Program Name: M. Sc. Statistics

Program Specific Outcomes

PSO1 Student will develop good understanding of the advanced topics in the discipline of Statistics.
PSO2 Student will acquire skills of using various statistical tools and techniques of intermediate and advanced level involving multivariate techniques.
PSO3 Student will be able to quickly grasp the essential knowledge of the application domains of Statistics and investigate the problems in application domain from statistical perspective.
PSO4 Student will develop problem solving skills to tackle the real world problems involving real world challenges. Student will be able to apply the skills acquired by him/her for obtaining optimal solutions to the problems.
PSO5 Student will be able to identify the skills and the techniques needed to tackle the challenges and carry out self exploration to acquire the needed skills and knowledge.
PSO6 Student will be able to effectively use advanced software platforms for carrying out analytic investigations, including computer intensive approaches.
PSO7 Student will acquire in depth understanding of the academic field of Statistics and will develop the ability to explore and understand the research material in the theory and applications of Statistics.
PSO8 Student will be able to build stochastic models of real world phenomena and investigate various properties of the phenomena.
PSO9 Student will be able to work independently as well as in team to undertake a statistical projects to investigate and solve real world problems in wide application domains.
PSO10 Student will be able to undertake research investigations, and pursue research career in the specialized area of his/her interest.
PSO11 Student will develop competencies such as
(i) problem-solving skills
(ii) investigative skills
(iii) communication skills
(iv) analytical skills
(v) ICT skills
(vi) inter-personal skills
(vii) Counseling skills

	The Maharaja Sayajirao University of Baroda Faculty of Science Department of Statistics			Academic Year	2019-20
M.Sc. in Statistics: Regular Programme					
Year	I	Core Course **STA2101C01: Measure Theory**		**Credits**	**04**
Semester	I	Year of Introduction: 2012 Year of Syllabus Revision: -		**Maximum Marks**	**100**
Mode of Transaction	Lectures and Tutorials				

Course Outcomes

After going through this course, the students will acquire

CO1 knowledge of fundamental concepts about sequences of sets, fields, sigma fields and their properties.
CO2 knowledge of the set functions , measures and their properties.
CO3 knowledge of Lebesgue and Lebesgue-Stiltjes measure and associated results.
CO4 knowledge of measurable functions and and related results.
CO5 knowledge of different modes of convergenceof sequence of measurable functions and their inter-relations..
CO6 knowledge of integration of measurable functions and properties of integrals.
CO7 knowledge of various convergence theorems and their applications.
CO8 knowledge of the concept of absolute continuity and singularity, Radon-NIkodym Theorem.
CO9 Knowledge of product measure and related results.

Unit No.	**Topic/Unit**	**Contact Hours**	**Weightage (%)**	**BT Level**	**CO**	**PSO**	**Elements of** Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	**Relevance to** Local (L)/ National (N)/ Regional(R)/ Global (G) development al needs	**Relation to** Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)

1	Convergence of a sequence of sets, fields and sigma fields, monotone classes, Borel sets in R and R^n. Additive set functions, measures, probability measures, σ-finite measures, properties of measures, Caratheodory extension theorem (only statement), its application for the construction of Lebesgue and Lebesgue-Stieltjes measures.	20	25	1,2,3	CO1 CO2 CO3	**PSO1** **PSO2**	**SD**	**N**	**PE**
2	Measurable functions, Borel measurable functions, convergence almost everywhere, convergence in measure.	12	25	1,2,3	CO4 CO5	**PSO1** **PSO2**	**SD**	**N**	**PE**
3	Integration of measurable functions with respect to a measure, properties of the integral.	12	25	1,2,3 4	CO6	**PSO1** **PSO2**	**SD**	**N**	**PE**
4	Monotone convergence theorem, Fatou's lemma, the dominated convergence theorem, its application to differentiation under integral sign. Absolute continuity and singularity of measure, Lebesgue decomposition theorem and Radon-Nikodym theorem (only statements and applications), product measures and iterated integrals, statement of Fubini's theorem.	16	25	1,2,3, 4	CO7 CO8 CO9	**PSO1** **PSO2**	**SD**	**N**	**PE**

Reference Books

1.	**Loeve, M.: *Probability Theory*.**
2.	**Billingsley,P.(1988) : Probability and Measure, Wiley.**
3.	**Kingman, J.F.C. and Taylor, S.J.(1966) : Introduction to Measure and Probability, Cambridge University Press. ..**
4.	**Modern Probability Theory : B R Bhat, New Age International (P) Ltd.**

	The Maharaja Sayajirao University of Baroda **Faculty of Science** **Department of Statistics**		**Academic Year**	**2019-20**
M.Sc. in Statistics: Regular Programme				
Year	I	Core Course **STA2102C02-Linear Models**	**Credits**	**04**
Semester	I	Year of Introduction: 2012 Year of Syllabus Revision: -	**Maximum Marks**	**100**
Mode of Transaction	Lectures and Tutorials			

Course Outcomes

After going through this course, the students will

C01: develop understanding of Gauss-Markov set up for uncorrelated variables, correlated variables and model under linear restrictions in parameters.

C02: be able to estimate the parameters for the above model using least square principles.

C03: develop understanding to test one and more linear parametric functions.

C04: come to know how to determine sample size using power of F-test.

C05: understand to use post hoc test: Tukey's and Scheffe's test.

C06: understand the difference between one way fixed effect model and one way random effect model.

C07: learn to estimate parameters for one way random effect model.

C08: learn about MINQUE theory.

C09: learn to check the adequacy of the model.

C10: learn about outliers and its remedies.

C11: aquire knowledge about non linear models.

C12: learn about multicollinearity: its detection, source and remedies.

C13: learn how to develop a model for real life data.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/ Global (G) development al needs	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)
1	Gauss-Markov setup, Normal equations and least squares estimates, Error and estimation spaces, Variances and covariance's of least squares estimates, estimation of error variance, estimation with correlated observations, Least squares estimates with restriction on parameters, simultaneous estimates of linear parametric functions.	10	20	2 3	C01 C02	**PS01** **PS07**	**SD**	**G**	**PE**
2	Tests of hypothesis for one or more linear parametric functions, confidence intervals and regions, Analysis of variance, Power of F-test, Multiple comparison test due to Tukey and Schefe, Simultaneous confidence intervals.	15	25	2 3	C03 C04 C05	**PS01** **PS02** **PS07**	**SD**	**G**	**PE**
3	Introduction to one-way random effects linear models and estimation of variance components, MINQUE theory. Residuals and their plots as tests of departure from assumptions such as fitness of the model, normality, homogeneity of variances and detection of outliers, Remedies.	15	25	2 3 4	C06 C07 C08 C09 C10 C13	**PS01** **PS02** **PS03** **PS08** **PS010** **PS011**	**SD**	**G**	**PE**

4	Introduction to non-linear models. Multicollinearity, Ridge regression and principal component regression, Subset selection of explanatory variables, Mallow,s C_p statistic.	20	30	2 3 4	C11 C12 C13	**PS01** **PS02** **PS03** **PS08** **PS010** **PS011**	**Emp**	**G**	**PE**

REFERENCES :

1. **Rao,C.R.(1973) : Linear Statistical Inference and its applications, Wilet Eastern.**

   Ch-4: 41.1-4a.5, 4a.7, 4a.9, 4a.10; 4b.1, 4b.2; 4j.1, 4k.2

2. **A.M. Kshirsagar (1983): A course in Linear Models, Marcel dekker.**

   Ch-2: Full; Ch-3:1 to 6; Ch-5:Full; Ch-6:1 to 4, 6,7; Ch-12:1-3,5,7.

3. **Cook, R.D. and Weisberg,S.(1982) :Residual and influence in Regression, Chapman and Hall.**

   Ch-2:2.1, 2.3.

4. **Searle S.R.(1971): :Linear Models, John Wiley.**

5. **Irwin Guttman (1982): Linear Models, John Wiley.**

6. **Draper,N.R. and Smith,H(1998) : Applied Regression Analysis, 3rd edition, Wile.**

7. **Weisberg,S.(1985) : Applied Linear Regression, Wiley.**

	The Maharaja Sayajirao University of Baroda Faculty of Science Department of Statistics			Academic Year	2019-20
M.Sc. in Statistics: Regular Programme					
Year	II	Core Course **STA2103C03 Multivariate Analysis-I**		**Credits**	**03**
Semester	I	Year of Introduction: 2012 Year of Syllabus Revision: -		**Maximum Marks**	**100**
Mode of Transaction	Lectures and Tutorials				

Course Outcomes

After going through this course, the students will acquire

CO1 Student will be able to produce visualization of multivariate data.
CO2 Student will be able to work with multivariate probability distributions
CO3 Student will understand issues and challenges of analyzing multivariate data
CO4 Student will have good in-depth understanding of multivariate normal distribution and its applications
CO5 Student will have good understanding of sampling distributions such as Wishart distribution in the context of multivariate setup
CO6 Student understands discrimination techniques, in particular Fisher's approach.
C07 Student understands classification problem and can solve it using Bayesian approach.
C08 Student understands the concept of relationship between two sets of variables and understands its measure in terms of canonical correlations.

Unit No.	**Topic/Unit**	**Contact Hours**	**Weightage (%)**	**BT Level**	**CO**	**PSO**	**Elements of** Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	**Relevance to** Local (L)/ National (N)/ Regional(R)/ Global (G) developmental needs	**Relation to** Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)

1.	Multivariate Normal Distribution: Definition (density free approach), Important properties of Multivariate Normal Distribution, Derivation of density function, MLEs of parameters. Orthogonal transformation; concept of elliptically contoured distribution.	15	35	**1, 2**	**1, 2, 3, 4**	**1,2,3, 4,5**	**Emp SD**	**N, G**	**PE**
2.	Wishart Distribution: Definition and important properties, Derivation of Wishart distribution, Joint distribution of mean vector and co-variance matrix, Results associated with Wishart distribution.	10	35	**1, 2, 3**	**5**	**1,2,3, 6,7**	**Emp SD**	**N, G**	**PE**
3.	Discriminant analysis and classification procedures: A linear discriminant function for two groups, Classification with known parameters, Estimation of misclassification probabilities. Best regression equation, Idea of canonical correlation and discriminant analysis (Fisher's approach only)	20	30	**2, 3, 4**	**6, 7, 8**	**1,2,4, 5,9**	**Emp SD**	**N, G**	**PE**
	References								
	1. D.F. Morrison (2004): Multivariate Statistical Methods, 4E, Duxbury Press. 2. Kshirsagar A.M. (1972): Multivariate Analysis, Marcel Dekker 3. Rao C.R.(2009): Linear Statistical Inference & its Applications, 2E, Wiley 4. Draper and Smith (1998): Applied regression Analysis, 3E, Wiley								

	The Maharaja Sayajirao University of Baroda Faculty of Science Department of Statistics	Academic Year	2019-20

M.Sc. in Statistics: Regular Programme

Year	I	Core Course **STA2104C04 Statistical Decision Theory**	**Credits**	**04**
Semester	I	Year of Introduction: 2012 Year of Syllabus Revision: -	**Maximum Marks**	**100**
Mode of Transaction	Lectures and Tutorials			

Course Outcomes

After going through this course, the students will acquire

CO1 The knowledge of Decision Theory Basics
CO2 knowledge of the decision theory as a two person zero sum game
CO3 knowledge of loss functions and expected loss
CO4 The concept of r randomized and Non-randomized decision rules and risk function
CO5 knowledge of different types of decision rules like: Bayes, Minimax, optimal decision rules.
CO6 knowledge of inference problems as decision problem and geometric interpretation of decision problem.
CO7 concept of admissibility and completeness admissibility of Bayes rules and existence of Bayes rules.
CO8 knowledge of complete class Theorem, supporting hyper plane theorems
CO9 the knowledge of sufficient statistics and its use finding the best decision rule
C10 the knowledge of invariant decision rules ,admissibility of decision rules.

Unit No.		Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/ Global (G) development al needs	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)
1	Decision problem and 2-person game, utility theory, loss functions, expected loss, decision rules (non-randomized and randomized), risk function, Optimal decision rules-Unbiasedness, Invariance, Bayes principel, Minimax principle; decision principles; inference problems as decision problems; geometric interpretation of decision problem.	20	35	2,3,5, 6	C 01 C02, C 03C0 4	01,02, 04	Ent, SD	N, R, G	PE

2	Concepts of admissibility and completeness, admissibility of Bayes' rules, existence of Bayes rules, existence of a minimal complete class. Essential completeness of the class of non-randomized decision rules, minimax theorem for finite parameter space, complete class theorem, Supporting and separating hyperplane theorems. (only statement)	20	35	2,4,5, 6	C04, C05 C 07C0 8	**01,02, 05**	**Ent. SD**	**N, G**	**HV, PE**
3	Review of sufficient Statistics, essentially complete classes of rules based on sufficient statistics. Concept of invariance, Invariant decision rules, Admissibility of invariant decision rules, minimax invariant decision rules;	20	30	1,2,4, 5	C 09 C10	**01,02, 07**	**SD**	**N, G**	**HV, PE**

Reference Books

1. Ferguson, T. S.(1967): Mathematical Statistics-A Decision Theoretic Approach, Academic Press.
2. Berger, J. O. (1985): Statistical Decision Theory and Bayesian Analysis, 2nd Ed., Springer
3. DeGroot, M/H.: Optimal Statistical Decisions, McGraw Hill.

Bloom's Taxonomy Levels: 1. Remember 2. Understand 3. Application 4. Analysis 5. Evaluation 6. Creation

	The Maharaja Sayajirao University of Baroda **Faculty of Science** **Department of Statistics**		**Academic Year**	**2019-20**
M.Sc. in Statistics: Regular Programme				
Year	**I**	Core Course **STA2108C08 - Introduction to R Programming**	**Credits / Hours per week**	**03**
Semester	**I**	Year of Introduction: 2017-18 Year of Syllabus Revision:	**Maximum Marks / Grade**	**100**
Mode of Transaction	Lectures			

Course Outcome (CO) STA2108C08

After studying this course students will be exposed to

CO1 Basic understanding of R language, the R environment and introduction to basic data structures in R

CO2 Use of built-in R functions for exploratory data analysis of univariate data

CO3 Use of built-in R functions for exploratory data analysis of bivariate data

CO4 Use of built-in R functions for probability distributios and random number generations

CO5 Importing and exporting data files

CO6 Developing simple programs in R

CO7 Fitting various linear models using R

CO8 Creating 2D and 3D graphics using R

CO9 Cross tabulation and analysis of categorical data

CO10 Fitting various nonlinear models using R

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/ Global (G) developmental needs	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)
1	Introduction to R- A programming language and environment for data analysis and graphics, S implementations - 'Old S engine', 'new S engine' and 'R engine'. Syntax of R expressions: names and assignments, Operators and their precedence, subscripting, Data classes, modes and types. Data objects: Basic data objects, vectors, matrices, arrays, lists, factors and ordered factors, Creating and using these objects; Functions- Elementary functions and summary functions, applying functions to subsets of data. Data frames: The benifits of data frames, Creating data frames, Combining data frames, Adding new classes of variables to data frames; Data frame attributes.	12	20	1, 2	CO1	**3, 4, 5, 6, 8, 9, 10, 11**	**Emp, SD**	**N, R, G**	**PE**
2	Performing data analysis tasks: Reading data with scan function, Exploring data using graphical tools, computing descriprtive statistics, One sample tests, two sample tests, Goodness of fit tests Exploring relationhips between data: plotting scatter diagrams, correlation coefficient and testing its significance, regression analysis- Fitting the model, examining residuals, pairwise scatter plots, Adding and dropping terms from a model, Stepwise regression, Updating models. Mathematical computing in R: vector and matrix computations, probability and random numbers; The object	14	30	2, 3, 4	CO2, CO3, CO4	**3, 4, 5, 6, 8, 9, 10, 11**	**Emp, SD**	**N, R, G**	**PE**

	oriented matrix library.								
3	Importing data files: import.data function, read.table function; Exporting data: export.data function, cat, write, and write.table functions; Outputting results - sink function, formatting output - options, and format functions; Exporting graphs - export.graph function. Developing simple programs in R for data analysis tasks, saving programs, executing stored programs. Specifying models in R: Basic formulas, effect of a categorical variable, specifying interactions, specifyng nested effects, Specifying contrasts; Using models with fitting formulas, Useful functions for model fitting; Analysis of variance for designed experiments.	10	20	2, 3, 6	CO5, CO6, CO7	**3, 4, 5, 6, 8, 9, 10, 11**	**Emp, SD**	**N, R, G**	**PE**
4	Graphics in R: creating graphs using plot function, Plot shapes, plot types, multiple plot layout, plot titles, formating plot axes; 3-D plots: Contour plots, perspective plots, and image plots; Graphics using 'ggplot2' package. Interactively adding information of plot - Identifying the plotted points, adding trend lines to current scatter plot, adding new data to current plot, adding text and legend. Visualizing the multivariate data: Scatter plot matrices, Star plots, Faces. Cross tabulating data, cross classifying subsets of data frames, manipulating and analysing cross classified data; Weighted regression, Polynomial regression, linear mixed effect models.	10	30	2, 3, 4, 6	CO8, CO9, CO10	**3, 4, 5, 6, 8, 9, 10, 11**	**Emp, SD**	**N, R, G**	**PE**

Reference Books	
1.	Chambers J. M. (1998): Programming with Data: A guide to S language, Springer.
2.	Venables W N and Ripley B D (2000): S Programming, Springer
3.	Everitt B. S. (1994): A handbook of Statistical Analysis using S-Plus, Chapman & Hall.
4.	Venables W N and Ripley B D (1999): Modern Applied Statistics with S-Plus, 3e, Springer.
5.	S-PLUS 2000 Programmer's Guide, Data Analysis Products Division, MathSoft Inc., WA.
6.	S-PLUS 2000 Guide to Statistics Vol I & II, Data Analysis Products Division, MathSoft Inc., WA.

	The Maharaja Sayajirao University of Baroda Faculty of Science Department of Statistics		Academic Year	2019-20
M.Sc. in Statistics: Regular Programme				
Year	I	**STA 2204C13: Theory of Estimation**	**Credits**	**02**
Semester	II	Year of Introduction: Year of Syllabus Revision: -	**Maximum Marks**	**50**
Mode of Transaction	Lectures and Tutorials			

Course Outcomes

After going through this course, the students will acquire

CO1 basic understanding of the properties of good estimators
CO2 knowledge of sample and population
CO3 The necessity of estimating population characteristics through sample informations parametric inference
CO4 knowledge of large sample concepts of point estimators
CO5 the skill to identify the best possible estimators from a class of estimators.
CO6 the knowledge about the importance of parametric inference in statistical decision making

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/ Global (G) developmental needs	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)
1	Revision of the concepts of sufficiency and ubbiasedness, BLUE, Cramer-Rao inequality and its extensions. MVU Estimation, Rao-Blackwell theorem and its implication in MVU estimation, complete sufficient statistics, Lehmann-Scheffe theorem, use of the concept of completeness in estimation. UMVU estimation, Basu's theorem(without	**15**	**50**	**1,2,3,4, 5,6**	**CO1 CO2 CO3 CO4 CO5 CO6**	**PSO1 PSO2 PSO3 PSO5**	**SD**	L R G	**ES HV PE**

	proof), & its applications.								
2	Criteria of estimation in large samples, asymptotic efficiency, CAN estimators. Methods of estimation in large samples: Method of moments, Minimum $\chi 2$ method, MLE, method of scoring, Asymptotic properties of MLE-consistency, asymptotic normality, Cramer's conditions for asymptotic normality.	**15**	**50**	**1,2,3,4, 5,6**	**CO1 CO2 CO3 CO4 CO5**	**PSO4 PSO5 PSO6 PSO7 PSO8**	**SD**	L R G	**ES HV PE**

References:

1. Kale B.K., and Muralidharan, K. (2015): A First course in parametric inference. Ch:2-Up to 2.5; Ch: 3-Full
2. Rao C.R. (1973): Linear Statistical Inference and its applications, 2nd Edition, Wiley Eastern. Ch: 5-5a.1, 5a.2, 5d, 5f, 5f
3. Lehmann E.L. (1983): Theory of Point Estimation, John Wiley and Sons. Ch: 2-2.1 (Except Theorem 1.3)

	The Maharaja Sayajirao University of Baroda Faculty of Science Department of Statistics		Academic Year	2019-20
M.Sc. in Statistics: Regular Programme				
Year	I	Core Course **STA2201C10: probability Theory**	**Credits**	**04**
Semester	I	Year of Introduction: 2012 Year of Syllabus Revision: -	**Maximum Marks**	**100**
Mode of Transaction	Lectures and Tutorials			

Course Outcomes

After going through this course, the students will be equipped with knowledge about

CO1 various inequalities in terms of moments of R.V.s
CO2 decomposition of distribution function .
CO3 convergence theorems associated with distribution function..
CO4 characteristic function, it's properties and it's form for various standard probability distributions.
CO5 independent classes, independent random variables and relared theorems.
CO6 laws of large numbers, various forms of central limit theorem, and their applications in Statistics.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/ Global (G) development al needs	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)
1	Probability spaces, random variables and random vectors, expectations, moments, Holder's inequality, Minkowski inequality, Schwartz's inequality, Markov's inequality, Jensen's inequality.	10	25	1,2	CO1 CO2	**PSO1** **PSO2**	**SD**	**N**	**PE**

2	Probability distribution of a random variable, distribution function (d.f.), the change of variable theorem, mixtures of distributions with examples, joint d.f.s, decomposition into absolutely continuous and singular parts. Convergence of d.f., Weak convergence and complete convergence, weak compactness Theorem, Helly-Bray Theorem, Slutsky's Theorem.	16	25	1,2,3	CO3 CO4 CO5	**PSO1** **PSO2**	**SD**	**N**	**PE**
3	Characteristic function (c.f.), its properties (only statements), c.f.'s and moments, inversion Theorem (only statement): Application to various distributions, continuity Theorem (only statement), compositions of d.f.s, c.f.'s of compositions, compound distributions. Independent classes and independent random variables, the multiplication Theorem, sequences of independent random variables: Borel 0-1 criterion, Borel-Cantelli lemma.	18	25	1,2, 3, 4.	CO6 CO7	**PSO1** **PSO2**	**SD**	**N**	**PE**
4	Kolmogorov's 0-1 law. WLLN's; Khinchine's Theorem. Kolmogorov's inequality, Kolmogorov's sufficiency condition for SLLN, Kolmogorov's SLLN (only statement) The central limit Theorem, Liapounov's Theorem, statement of the Lindberg-Feller Theorem, Khinchine's Theorem	16	25	1, 2, 3,4.	CO8	**PSO1** **PSO2**	**SD**	**N**	**PE**

Reference Books

1.	**Loeve, M.: *Probability Theory*.**
2.	**Billingsley,P.(1988) : Probability and Measure, Wiley.**
3.	**Kingman, J.F.C. and Taylor, S.J.(1966) : Introduction to Measure and Probability, Cambridge University Press. ..**
4.	**Modern Probability Theory : B R Bhat, New Age International (P) Ltd.**
5	**An introduction to probability and Statistics (2nd edition) by V K Rohatgi and A K Md Ehsanes Saleh**

Bloom's Taxonomy Levels: 1. Remember 2. Understand 3. Application 4. Analysis 5. Evaluation 6. Creation

	The Maharaja Sayajirao University of Baroda **Faculty of Science** **Department of Statistics**		**Academic Year**	**2019-20**
M.Sc. in Statistics: Regular Programme				
Year	I	Core Course **STA2202C11 Sampling Theory**	**Credits**	**03**
Semester	II	Year of Introduction: 2012 Year of Syllabus Revision: -	**Maximum Marks**	**100**
Mode of Transaction	Lectures and Tutorials			

Course Outcomes

After going through this course, the students will acquire

CO1 understanding of Unified sampling theory, best linear estimator such as Horvitz Thomson estimator, Yates grundi estimators
CO2 understanding of equal and varying probability sampling, various methods of varying probability sampling, pps in stratified sampling method
CO3 understanding of Two stage sampling, multi stage sampling
CO4 understanding of the need of ratio estimator, product estimator and their biases.
CO5 understanding of the difference estimator, regression estimator.

Unit No.	**Topic/Unit**	**Contact Hours**	**Weightage (%)**	**BT Level**	**CO**	**PSO**	**Elements of** Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	**Relevance to** Local (L)/ National (N)/ Regional®/Global (G) development al needs	**Relation to** Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)

Unit-I	Unified sampling theory, best linear estimator, Horvitz-Thompson estimator, its variance and variance estimators due to HT and YGS. Varying probability sampling: (PPS sampling): sampling in case of unstratified population with replacement, estimation of population mean and population total, its variance and estimator of the variance. Gain due to PPS sampling, procedure of selecting PPS sample (Cumulative total method, Lahiri's method, split method). Sampling from stratified population, allocation of sample size to various strata, interpenetrating sub-sampling.	**20**	**40**	**1, 2, 3, 4**	**C01 C02**		**SD**	**G**	**PE**
Unit-II	Two-stage sampling: Sampling procedure, estimation and sampling variance. Two-stage sampling with SRS, SRSWOR at both the stages, Estimation of population mean, multistage sampling & multiphase sampling.	**10**	**25**	**1, 2, 3, 4**	**C03**		**SD**	**G**	**PE**
Unit-III	Use of supplementary information at estimation stage: Ratio estimator: Need for ratio estimator, bias of estimator, MSE, Variance, Ratio method of estimation for population mean and total. (For basic sampling schemes: SRS, systematic, varying probability (PPSWR), stratified sampling). Almost unbiased ratio estimator, unbiased ratio type estimator.Difference and regression estimators, (Bias and Variance for interpenetrating sub-sampling, SRS)	**15**	**35**	**1, 2, 3, 4**	**C04 C05**		**SD**	**G**	**PE**

REFERENCES :

1. M.N.Murthy: *Sampling Theory and Methods*
2. Sukhatme P.V. & Sukhatme B.V.: *Sampling theory of surveys with applications*
3. Desraj: *Sampling Theory*
4. Clase, Magus Cassel: *Foundations of Inference in Survey Sampling*
5. Kish L.: *Survey Sampling*

	The Maharaja Sayajirao University of Baroda Faculty of Science Department of Statistics							Academic Year	2019-20
M.Sc. in Statistics: Regular Programme									
Year	II	Core Course **STA2203C12 Multivariate Analysis-II**						**Credits**	**03**
Semester	I	Year of Introduction: 2012 Year of Syllabus Revision: -						**Maximum Marks**	**100**
Mode of Transaction	Lectures and Tutorials								

Course Outcomes

After going through this course, the students will acquire

CO1 good understanding of issues involved in doing inference for multivariate distribution.
CO2 knowledge of estimation of the parameters of multivariate normal distribution and can test hypothesis concerning population mean vector(s) involving one sample or two independent samples.
CO3 knowledge of multivariate variant of Fisher-Behren problem and strategy for its solution.
CO4 skills to analyze repeated measurement data.
CO5 Knowledge and skills to carry out dimensionality reduction using techniques such as Principal component Analysis
CO6 knowledge and skills to develop regression models that uses the principal components (PCR)
C07 good understanding and skills to perform multivariate analysis of variance.
C08 Knowledge of developing linear models for multivariate response data.

Unit No.	**Topic/Unit**	**Contact Hours**	**Weightage (%)**	**BT Level**	**CO**	**PSO**	**Elements of** Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	**Relevance to** Local (L)/ National (N)/ Regional(R)/ Global (G) development al needs	**Relation to** Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)

1.	Hotelling's T^2 statistic: Definition of T^2 Statistics, its distribution, Properties and computation. Tests of hypothesis on mean, Simultaneous inference for mean, Case of two samples, Analysis of repeated measurements, Multiple comparison, Profile analysis for two independent groups, Fisher-Behren problem in multivariate case, Test of symmetry of organs, The power of the tests on mean vectors, Some tests with known covariance matrices, Samples with incomplete data	20	45	**1, 2, 3**	**1, 2, 3, 4**	**1,2,3, 5,7**	**Emp, SD**	**N, G**	**PE**
2.	The principal components: The principal components of multivariate observations, its geometrical meaning, Computations, interpretation, principal components of some patterned matrices, Sampling properties of principal components, principal component regression.	15	30	**1, 2, 3, 4**	**5, 6**	**1,2,3, 5,8,9**	**Emp SD**	**N, G**	**PE**
3.	The multivariate Analysis of variance: The multivariate general linear model, The multivariate analysis of variance, Curve fitting for repeated measurements	10	25	**2, 3, 4**	**7, 8**	**1,2,3, 6,7,8**	**Emp, SD**	**N, G**	**PE**
	References								
	1. D.F. Morrison (2004): Multivariate Statistical Methods, 4E, Duxbury Press. 2. Anderson T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3E, Wiley. 3. Kshirsagar A.M. (1972): Multivariate Analysis, Marcel Dekker 4. Rao C.R.(2009): Linear Statistical Inference & its Applications, 2E, Wiley 5. Draper and Smith (1998): Applied regression Analysis, 3E, Wiley								

Bloom's Taxonomy Levels: 1. Remember 2. Understand 3. Application 4. Analysis 5. Evaluation 6. Creation

	The Maharaja Sayajirao University of Baroda **Faculty of Science** **Department of Statistics**		**Academic Year**	**2020-21**
M.Sc. in Statistics: Regular Programme				
Year	**I**	Core Course **STA2213C19: Programming in Python**	**Credits / Hours per week**	**04**
Semester	**II**	Year of Introduction: 2017-18	**Maximum Marks / Grade**	**100**
Mode of Transaction	Lectures			

Course Outcome (CO) **STA2209C18**

This course will enable students to

CO1 understand the basics of Python language, use of different editors

CO2 understand various basic data structures in Python

CO3 understand use control structures and loops in Python

CO4 understand use of built-in functions from different Python libraries and modules

CO5 develop user-defined functions and using them

CO6 develop custom modules in Python

CO7 read data from files and write the output to the file

CO8 understand the concept of Object oriented programming in Python

CO9 learn creating own class, concepts of inheritance and polymorphism

CO10 understand the concept of Scientific computing using Python

CO11 study the basics of SciPy, NumPy, pandas and matplotlib

CO12 understanding and creating arrays and operations on arrays

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/ Global (G) developmental needs	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)
1	Introduction to Python – creating and running python programs, Data types in Python, variables and variable naming. Collection data types – sequence types, set types. Python statements – Assignment, Control structures – Conditional branching and loops. List comprehensions, Dict comprehensions; iterators, iterables and generators.	15	25	2, 3, 4	CO1, CO2, CO3,	**3, 4, 5, 6, 8, 9, 10, 11**	**Emp, SD**	**N, R, G**	**PE**
2	Library functions and user defined functions, Local and recursive functions, Lambda functions. Exception handling. Python Modules and packages – importing a module/ package in a Python program, Developing custom modules and packages. Overview of Python's standard library – string handling, mathematics and numbers, Times and Dates, File, Directory and Process handling.	10	25	2, 3, 4, 5, 6	CO4, CO5, CO6, CO7	**3, 4, 5, 6, 8, 9, 10, 11**	**Emp, SD**	**N, R, G**	**PE**
3	Object Oriented Programming : Object Oriented concepts and terminology, defining classes – attributes and methods. Inheritance, understanding and using access control, multiple inheritance, polymorphism Creating collection classes.	10	25	2, 3, 4, 5, 6	CO8, CO9	**3, 4, 5, 6, 8, 9, 10, 11**	**Emp, SD**	**N, R, G**	**PE**

	Debugging, testing and Profiling Python code								
4	Introduction to essential python libraries for scientific computing – NumPy, pandas, matplotlib, SciPy; Introducing Jupyter notebooks Arrays and vectorized computation using NumPy, creating ndarrays, operations on arrays, element-wise array functions, Mathematical and Statistical methods, File I/O, random number generation.	10	25	2, 3, 4, 5, 6	CO10, CO11, CO12	**3, 4, 5, 6, 8, 9, 10, 11**	**Emp, SD**	**N, R, G**	**PE**

Reference Books

1.	Mark Summerfield (2010):Programming in Python 3, 2E, Addison-Wesley.
2.	Francisco J. Blanco-Silva (2013)Learning SciPy for Numerical and Scientific Computing, Packt Publishing

	The Maharaja Sayajirao University of Baroda **Faculty of Science** **Department of Statistics**		**Academic Year**	**2019-20**
M.Sc. in Statistics: Regular Programme				
Year	II	Elective Course **STA2001E23-Operations Research-I**	**Credits**	**02**
Semester	I	Year of Introduction: 2018-19 Year of Syllabus Revision: -	**Maximum Marks**	**50**
Mode of Transaction	Lectures and Tutorials			

Course Outcomes

After going through this course, the students will

C01: understand the difference between deterministic and stochastic models.

C02: acquire knowledge about various deterministic models of inventory control.

C03: acquire knowledge about various stochastic inventory control models.

C04: be able to model real life data using inventory control.

C05: be able to understand queuing theory as an application of stochastic process.

C06: be able to develop various queuing models.

C07: be able to model real life data using queuing theory.

Unit No.	**Topic/Unit**	**Contact Hours**	**Weightage (%)**	**BT Level**	**CO**	**PSO**	**Elements of** Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	**Relevance to** Local (L)/ National (N)/ Regional(R)/ Global (G) developmental needs	**Relation to** Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)

1	Inventory Theory: Components of inventory models; Deterministic Models - continuous review and uniform demand models with or without shortages, models with quantity discounts; periodic review and production planning: A general model - dynamic programming solution, integer programming formulation. Stochastic Models: single period model with no set up cost, single period model with set up cost ((s, S) policy), a two-period model with no set up cost, multi-period model with no set up cost.	15	50	1 2 3	C01 C02 C03 C04	**1,23,5**	**Emp,SD**	**G**	**PE**
2	Queuing Theory: The basic queuing process, models based on birth and death process: The basic model (constant arrival and service rates), the basic model with a finite queue, the basic model with a limited resource. Multi-server models, A model with state dependent arrival and service rates, models involving non-exponential distribution. Applications of queuing theory.	15	50	1 2 3	C05 C06 C07	**1,2,3, 5,7**	**Emp,SD**	**G**	**PE**
	References								
1	Hillier and Lieberman: Operations Research								
2	Sasieni, Yaspan and Friedman: Operations Research - Methods and Problems.								
3	T. L. Satty (1961): Elements of queuing theory with applications, McGraw Hill.								
4	Hadly G., and Whitin T, M. (1963) Analysis of Inventory Systems, Prentice Hall.								
5	Starr M. K. and Miler D. W. (1962) Inventory Control - Theory and Practice, Prentice Hall.								

	The Maharaja Sayajirao University of Baroda Faculty of Science Department of Statistics		Academic Year	2019-20
M.Sc. in Statistics: Regular Programme				
Year	II	Core Course **STA2301C20 Stochastic processes-I**	**Credits**	**04**
Semester	III	Year of Introduction: 2018-19 Year of Syllabus Revision: -	**Maximum Marks**	**100**
Mode of Transaction	Lectures and Tutorials			

Course Outcomes

After going through this course, the students will understand

CO1 The stochastic events and processes
CO2 The general dependence of random processes and phenomena
CO3 How the states of a process depends on the time of its occurrence
CO4 The importance of Transition probability matrix and their uses in generating joint and conditional probabilities
CO5 The Markov property, Markov process, and Markov chains
CO6 The processes where discrete time discrete state space processes like Markov process, Random walk, Branching process, Martingales etc.

Unit No.	**Topic/Unit**	**Contact Hours**	**Weightage (%)**	**BT Level**	**CO**	**PSO**	**Elements of** Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	**Relevance to** Local (L)/ National (N)/ Regional(R)/ Global (G) development al needs	**Relation to** Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)
1	Definition of a stochastic process, classification according to the nature of index set and state-space, use of Kolmogorov's consistency Theorem in defining a stochastic process.	**25**	**40**	**1,2,3,4, 5,6**	**CO1 CO2 CO3 CO4**				

	Markov chains with stationary transition probabilities, classification of states: essential states, recurrent states, positive recurrent states.								
2	Limiting behaviour of transition probabilities, existence of stationary initial distributions, absorption probabilities. Random walk, Gambler's ruin.	**20**	**35**	**1,2,3,4, 5,6**	**CO3 CO4 CO5**				
3	Branching processes- probability of extinction, critical processes and branching processes with immigration and Martingales.	**15**	**25**		**CO5 CO6**				

References:

1. Loeve: *Probability Theory*
2. Karlin and Taylor: *A first course in stochastic processes*, 2nd edition.
3. Feller: *Introduction to Probability Theory and its Applications*, Volume 1

	The Maharaja Sayajirao University of Baroda Faculty of Science Department of Statistics			Academic Year	2019-20
M.Sc. in Statistics: Regular Programme					
Year	II	Core Course **STA2303C22- Design of Experiments**		**Credits**	**03**
Semester	I	Year of Introduction: 2013 Year of Syllabus Revision: -		**Maximum Marks**	**100**
Mode of Transaction	Lectures and Tutorials				

Course Outcomes

After going through this course, the students will

C01: understand the concept of complete and incomplete block designs.

C02: understand connectedness, balancedness and orthogonality in context of block designs.

C03: understand the difference between intra and interblock analysis.

C04: be able to analyse and interpret BIBD and PBIBD.

C05:be able to analyse and interpret Response surface design and repeated measure designs.

C06: understand concept of factorial designs, also the concept of total confounding and partial confounding in factorial design.

C07: be able to analyse and interpret 3^K full factorial and confounded factorial designs.

C08: be able to use appropriate designs to the experimental data.

Unit No.	**Topic/Unit**	**Contact Hours**	**Weightage (%)**	**BT Level**	**CO**	**PSO**	**Elements of** Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	**Relevance to** Local (L)/ National (N)/ Regional(R)/ Global (G) developmental needs	**Relation to** Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)

1	General Block Design and its information matrix, connectednes balance and orthogonality, intra block analysis(estimablity, bes point/interval estimates, testing of linear hypothesis).	10	25	1 2 3	C01 C02 C03	**PS01 PS02 PS03 PS08 PS011**	**SD**	**G**	**PE**
2	Intra block and inter block analysis of BIBD. Intra Block and inter block analysis of PBIBD.	15	25	2 3 4	C04 C05 C09	**PS01 PS02 PS03 PS08 PS011**	**SD**	**G**	**PE**
3	Analysis of Response surface design and method of steepest ascent. Analysis of repeated measurement designs (first order residual effects)	10	25	2 3 4	C06 C09	**PS01 PS02 PS03 PS08 PS011**	**Emp**	**G**	**PE**
4	Analysis of 3^m factorial and confounded 3^m factorial designs.	10	25	2 3 4	C07 C08 C09	**PS01 PS02 PS03 PS08 PS011**	**Emp**	**G**	**PE**
	REFERENCES: 1. M.N.Das & N.C.Giri: Construction & Analysis of experiments 2nd edition, Wiley Eastern Ltd., 1986. 2. D.D.Joshi : Linear estimation & Design of Experiments., Wiley Eastern Ltd., New Delhi, 1987. 3.Alok Dey(1986) : Theory of block designs, Wiley Eastern. 4.Khuria, A. and Cornell,M. (1991) Response Surface Methodology, Marcel Dekker. 5.Cornell M. (1963) Mixture Experiments, Wiley.								

	The Maharaja Sayajirao University of Baroda Faculty of Science Department of Statistics			Academic Year	2019-20
M.Sc. in Statistics: Regular Programme					
Year	2	**STA2307E05: Six Sigma for Quality Improvement**		**Credits**	**04**
Semester	I	Year of Introduction: Year of Syllabus Revision: -		**Maximum Marks**	**100**
Mode of Transaction	Lectures and Tutorials				

Course Outcomes

After going through this course, the students will acquire

CO1 understanding of the basic concept of probability and the approach of its theoretical development
CO2 ability to distinguish between random and non-random experiments
CO3 fundamental understanding of concept of probability as a tool for modelling data
CO4 understanding of the notion of conditional probability including the concept of Bayes' Theorem
CO5 ability to distinguish between independent & dependent event
CO6 gain the knowledge related to concept of discrete and continuous random variables
CO7 ability to identify random variables from real life, and develop the understanding of the probability distribution of random variables
CO8 ability to establish the joint, marginal and conditional probability distribution of random variables
CO9 fundamental understanding of relating probability theory with descriptive statistics and inference

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/ Global (G) developmental needs	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)

1	Quality concepts (Deming, Juran, Philip Crosby and Tagucchi), Overview of Six Sigma Methodology, Review Strategies for effectively implementing six sigma in an organization, Understanding of Deployment Strategies – Business Goals/ Dashboards/ Balance Business Score Card or Customer Goals including linkages with financial goals, Executive and other roles and responsibilities in Six Sigma implementation, Over view of Six Sigma Project execution (DMAIC or DFSS/ DMADV) (Define-Measure- Analyze- Improve & Control, Design for Six Sigma, Define Measure Analyse Design and Validate), Voice of Customer & Quality Function Deployment	**10**	**20**		**CO1** **CO2** **CO3**	**PSO1** **PSO2** **PSO3** **PSO4** **PSO5** **PSO6** **PSO7** **PSO8**	**SD** **ENT** **EMP**	L N R G	**ES** **HV** **PE**
2	Prioritization Matrix and FMEA and use of it in Data Collection Planning, Type of Data, Measurement System Evaluation (Gauge R&R) for variables as well as for attribute measurements (Kappa Value and Confidence interval for agreement with expert), Understanding variations: special causes vs. common causes (like dot plots, box plots, histogram and control charts, Stratification methods (like Pareto, Bar Diagrams, stratified dot plot, stratified scatter plot, Box Plot, Multi Vari Charts etc), Normality test of a data, evaluation of Process Capability for data from a Normal distribution and concept of confidence interval, Evaluation of Process Capability for Data from Normal Distribution and Concept of Short Term, Long Term Process, Capability and assessment of Sigma level, knowledge of Statistical distributions.	**20**	**30**		**CO4** **CO5** **CO2** **CO3** **CO6** **CO7** **CO8**	**PSO2** **PSO3** **PSO4** **PSO5** **PSO6** **PSO7** **PSO8** **PSO9**	**SD** **ENT** **EMP**	L N R G	**ES** **HV** **PE**
3	Identification of value added and non value added activities (use of lean concept) & Value Stream Mapping, Organizing for potential causes using cause and effect diagram, FMEA & Tree Diagram, Verification/validation of causes using work place investigation (GEMBA), Correlation and simple & multiple regression and use of the same in validating cause, Estimation &Test of Hypothesis and use of the	**20**	**30**		**CO2** **CO3** **CO6** **CO7** **CO8** **CO9**	**PSO1** **PSO2** **PSO3** **PSO4** **PSO5** **PSO6** **PSO7** **PSO8**	**SD** **ENT** **EMP**	L N R G	**ES** **HV** **PE**

	same in validating the causes, Logistic regression and use of the same in validating the cause, Design of experiment and details of full factorial, fractional factorial and screening design, Reliability Theory, Pugh Matrix, TRIZ, Fault Tree Analysis.								
4	Taguchi Methods of Parameter Design and Tolerance Analysis, Exploratory Data Analysis, Multivariate Analysis, Process of piloting the solutions& Risk Analysis through use of FMEA or related methodologies, Concept and Examples of Poke Yoke, Visual Workplace and 5S, Monitoring the results through statistical Process Control (like Control Charts, Pre-Control Charts etc) after implementation of the solutions & Monitoring the results as a part of established QMS and Institutionalization and integration of the solutions, Process of Closing the Project, Work through a sample six sigma project.	**10**	**20**		**CO6** **CO7** **CO8** **CO9**	**PSO4** **PSO5** **PSO6** **PSO7** **PSO8**	**SD** **ENT** **EMP**	L N R G	**ES** **HV** **PE**

References:

1. Muralidharan, K. (2015). Six Sigma for Quality improvement, Springer Nature, India.
2. Feigenbaum, A. (1991). Total Quality Control, 3rd ed. revised, McGraw-Hill, New York.
3. Kubiak, T. M. and Benbow, D. W. (2010). The Certified Six Sigma Black Belt Handbook, 2nd ed., Dorling Kindersley (India) Pvt. Ltd.
4. Pande, P. S. Newuman, R. P. And Cavanagh, R.R. (2003). The Six Sigma way. Tata McGraw Hill, New Delhi.
5. Crosby, P. (1979). Quality is Free, McGraw-Hill, New York.
6. Montegomory, D. C. (2003). Introduction to Statistical Quality Control, Wiley India.
7. Juran, J. M., and F. M. Gryna, Jr. (1980). Quality planning and analysis, 2nd ed., McGraw-Hill, New York.

Bloom's Taxonomy Levels: 1. Remember 2. Understand 3. Application 4. Analysis 5. Evaluation 6. Creation

	The Maharaja Sayajirao University of Baroda **Faculty of Science** **Department of Statistics**		**Academic Year**	**2019-20**
M.Sc. in Statistics: Regular Programme				
Year	**II**	Elective Course **STA2311E09 Advanced R Programming**	**Credits / Hours per week**	**03**
Semester	**I**	Year of Introduction: 2018-19 Year of Syllabus Revision:	**Maximum Marks / Grade**	**100**
Mode of Transaction	Lectures			

Course Outcome (CO) STA2311E09

After studying this course students will acquire the ability

CO1 to use built-in R functions for multivariate analysis

CO2 to use built-in R functions for time series analysis

CO3 to use built-in R functions for statistical quality control

CO4 create user-defined functions and using them

CO5 to define control structures and loops in R

CO6 to use R functions for debugging and tracing the code

CO7 to understand object oriented programming in R

CO8 to learn Interface of R with C

CO9 to learn how to contribute to R through defining own methods and functions / packages

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/ Global (G) development al needs	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)
1	Multivariate analysis of variance, analysing data from repeated measures designs. Creating and viewing time-series, analysing time-series data, ARIMA modelling. Quality control charts - Shewhart charts, Cusum charts, Process capability. Writing functions in R: functions and names, arguments, function body, return values and side effects; using user defined functions; Extraction and replacement functions.	15	35	2, 3, 4	CO1, CO2, CO3, CO4	**3, 4, 5, 6, 8, 9, 10, 11**	**Emp, SD**	**N, R, G**	**PE**
2	Control structures: if, if...else, ifelse, switch, while, repeat, for, break, next, stop.Error handling using traceback function, wrap-up using on.exit function. Debugging the R code: error messages, printing intermediate results, inspecting the execution and interactive debugging, browser function, debugger function, trace function. Creating function libraries- library function, attaching and detaching the libraries.	15	35	2, 3, 4, 5, 6	CO5, CO6	**3, 4, 5, 6, 8, 9, 10, 11**	**Emp, SD**	**N, R, G**	**PE**

3	OOP in R: Generic functions, classes and methods, public and private view of methods, defining new classes, group methods, replacement methods. Interfacing with C: Calling C routines from R, Writing C routines suitable for use in R; Calling R from C, Using DLLs. Obtaining contributed R code from the Internet.	15	30	2, 3, 4, 5, 6	CO7, CO8, CO9	**3, 4, 5, 6, 8, 9, 10, 11**	**Emp, SD**	**N, R, G**	**PE**

Reference Books

1.	Chambers J. M. (1998): Programming with Data: A guide to S language, Springer.
2.	Venables W N and Ripley B D (2000): S Programming, Springer
3.	Everitt B. S. (1994): A handbook of Statistical Analysis using S-Plus, Chapman & Hall.
4.	Venables W N and Ripley B D (1999): Modern Applied Statistics with S-Plus, 3e, Springer.
5.	S-PLUS 2000 Programmer's Guide, Data Analysis Products Division, MathSoft Inc., WA.

	The Maharaja Sayajirao University of Baroda Faculty of Science Department of Statistics			Academic Year	2020-21
M.Sc. in Statistics: Regular Programme					
Year	II	Elective Course **STA2324E22 Data Analysis using Python**		**Credits**	**03**
Semester	I	Year of Introduction: 2017-18 Year of Syllabus Revision:		**Maximum Marks**	**100**
Mode of Transaction	Lectures and Tutorials				

Course Outcomes

At the end of the course

CO1 Student will be able to manage packages in local Python installation
CO2 Student will have knowledge of the scipy ecosystem of Python packages
CO3 Student will be able to perform numerical computations using numpy functionality
CO4 Student will be able to acquire data from various data sources into Python data structures
CO5 Student will be able to preprocess data using pandas package and other Python tools
CO6 Student will be able to generate data visualizations using matplotlib, Seaborn and other visualizations tools of Python
CO7 Student will be able to carry out data analysis using various tools in Python
CO8 Student will be able to share their work with others using Jupyter notebook.

Unit No.	**Topic/Unit**	**Contact Hours**	**Weightage (%)**	**BT Level**	**CO**	**PSO**	**Elements of** Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	**Relevance to** Local (L)/ National (N)/ Regional(R)/ Global (G) developmental needs	**Relation to** Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)

1	Pandas: Introduction to pandas data structures – Series, DataFrame, Index Objects, Applying functions, mapping. Computing descriptive statistics, Handling missing data, hierarchical indexing Data Aggregations and Group operations, Pivot tables and cross tabulations.	**15**	**25**	**1, 2**	**1, 2, 3, 4, 8**		**SD**		
2	Combining and merging datasets, reshaping and pivoting, Data transformation, string manipulation. Importing data in python – text files, proprietary file types: Excel, SAS, SPSS, etc., Interacting with databases; importing files from internet, importing data using web APIs, A brief introduction to web scraping using Beautiful Soup library. Loading large files into memory, processing large amounts of data, using iterators/ generators to load and process data in chunks, Working with streaming data. Exporting data from Python.	**10**	**25**	**1, 2, 3, 4**	**4, 5**		**Emp** **SD**	**N, G**	
3	Plotting and visualization using matplotlib, plotting functions in pandas. Introduction to Seaborn library for statistical data visualization, visualization statistical relations, Visualizing the distribution of a dataset, building multi-plot grids; Controlling plot aesthetics. A brief introduction to development of dashboards	**10**	**25**	**2, 3, 4**	**6, 7**		**Emp** **SD**	**N, G**	

	using dash framework.								
4	Time series data – Date and Time data types and tools, data ranges, frequencies and shifting data, Time zone handling. Periods, and period arithmetic, resampling; Moving window functions Fitting various statistical models through the modeling tools of StatModels module.	**10**	**25**	**1, 2, 3**	**3, 4**		**Emp** **SD**	**N, G**	
	References								
	1. Massaron and Boschetti (2018): Python Data Science Essentials, 3E, Packt Publishing 2. Fandango (2017): Python Data Analysis, 2E, Packt Publishing 3. Wes McKinney (2013): Python for Data Analysis, O'reilly. 4. Nelli, Fabio (2015):Python Data Analytics, Apress 5. https://jakevdp.github.io/PythonDataScienceHandbook/Massaron and Boschetti (2018): Python Data Science Essentials, 3E, Packt Publishing								

	The Maharaja Sayajirao University of Baroda Faculty of Science Department of Statistics	Academic Year	2018-19

M.Sc. in Statistics: Regular Programme

Year	II	Elective Course **STA2327E25 Database Theory and Data Warehousing**	**Credits**	**03**
Semester	I	Year of Introduction: 2018-19 Year of Syllabus Revision:	**Maximum Marks**	**100**
Mode of Transaction	Lectures and Tutorials			

Course Outcomes

After going through this course, the students will acquire

CO1 understanding of the need and importance of Data Sources and Data Management
CO2 fundamental understanding of Databases and Data Warehouses
CO3 ability to extract required data by writing queries in SQL language using a client software
CO4 understanding of the need of Data warehouses and their functionality
CO5 understanding the challenges posed by bigdata
CO6 knowledge of the modern approach for Data warehousing

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/ Global (G) development al needs	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)
1	Database systems: Purpose of database systems, database systems v/s file systems. Relational model: Basic structure, database schema, keys, and query languages, relational algebra. Entity-Relationship model: Entity sets, relationship 33sets, ER	**15**	**33.33**	**1, 2, 3, 4, 6**	**1, 2, 3**		**Emp SD**	**N, G**	

	diagram, deriving relational schema from ER model. SQL: DDL, DML, and DCL components of the language, select from, and where clauses, tuple variables; string operations, aggregate functions, using group by clause, in and not in predicates; delete, insert and update transactions.								
2	Schema definition - create table, drop table, and alter table statements; Data integrity - domain constraints, Referential integrity. Data warehouse: Concept of a data warehouse, Differences between OLTP systems and OLAP systems. Traditional data warehousing - Data Architecture from data warehousing perspective, Data warehousing infrastructure, Architectural approaches; Limitations of traditional approach. Second generation data warehousing – Overview of Innmon's DW 2.0, DSS 2.0.	**15**	**33.33**	**2, 3, 6**	**2, 4**		**Emp** **SD**	**N, G**	
3	Introduction to big data, characteristics of big data, Big data processing architectures. Big data technologies – distributed processing, Hadoop, NoSQL, Textual ETL processing. Reengineering the Data warehouse, modernizing a data warehouse. Understanding data warehouse workloads, Applying new technologies to Data warehousing – Cloud computing, Data virtualization. Integration of Big Data and data warehousing Hadoop and RDBMS, big data appliances; data driven architecture for big data, information management and big data lifecycle. Big data analytics and visualization.	**15**	**33.33**	**2, 4**	**5, 6**		**Emp** **SD**	**L, N**	**ES**
	REFERENCES								
	1. J. D. Ullman , J. Widom (2007): A First Course in Database Systems, 3e, Prentice Hall 2. Krish Krishnan (2013): Data Warehousing in the Age of Big Data, Morgan Kaufmann 3. Inmon et al. (2008): DW 2.0: The Architecture for the Next Generation of Data Warehousing, Morgan Kaufmann. 4. Kimball and Ross (2013): The Data Warehousing Toolkit, 3E, Wiley								

	The Maharaja Sayajirao University of Baroda Faculty of Science Department of Statistics		Academic Year	2019-20
M.Sc. in Statistics: Regular Programme				
Year	II	Core Course **STA2401C26-Stochastic processes-II**	**Credits**	**03**
Semester	IV	Year of Introduction: 2018-19 Year of Syllabus Revision: -	**Maximum Marks**	**100**
Mode of Transaction	Lectures and Tutorials			

Course Outcomes

After going through this course, the students will understand

CO1 The stochastic events and processes
CO2 The general dependence of random processes and phenomena
CO3 How the states of a process depend on the time of their occurrence
CO4 The importance of generating functions in studying the characteristics of processes
CO5 The Continuous time discrete stochastic processes like Poisson Process, Birth and Death process and their applications
CO6 The continuous time continuous state processes like Weiner process and Wide sense stationary processes etc.

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/ Global (G) development al needs	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)
1	Poisson process and its main properties, pure birth process, Yule Process, birth and death process, Linear growth model, application to queues.	**20**	**40**	**1,2,3,4, 5,6**	**CO1 CO2 CO3 CO4**				

					CO5				
2	Renewal processes, renewal equation and renewal Theorem. Processes with stationary and independent increments, the Wiener process and its main properties	**15**	**35**	**1,2,3,4, 5,6**	**CO1 CO2 CO3 CO4 CO5**				
3	Wide sense stationary processes, Mean square ergodic Theorem, linear operators on a stationary process, Statement of the spectral Theorem.	**10**	**25**		**CO3 CO4 CO5 CO6**				

References:

1 Loeve: *Probability Theory*
2 Karlin and Taylor: *A first course in stochastic processes*, 2nd edition
3 Feller: *Introduction to Probability Theory and its Applications*, Volume 1

Bloom's Taxonomy Levels: 1. Remember 2. Understand 3. Application 4. Analysis 5. Evaluation 6. Creation

	The Maharaja Sayajirao University of Baroda **Faculty of Science** **Department of Statistics**		**Academic Year**	**2019-20**
M.Sc. in Statistics: Regular Programme				
Year	**II**	Core Course **STA2403C28 Theory of Hypothesis Testing**	**Credits / Hours per week**	**04**
Semester	**II**	Year of Introduction: 2013 Year of Syllabus Revision:	**Maximum Marks / Grade**	**100**
Mode of Transaction	Lectures			

Course Outcome (CO) **STA2403C28**

This course is framed to equip the students to

CO1 revisit the concepts of hypothesis testing

CO2 the introduction of randomized tests

CO3 learn how to obtain MP tests using fundamental Neyman-Pearson Lemms

CO4 understand the idea of UMP tests and Families of distributions with monotone likelihood ratio

CO5 understand the generalized N-P lemma and hypothesis tests for two-sided hypothesis

CO6 understand the idea of unbiased and similar tests

CO7 understand idea of Completeness and Neyman-Structure tests

CO8 learn how to construct UMP unbiased tests and importance of Basu's theorem

CO9 understand how to construct family of confidence sets

CO10 to understand the concept of sequential analysis, SPRT

CO11 to understand the concept of Invariance and invariant tests of hypotheses

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/ Global (G) development al needs	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)
1	The basic problem of testing, critical region, level, size and power of the test, randomized tests, the Neyman-Pearson Lemma, application to distributions with monotone likelihood ratio, confidence bounds. Statement of generalized Neyman-Pearson lemma, two-sided hypothesis testing	15	25	1, 2, 3, 4	CO1, CO2, CO3, CO4, CO5	PSO1 PSO2	**SD**	**N**	**PE**
2	Unbiased tests, similar tests, relation between a UMP unbiased test and a UMP similar test, application to one parameter exponential family. Similarity and completeness, tests with Neyman structure, application to one parameter and multiparameter exponential families	15	25	2, 3, 4	CO6, CO7	PSO1 PSO2 PSO6	**SD**	**N**	**PE**
3	Construction of UMP unbiased tests, use of Basu's Theorem , application to the normal distribution, unbiased confidence sets	15	25	2, 3, 4	CO8, CO9	PSO1 PSO2 PSO6	**SD**	**N**	**PE**
4	Sequential probability ratio tests (SPRT), power and expected sample size of SPRT, properties of SPRT. Concept of invariance, Symmetry and invariance, Maximal invariants, Most powerful invariant Test, Unbiasedness and invariance	15	25	2, 3, 4	CO10, CO11	PSO1 PSO2 PSO6	**SD**	**N**	**PE**

Reference Books	
1.	Kale B.K A First course in parametric inference.
2.	Lehmann E.L. : Testing Statistical Hypothesis.
3.	Rao C.R. : Linear Statistical Inference and its application

4.	Rohatagi,V.K.:Introduction to probability theory and mathematical Statistics.(1st edition)

	The Maharaja Sayajirao University of Baroda Faculty of Science Department of Statistics	Academic Year	2019-20

M.Sc. in Statistics: Regular Programme

Year	I	**STA2413E33 ECONOMETRICS**	**Credits**	**03**
Semester	I	Year of Introduction: 2013 Year of Syllabus Revision: -	**Maximum Marks**	**100**
Mode of Transaction	Lectures and Tutorials			

Course Outcomes

After going through this course, the students will acquire

CO1 Introductory knowledge of Econometrics. The matrix approach to Linear regression models, assumptions of CLRM

CO2 knowledge of OLS estimation, coefficient of determination

CO3 Hypothesis testing, Analysis of variance, The correlation matrix R.

CO4 Violations of the assumptions of the classical model: The nature of multicollinearity,

CO5 Estimation in the presence of multicollinearity consequences of multicollinearity

CO6 Detection of multicollinearity, Remedial measures

CO7 The nature of heteroscedastcity, Consequences of heteroscedastcity,

CO8 Detection of heteroscedastcity, Remedial measures

CO9 Autocorrelation: The nature of the problem, Consequences of autocorrelation,

C10 detecting autocorrelation, Remedial measures.

Unit No.	topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/ Global (G) development al needs	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and
1	Introduction to Econometrics. The Matrix approach to linear regression model, The assumptions of classical linear regression model, OLS estimation, Coefficient of determination R^2, Hypothesis testing, Analysis of	10	25	1,2,3,	C 01,C 02,C 03	01,04, 07	Emp, Ent, SD	N, R, G	

	variance, The correlation matrix R.								Professional Ethics (PE) HV, PE
2	Violations of the assumptions of the classical model: The nature of multicollinearity, Estimation in the presence of multicollinearity consequences of multicollinearity, Detection of multicollinearity, Remedial measures.	15	25	2,3,4, 5	C 04,C 05 C06	**05,07**	**Emp, Ent, SD**	**N, R, G**	**HV, PE**
3	The nature of heteroscedasticity, Consequences of heteroscedasticity, Detection of heteroscedasticity, Remedial measures.	10	25	1,2,4, 5	C07, C08	**01,05, 07**	**Emp, Ent, SD**	**N, R, G**	**HV, PE**
4	Autocorrelation: The nature of the problem, Consequences of autocorrelation, detecting autocorrelation, Remedial measures. Econometric modeling	10	25	1,2,,4	C 09C1 0	01,05, 07	**Emp, Ent, SD**	**L, R, N, G**	**PE**

Reference Books

1. Guajarati D.N., Dawn C Porter Sangeetha Gunasekar: Basic Econometrics, McGraw Hill. 5th Edition
2. J. Johnston: *Econometric Methods* (1985), Mc-Graw Hill.
3. Klein, L.R. (1962): An introduction to Econometrics, Prentice Hall of India.

	The Maharaja Sayajirao University of Baroda Faculty of Science Department of Statistics			Academic Year	2019-20
M.Sc. in Statistics: Regular Programme					
Year	II	**STA2418E38 Machine Learning**		**Credits**	**04**
Semester	I	Year of Introduction: 2018-19 Year of Syllabus Revision: -		**Maximum Marks**	**100**
Mode of Transaction	Lectures and Tutorials				

Course Outcomes

After going through this course, the students will acquire

CO1 Student has knowledge of the basic concepts of Machine Learning
C02 Student has knowledge about the potential applications of ML and also its limitations
C03 Student knows different types of ML models viz. supervised learning, unsupervised learning and Reinforcement learning.
C04 Student knows the Theory behind different supervised learning models and also knows how to apply using sci-kit learn library of Python
C05 Student knows the Theory behind different unsupervised learning models and also knows how to apply using sci-kit learn library of Python
C06 Student understands and is able to apply the ML methods based on Neural Networks
C07 Student knows different approaches to evaluate and improve the ML models
C08 Student has basic understanding of Deep Learning methods

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/ Global (G) developmental needs	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)

1	Machine Learning Basics Concept of Machine Learning, Artificial intelligence (AI), Machine learning as a subfield of AI, Limits of ML, Machine learning and Data mining. Learning methods – Supervised learning, Unsupervised learning, Reinforcement learning, Black box methods; Deep learning vs shallow learning PAC Learning, Regression – Linear Regression, Fitting regression models, Dealing with qualitative predictors. Classification – K-nearest neighbors, Logistic regression, Multi-class predictors, A Naïve Bayes classifier, The Fisher method, Feature detection – finding independent features.	**15**	**25**	**1, 2, 3, 4, 6**	**1, 2, 3, 4**		**Emp SD**	**N, R, G**	
2	Decision Tree modeling – Classification Tree, Training the tree, Tree building Tree pruning; Regression Trees. Linear discriminant analysis (LDA) Model selection: Subset selection, Regularization; Dimension reduction methods – PCR, dealing with high-dimensional data Cross Validation – Leave-One-Out cross validation, k-fold cross validation, Bias-Variance trade-off for k-fold cross validation, Bootstrap methods. Assessment of model accuracy – Measuring the quality of fit	**15**	**25**	**2, 3, 4, 5, 6**	**4, 7**		**Emp SD**	**N, R, G**	
3	Association rules – The apriori algorithm, generalized association rules Cluster Analysis: K-Means clustering, Hierarchical clustering,	**15**	**25**	**2, 3, 4, 6**	**3, 5**		**Emp SD**	**N, R, G**	

	Principal component analysis, Principal Curves and surfaces Kernel methods: Kernels as a Way to Express Prior Knowledge, Kernel Machines								
4	Support Vector Machines (SVM) – Maximal margin classifier, Support vector classifiers, SVM and Kernels Neural networks – Introduction, Perceptrons, Multilayer perceptrons, Backpropagation Algorithm, Bayesian Neural networks Model Improvements – Bagging and boosting Deep Learning – Introduction, Deep Generative models, Deep neural networks	**15**	**25**	**2, 3, 4**	**3, 4, 6, 7, 8**		**Emp SD**	**N, R, G**	
	References								
	1. James et al. (2013): An Introduction to Statistical learning: With applications in R, Springer 2. Alpaydin (2010): Introduction to Machine learning, 2E, MIT Press 3. Bowles (2015): Machine Learning in Python, Wiley								

	The Maharaja Sayajirao University of Baroda Faculty of Science Department of Statistics			Academic Year	2020-21
M.Sc. in Statistics: Regular Programme					
Year	II	Elective Course **STA2422E34 Statistical Pattern Recognition**		**Credits**	**03**
Semester	IV	Year of Introduction: 2021 (Due to progressive implementation) Year of Syllabus Revision: -		**Maximum Marks**	**100**
Mode of Transaction	Lectures and Tutorials				

Course Outcomes

After going through this course, the students will

C01: develop understanding for pattern recognition problem and how to formulate the problem
C02: will develop various statistical approaches for pattern recognition problem
C03: will develop understanding for various fields related to pattern recognition problem
C04: will be able to estimate the density using various algorithm by parametric approach
C05: will be able to estimate the density using non parametric approaches
C06: will be able to classify a data using supervised as well unsupervised learning
C07: understand the use of moment invariants in pattern recognition
C08: will develop understanding for markov models and hidden markov models
C09: be able to use various algorithm for solving sequential data in pattern recognition
C10: be able to apply above techniques for real life data.

Unit No.	**Topic/Unit**	**Contact Hours**	**Weightage (%)**	**BT Level**	**CO**	**PSO**	**Elements of** Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	**Relevance to** Local (L)/ National (N)/ Regional(R)/ Global (G) developmental needs	**Relation to** Gender (G), Environment and Sustainability (ES), Human Values (HV)and Professional Ethics (PE)

1	The pattern recognition problem, formulation of pattern recognition problems, pattern recognition systems, approaches to statistical pattern recognition. Field related to pattern recognition – Artificial Intelligence, Machine Learning, image analysis. Density estimation: parametric approach – a quick review MLE, EM algorithm, Bayesian estimation, Markov Chain Monte Carlo method – Gibbs Sampling, Metropolis-Hastings algorithm.	15	35	2 3 4	C01 C02 C03 C04 C10	**PS01 PS02 PS04 PS08 PS10 PS11**	**Emp**	**G**	**PE**
2	Nonparametric density estimation – Bayesian belief networks, KNN method, Kernel density estimation. Supervised and unsupervised learning, Supervised learning – classification problem, regression problem. Unsupervised Learning – clustering problem: partition methods – k-means clustering, k-medoid clustering; Hierarchical methods – Agglomerative algorithms: single linkage algorithm, complete linkage algorithm; evaluation of clustering.	20	35	2 3 4	C05 C06 C10	**PS01 PS02 PS04 PS08 PS10 PS11**	**SD**	**G**	**PE**

3	Use of moment invariants in pattern recognition. Pattern recognition for sequential data - Markov models, Hidden Markov models – MLE, forward-backward algorithm, sum-product algorithm Viterbi algorithm. Applications of various tools and techniques covered in the curriculum. Case studies.	10	30	2 3 4 5	C07 C08 C09 C10	**PS01** **PS02** **PS04** **PS08** **PS10** **PS11**	**SD**	**G**	**PE**

REFERENCES:35

1. R. O. Duda and P.E. Hart (2001): Pattern recognition and scene analysis,2E, Wiley
2. K. Fukunaga (1990): Introduction to statistical pattern recognition, 2e, AP
3. Andrew R. Webb (2002): Statistical Pattern Recognition, 2E, John Wiley and Sons.
4. B. D. Ripley (1996): Pattern Recognition and Neural Networks, Cambridge university Press.
5. Ming Kuei Hu: Visual pattern recognition by moment invariants, IRS transactions on information theory.
6. L R Rabiner (1989): Atutorial on Hidden Markov Models and selected applications in speech recognition., Proceedings of IEEE, 77(2), 257-286.

Bloom's Taxonomy Levels: 1. Remember 2. Understand 3. Application 4. Analysis 5. Evaluation 6. Creation

	The Maharaja Sayajirao University of Baroda **Faculty of Science** **Department of Statistics**		**Academic Year**	**2019-20**
M.Sc. in Statistics: Regular Programme				
Year	**I/II**	Elective Course **STA2003E27 - Numerical Methods**	**Credits / Hours per week**	**03**
Semester	**I/II**	Year of Introduction: 2018-19 Year of Syllabus Revision:	**Maximum Marks / Grade**	**100**
Mode of Transaction	Lectures			

Course Outcome (CO) STA2003E27

This course is framed to equip the students to

CO1 understand the computer representation of numbers

CO2 understand the types and causes of errors in numeric computations

CO3 understand the propagation of errors in basic arithmetic operations

CO4 understand the use of process graphs for approximating the errors in computations

CO5 understand the problem of interpolation and Lagrange interpolation method

CO6 understand the need of numerical integration

CO7 Newton-Cotes formulae for numerical intergration

CO8 learn how to find roots of an equation using Newton-Raphson and Regula Falsi method

CO9 study solving the system of homogeneous and Nonhomogeneous system of equations using Gauss Elimination, Gauss Jordan and Gauss-Seidel methods

CO10 Triangularize a matrix using Householder's and Modified Gram-Schmidt methods

CO11 develop R/Python codes for each technique

Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/ Global (G) developmental needs	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)
1	Representation of numbers in computer, fixed point and floating point arithmetic; Errors in numeric computations, error analysis using process graphs. Error formula for the interpolating polynomial, Lagranges interpolation formula, uniform spacing interpolation.	15	30	1, 2, 3	CO1, CO2, CO3, CO4, CO5, CO11	**3, 4, 5, 6, 8, 9, 10, 11**	**Emp, SD**	**N, R, G**	**ES, PE**
2	Numerical integration: need, Newton-Cote's quadrature, Romberg integration. Numerical solution to equations: Review of Newton-Raphson method&, regula falsi method, their applications in statistical computations; method of synthetic division for finding zeros of polynomials.	15	30	2, 3, 4, 5	CO6, CO7, CO8, CO11	**3, 4, 5, 6, 8, 9, 10, 11**	**Emp, SD**	**N, R, G**	**ES, PE**
3	Solving a system of linear equations- Gauss elimination method, Gauss-Seidal method, matrix inversion. Triangularization of matrices - Using Householder transformations, Using modified Gram-Schmidt method.	15	40	2, 3, 4, 5, 6	CO9, CO10, CO11	**3, 4, 5, 6, 8, 9, 10, 11**	**Emp, SD**	**N, R, G**	**ES, PE**

Reference Books

1.	Hildebrand F.B.(1974): Introduction to numerical analysis, 2nd Ed,TMH.
2.	Mathews J.H.(1992):Numerical Methods for Mathematics, Science and Engineering, 2nd Ed, PHI
3.	Kennedy and Gentle: Statistical Computing, Marcel Deker, New York.
4.	McCracken and Dorn: Numerical methods and FORTRAN Programming.