learning: A Probabilistic Perspective", Kevin P. Murphy, MIT Press, 2012
5. "Practical Data Science", Andreas Francois Vermeulen, APress, 2018
6. "Principles of Data Science", Sinan Ozdemir, Packt, 2016.

S III / P II

Course code	Course name	Group	Teaching Scheme (Hrs/Week)		credits
RJSPSTA302	**Big Data Technology**	**CC**	**Lectures**	**Practical**	
			4	**-**	**4**

Course Objectives

1. To provide theoretical foundations for basic and advanced methods of big data technology and tools.
2. To expose students to understand the knowledge of MapReduce, Hadoop and its ecosystem.

Learning Outcomes

Upon completion of this course, the student should be able to understand build and maintain reliable, scalable and distributed systems with Apache Hadoop.

	Topic	Lectures
I	INTRODUCTION TO BIG DATA Introduction: Distributed file system, Big Data and its importance, Four Vs, Drivers for Big data, Big data analytics, Big data applications. Algorithms using map reduce, Matrix-Vector Multiplication by Map Reduce. INTRODUCTION HADOOP Big Data: Apache Hadoop & Hadoop Ecosystem, Moving Data in and out of Hadoop, Understanding inputs and outputs of MapReduce, Data Serialization.	15
II	HADOOP ARCHITECTURE Hadoop Architecture, Hadoop Storage: HDFS, Common Hadoop Shell commands, Anatomy of File Write and Read., Name Node, Secondary Name Node, and Data Node, Hadoop MapReduce paradigm, Map and Reduce tasks, Job, Task trackers, Cluster Setup, SSH & Hadoop Configuration, HDFS Administering, Monitoring & Maintenance.	15
III	HADOOP ECOSYSTEM AND YARN Hadoop ecosystem components: Schedulers, Fair and Capacity, Hadoop 2.0 New Features Name Node High Availability, HDFS Federation, MRv2, YARN, Running MRv1 in YARN.	15
IV	Hive and HiveQL, HBase Hive Architecture and Installation, Comparison with Traditional Database. HiveQL Querying Data, Sorting and Aggregating, Map Reduce Scripts, Joins & Subqueries. HBase concepts Advanced Usage, Schema Design, Advance Indexing, PIG, Zookeeper, how it helps in monitoring a cluster, HBase uses Zookeeper and how to Build Applications with Zookeeper.	15

References

1. "Professional Hadoop Solutions", Boris lublinsky, Kevin t. Smith, Alexey Yakubovich, Wiley, ISBN: 9788126551071, 2015.
2. "Understanding Big data", Chris Eaton, Dirk deroos et al, McGraw Hill, 2012
3. "HADOOP: The definitive Guide", Tom White, O Reilly 2012. 6 IT2015 SRM(E&T).

4. "Big Data Analytics with R and Hadoop", Vignesh Prajapati, Packet Publishing 2013.
5. "Oracle Big Data Handbook", Tom Plunkett, Brian Macdonald et al, Oracle Press, 2014.
6. "Big Data and Business analytics", Jy Liebowitz, CRC press, 2013.
7. http://www.bigdatauniversity.com/

S III / P III

Course code	Course name	Group	Teaching Scheme (Hrs/Week)		credits
RJSPSTA303	**Data Mining**	**CC**	**Lectures**	**Practical**	
			4	**-**	**4**

Course Objectives

1. To provide theoretical foundations for data mining.
2. To expose students to learn the computational approaches to Modelling and Feature Extraction.

Learning Outcomes

Upon completion of this course, the student should be able to design algorithms by employing Map Reduce technique for solving Big Data problems.

	Topic	Lectures
I	Data Mining—On What Kind of Data? Relational Databases, Data Warehouses, Transactional Databases, Advanced Data and Information Systems and Advanced Applications. Data Mining Functionalities—What Kinds of Patterns Can Be Mined? Concept/Class Description: Characterization and Discrimination, Mining Frequent Patterns, Associations, and Correlations, Classification and Prediction, Cluster Analysis, Outlier Analysis, Evolution Analysis. Classification of Data Mining Systems.	15
II	Data Pre-processing : Descriptive Data Summarization , Data Cleaning, Data Integration and Transformation, Data Reduction, Data Discretization and Concept Hierarchy Generation .	15
III	Data Warehouse and OLAP Technology: What is a Data Warehouse? A Multidimensional Data Model, Data Warehouse Architecture, Data Warehouse Implementation, From Data Warehousing to Data Mining.	15
IV	Classification and Prediction: What Is Classification?, What Is Prediction?, Issues Regarding Classification and Prediction, Classification by Decision Tree Induction, Bayesian Classification, Rule-Based Classification, Support Vector Machines, Lazy Learners (or Learning from Your Neighbours).	15

Reference

1.Jiawei Han University of Illinois at Urbana-Champaign Micheline Kamber : Data Mining: Concepts and Techniques (Second Edition).
2.Ian H.Witten, Eibe Frank, Morgan Kaufman: Data Mining – Practical Machine Learning Tools and Techniques.
3. GalitShmueli, Nitin Patel, Peter Bruce, (2010): Data Mining for Business Intelligence: Concepts, Techniques, and Applications in Microsoft Office Excel with XLMiner , Wiley.

4. David Hand, HeikkiMannila and Padhraic Smyth: "Principles of Data Mining", MIT PRESS.

S III / P IV

Course code	Course name	Group	Teaching Scheme (Hrs/Week)		credits
RJSPSTA304	**Time Series Analysis**	**CC**	**Lectures**	**Practical**	
			4	**-**	**4**
Course Objectives					
Learning Outcomes Upon completion of this course, the student should be able to understand Perform ETL process on source data and send it to data warehouse database.					

	Topic	Lectures
I	Time-series as discrete parameter stochastic process. Exploratory Time Series Analysis: Tests for trend and seasonality, Exponential and Moving average smoothing. Hot Winters smoothing. Forecasting based on smoothing, adaptive smoothing.	15
II	Auto covariance and auto correlation functions and their properties. Auto covariance and auto correlation functions and their properties, invertibility. Stationary processes: a) moving average) (MA), b) Auto Regressive (AR), c) ARMA and (d) AR integrated MA (ARIMA) models, Box-Jenkins models, Discussion of estimation of mean, auto covariance and auto correlation functions under large sample theory (without proof).	15
III	Choice of AR and MA periods, Estimation of ARIMA models parameters. Forecasting, Residual analysis and diagnostic checking.	15
IV	Spectral analysis of weakly stationary process, Periodogram and Correlogram analysis. Computations based on Fourier transform. Spectral Decomposition of weakly AR process and representations as a one-sided MA process- necessary and sufficient conditions	15

References

1. Anderson, T. W (1971): The Statistical Analysis of Time Series, Wiley, N.Y.
2. Brockwell, P.J. and Davis, R. A. Time-Series(1991): Theory and Methods (Second Edition), Springer-Verlag. 19
3. Box, G.E.P. and Jenkins, G.M. (1976): Time Series Analysis-Forecasting and control Hodlen-day, San Franciscor.
4. Kendall, Sir Maurice and Ord. J. K. (1990): Time Series (Third Edition) Edward Arnold.
5. Montgomery, D. C. and Johnson, L. A. (1977): Forecasting and Time Series Analysis, McGraw Hill.

Course code	Course name	Group	Teaching Scheme (Hrs/Week)		credits
RJSPSTAPA301	**Statistical Computing-I**	**CC**	**Lectures**	**Practical**	
				6	**3**

List of Practical's:
Practical 1: Linear and multiple linear regression
Practical 2: Logistics regression
Practical 3: Linear discriminant analysis & Quadratic discriminant analysis
Practical 4: Clustering using K-means and
Practical 5: K-nearest neighbours
Practical 6: Big Data Technology-I
Practical 7: Big Data Technology-II
Practical 8: Big Data Technology-III

Course code	Course name	Group	Teaching Scheme (Hrs/Week)		credits
RJSPSTAPA302	**Statistical computing-II**	**CC**	**Lecture**	**Practical**	
			-	**6**	**3**

List of Practical's:
Practical 1 : Cross-validation, model evaluation and selection
Practical 2: Bootstrap
Practical 3: Dimensionality reduction using feature extraction.
Practical 4: Dimensionality reduction using feature selection.
Practical 5: Polynomial Regression
Practical 6: Time series Analysis-1
Practical 7: Time Series Analysis-2
Practical 8: Time Series Analysis -3

SIII/OGIII

Course code	Course name	Group	Teaching Scheme (Hrs/Week)		Credits
RJSPSTA3I1	**Organizational Behaviour-III**	**CC**	**Lectures**	**Practical**	
			2	**-**	**2**

Course Objectives

1. To give students direct experience of the skills required in organization success.
2. To enhance understanding of organizational behaviour to influence students' success on the job.

Learning Outcomes

Upon completion of this course, Application through assignments and/or class room participation (of key skills to improve the students' skills of operating in a group)

Unit	Topic	Lectures
1	Business Ethics Introduction to Business Ethics, Business Ethics and Management, Business Ethics and Moral Obligations; Importance of Business Ethics Theories on Business Ethics Deontology, Utilitarianism, Rights, and Virtues Structure of ethics management: Ethics Committee, Ethics Officers, and the CEO Communicating ethics: Communication Principles, Channels, Training programmes, and evaluation and Ethical Audit, Whistle Blowing, Types of whistle blowers, Whistle Blower Policy, The whistleblower and developments in India.	7
2	Ethical Decision Making and Ethical Leadership Individual Factors: Moral philosophies Organisational Factors: The role of Ethical Culture and Relationships Ethical issues involved in employer employee relationship Developing an effective Ethics program Implementing and auditing an ethics program Business ethics in global economy Corporate Philanthrophy	8
3	Introduction to Corporate Social Responsibility, History of CSR, Concepts of Charity, Corporate Citizenship , Models of CSR (Friedman Model, Carroll Model, Ackerman model),CSR through triple bottom line, CSR-Legislation in India Section 135 of Companies Act 2013.Scope for CSR Activities under Schedule VII, Appointment of Independent Directors on the Board, and Computation of Net Profit's Implementing Process in India. International framework for Corporate Social Responsibility	7

	Sustainable Development Goals, UN guiding principles on business and human rights	
4	CSR initiatives in India ,Case studies on CSR	8

Semester IV

Course Code	Course Name	Group	Teaching Scheme (Hrs/Week)		edits
			Lectures	actical	
RJSPSTA4INT	Industrial Internship		-	24	12
RJSPSTA4MP	Major Project		-	24	12
	Total		**-**	**48**	**24**

Scheme of Examinations

1. Internal Examination 40 marks various modes with different weightage (Presentation, seminar, mcq, quiz etc.)

2. One External (Semester End Examination) of 60 marks. Duration 2 ½ hours.

3. One Practical at the end of Semester consisting of Practical I 100 marks (based on theory paper 1 and paper 2) and Practical II 100 marks (based on theory paper 3 and paper 4) marks separate passing in each practical

4. Minimum marks for passing Semester End Theory and Practical Exam is 40 %. Separate passing for Internal and Semester End examination.

5. For any KT examinations, there shall be ODD-ODD/EVEN-EVEN pattern followed.

6. A candidate will be allowed to appear for the practical examinations if he/she submits a certified journal of Botany or a certificate from the Head of the department / Institute to the effect that the candidate has completed the practical course of M Sc Semester I Botany as per the minimum requirements.

7. In case of loss of journal, a candidate must produce a certificate from the Head of the department /Institute that the practical for the academic year were completed by the student. However, such a candidate will be allowed to appear for the practical examination but the marks allotted for the journal will not be granted.

Structure- Evaluation

Semester-I

Course Code	Course Name	Group	Teaching Scheme (Hrs/Week)		Credits	Max Marks	Min Marks	End Sem Exam Marks	Internal Marks
			Lectures	Practical					
RJSPSTA101	Distribution Theory and Its Application	CC	4	-	4	100	40	60	40
RJSPSTA102	Estimation Theory	CC	4	-	4	100	40	60	40
RJSPSTA103	Sampling Theory	CC	4	-	4	100	40	60	40
RJSPSTA104	Linear models and Regression Analysis	CC	4		4	100	40	60	40
RJSPSTAPA101	Statistical Computing I (Practical based on Paper I and II in relevant software)	SC-1	-	6	3	100	40	100	
RJSPSTAPA102	Statistical Computing II (Practical based on Paper III and IV in relevant software)	SC-2	-	6	3	100	40	100	
RJSPSTA1I1	Organizational Behavior I	OB-1	2	-	2	50	20	-	50(*CE)
	Total		**18**	**12**	**24**				

***CE= Continuous Evaluation**

Semester-II

Course Code	Course Name	Group	Teaching Scheme (Hrs/Week)		Credits	Max Marks	Min Marks	End Sem Exam Marks	Internal Marks
			Lectures	Practical					
RJSPSTA201	Multivariate Analysis and Its Application	CC	4	-	4	100	40	60	40
RJSPSTA202	Design of Experiments	CC	4	-	4	100	40	60	40
RJSPSTA203	Stochastic Processes	CC	4	-	4	100	40	60	40
RJSPSTA204	Time Series Analysis	CC	4		4	100	40	60	40
RJSPSTAPA201	Statistical Computing I (Practical based on Paper I and II in relevant software)	SC-1	-	6	3	100	40	100	
RJSPSTAPA202	Statistical Computing II (Practical based on Paper III and IV in relevant software)	SC-2	-	6	3	100	40	100	
RJSPSTA2I1	Organizational Behavior II	OB-1	2	-	2	50	20	-	50(*CE)

	Total		**18**	**12**	**24**				

***CE= Continuous Evaluation**

Semester III

Course Code	Course Name	Group	Teaching Scheme (Hrs/Week)		Credits	Max Marks	Min Marks	End Sem Exam Marks	Internal Marks
			Lectures	Practical					
RJSPSTA301	Machine Learning	CC	4	-	4	100	40	60	40
RJSPSTA302	Big Data Technology	CC	4	-	4	100	40	60	40
RJSPSTA303	Data Mining	CC	4	-	4	100	40	60	40
RJSPSTA304	Time Series Analysis	CC	4		4	100	40	60	40
RJSPSTAPA301	Statistical Computing I (Practical based on Paper I and II in relevant software)	SC-1	-	6	3	100	40	100	
RJSPSTAPA302	Statistical Computing II (Practical based on Paper III and IV in relevant software)	SC-2	-	6	3	100	40	100	
RJSPSTA3I1	Organizational Behavior III	OB-1	2	-	2	50	20	-	50(*CE)
	Total		**18**	**12**	**24**				

***CE= Continuous Evaluation**

Semester IV

Course Code	Course Name	Group	Teaching Scheme (Hrs/Week)		Credits	Max Marks	Min Marks	End Sem Exam Marks	Internal Marks
			Lectures	Practical					
RJSPSTA4INT	Industrial Internship	II	-	24	12	350	140	-	-
RJSPSTA4MP	Major Project	II	-	24	12	300	120	-	-
	Total		-	**48**	**24**				

M.Sc. Statistics Syllabus