Progressive Education Society's

Modern College of Arts, Science and Commerce
Ganeshkhind, Pune 16

(An Autonomous College Affiliated to

Savitribai Phule Pune University)

Two Year Degree Program in Statistics

(Faculty of Science & Technology)

NEP 2020 (REVISED)

M.Sc. (Statistics) Part-I

Choice Based Credit System (REVISED) Syllabus under NEP

To be implemented from Academic Year 2024-25

Title of the Course: M. Sc. (Statistics)

Preamble:

M. Sc. Statistics (Honors) program is of semester pattern. There will be 2 semesters and in each semester a syllabus of 14 credits (Disciplinary Major Mandatory) +4 Credits (DSE Electives) +4 credits(Research Methodologies) will be covered. And in the 2nd semester along with this 4 credits for on job training will be discovered. The program is structured so as to increase the employability of the candidates in industry, academics and other by providing knowledge and skills in depth. Accordingly, the program has important features such as individual/ group projects, elective courses and courses on standard software packages such as MATLAB, MINITAB, SPSS, R. Syllabus of the first two semesters covers core courses. It is possible for the students to study basic courses from other disciplines such as economics, life sciences, computer science, and mathematics in place of electives.

Introduction:

(a) The program consists of core courses which may be compulsory or electives.

(b) In addition, there are lab courses (practical) and a project course.

(c) Some courses are termed Open Courses (O). The open courses are those which can be offered to other departments.

For every course, there will be Continuous Internal Assessment (CIA) conducted by department or college and End of Semester Examination (ESE) conducted by the college at the end of semester.

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Structure of the Syllabus:

Following is the structure of two year M.Sc. Statistics program.

T: Theory P: Practical O:Open C: Compulsory

E: Elective M.Sc.(Statistics)-Part I

Course Code	T/P	O/C/ E	Title	Credits	ESE Duration	Marks Assigned
Semester I						
STA51101	T	C	Basics of Real Analysis	2	2 Hours	50
STA51102	T	C	Multivariate Analysis	4	4 Hours	100
STA51103	T	C	Stochastic Processes	4	4 Hours	100
STA51105	T	E	Machine learning	2	2 Hours	50
STA51107	T	E	Numerical Methods	2	2 Hours	50
STA51104	P	C	Practical based on Real Analysis, Multivariate Analysis, Stochastic Processes	4	8 Hours	100
STA51106	P	E	Practical based on Machine learning	2	4 Hours	50
STA51108	P	E	Practical based on Numerical Methods	2	4 Hours	50
STA51209	T	C	Research Methodology	2	2 Hours	50
STA51210	P	C	Research Methodology	2	4 Hours	50
			Total	**22**		**550**
Semester II						
STA52101	T	C	Linear Algebra	2	2 Hours	50
STA52102	T	C	Bayesian Analysis	4	4 Hours	100
STA52103	T	C	Time series and Econometrics	4	4 Hours	100
STA52105	T	E	Categorical data analysis	2	2 Hours	50
STA52107	T	E	Sampling Methods	2	5 Hours	50
STA52104	P	C	Practical based on Linear Algebra, Bayesian Analysis, Time series and Econometrics	4	8 Hours	100
STA52106	P	E	Practical based on Sampling Methods	2	4 Hours	50
STA52108	P	E	Practical based on Power BI	2	4 Hours	50
STA52109	P	C	OJT	4	8hours	100
			Total	**22**		**550**

Semester I

STA51101: Basics of Real Analysis **No. of credit : 02**

Course Outcomes:-On completion of the course, the students will be able to:
CO1) Check the convergence of sequence and series
CO2) Apply the concept of series for Riemann integral
CO3) Differentiate proper and improper integral.
CO4) Real life situations where the above concepts can be used.

Unit1: Set Theory **[7 Hours]**

- Review of Set theory, Set of real numbers
- Supremum and infimum of sets of real numbers,
- Archimedean principal,
- countable and uncountable sets, countability of rational numbers, uncountability of real numbers, Metric space, Properties of metric space
- Neighborhood points, Exterior and interior points , boundary points , limit points, open , closed and compact sets.
- Bolzano – Weierstrass and heine- Borel theorem.

Unit2: Sequence and series **[7 Hours]**

- **Sequence**
  - ★ limit of sequence and its properties,
  - ★ Convergence and divergence of sequence Cauchy sequence and related theorems
  - ★ (Cauchy criteria of convergence),
  - ★ subsequence and their convergence and divergence, convergence of bounded monotone sequence.
- **Series**
  - ★ Convergence and divergence of series of real numbers,
  - ★ test for convergence (root test, ratio test) (without proof)
  - ★ absolute convergence (without proof), uniform convergence,
  - ★ power series , radius of convergence of power series (Binomial , Exponential, geometric and log series),
  - ★ term by term differentiation (integration) of absolute convergent series, change of order of summation of series.,

Unit3: Integral **[7 Hours]**

- **Riemann and Riemann –Stieltjes integral:**
  - ★ Partition of interval, norm of partition, finer partion, tagged partion,

- ★ Upper and Lower Riemann and R-S sums, order relation between Upper and Lower Riemann sums.
- ★ Effect of finer partition on the difference between Upper and Lower Riemann sums.
- ★ Necessary and sufficient condition for a function to be R and R-S integrable
- ★ Properties with proof
  - (i) Continuous bounded function is R and R-S integrable
  - (ii) Monotonic bounded function is R and R-S integrable
  - (iii) Fundamental theorem of integral calculus.

- **Improper integrals: Definition, convergence of an integral,**
  - ★ P- integral , exponential integral test for convergence (comparison test),
  - ★ convergence of beta and gamma integrals, relationship between beta and gamma functions

Sr. No.	Name of the Book	Author	Publisher
1	Introduction to probability models	Ross, S. (2000), 7th Edition	Academic Press
2	Stochastic processes	MedhiJ. (1982)	Wiley Eastern
3	Introduction to stochastic processes	Hoel ,P.G.,Port, S.C. ,Stone, C.J. (1972)	
4	Stochastic models: Analysis and applications	Bhat, B.R. (2000)	New Age International
5	An introduction to finite Markov processes	Adke, S.R., Manjunath, S.M. (1984)	Wiley Eastern
6	Stochastic processes (John Wiley)	Ross, S. (1996)	John Wiley
7	An introduction to stochastic modeling	Taylor, H N and Karlin, S. (1984)	Academic Press
8	Modeling and Analysis of Stochastic Systems	VidyadharG. Kulkarni	CRS Press Publications.
9	Stochastic modeling and its Applications	Tijms S	Wiley Publishers

STA51102: Multivariate Analysis

Course Outcomes:-On completion of the course, the students will be able to:

CO1) Differentiate between various distributions with respect to their probability function and probability curve

CO2) Compute moments and hence shape of the distribution

CO3) Interrelations between the distributions

CO4) Real life situations where they can use the probability distributions as models

Unit 1: [15 Hours]

- Exploratory multivariate Data Analysis: Sample mean vector, Dispersion Matrix, Correlation Matrix, Linear transformation and its mean and variance, graphical interpretation.
- Principal component Analysis (by using covariance and correlation method, standardized method) , Factor analysis (Their models, rotation types) , Canonical correlation with real life

Unit 2: [15 Hours]

- Cluster analysis (Hierarchical and Non hierarchical, Agglomerative, Single, complete, average , Wald's linkage , K- mean clustering method , qualitative method clustering)
- Multivariate normal distribution , Singular and nonsingular normal distribution , mean , variance of multivariate normal distribution, independence of variable ,M.G.F, Characteristic function, moments , Distribution of linear and quadratic form of normal variables, marginal and conditional distribution, multiple and partial correlation coefficient (3 random variable case)with examples on each of the topic.

Unit 3: [15 Hours]

- MLES of parametric of multivariate normal distribution and their sampling distribution, Tests and confidence region for the mean when dispersion matrix is known,
- Wishart distribution (generalized case of chi-square) and its properties
- Hotelling T^2 statistic and its distribution, applications of Hotelling T^2 statistic.
- Beharen- Fishers problem , confidence region for mean vector of multivariate normal distributions

Unit 4: [15 Hours]

- MANOVA technique , Likelihood ratio test , Test for equality of dispersion matrices, Discriminant analysis (by using prior probabilities , by using cost), Fisher Discriminant analysis, Mahalanobis D^2 Statistics

Sr. No.	Name of the Book	Author	Publisher
1	Introduction to Multivariate Analysis	Anderson, T. W. (1984)	John Wiley
2	Symmetric Multivariate and RelatedDistributions	Fang ,K., Kotz, S., Ng K. W. (1990)	Chapman and Hall
3	Applied Multivariate Statistical Analysis	Härdle, W. K. & Simar, L. (2012)	Springer, New York
4	Multivariate Statistics: Exercises andSolutions	Härdle, W. K., Hlávka, Z. (2007)	Springer, New York
5	Applied Multivariate Statistical Analysis	Johnson R.A. &Wichern, D.W. (1988)	Prentice Hall Inc.
6	Continuous Multivariate Distributions, Volume 1, Models and Applications,	Kotz, S., Balakrishnan N. and Johnson N. L. (2000)	John Wiley & Sons
7	Multivariate Analysis	Kshirsagar, A. M. (1983)	Marcel Dekker
8	Directional Statistics	Mardia,K. V. and Jupp, P. E. (2000)	John Wiley & Sons
9	Multivariate Statistical Methods,	Morrison, D.F. (1990)	McGraw Hill Co

STA51103: Stochastic Processes **No. of credit : 04**

Course outcomes: On completion of the course, the students will be able to:

CO1) Understand Markov chain process and apply it to the Birth and Death processes

CO2) Learn in detail continuous-time stochastic processes, with topics drawn from: Poisson Processes other Markov pure jump processes Brownian motion Other related Gaussian processes.

CO3) Understand to formulate simple stochastic process models in the time domain

CO4) Able to classify states of a given markov chain.

Unit1: **[15 Hours]**

- Stochastic processes, Markov property, Markov chains (MC), finite MC,
- transition probabilities, initial distribution, illustrations such as random walk, Ehrenfest chain, gambler's ruin chain, queuing chain, birth death chain, branching chain,
- Chapman Kolmogorov equation, n-step transition probabilities, transition probability matrix (t.p.m.) hitting times,

- probability of ever return, transient and recurrent states, decomposition of state space,
- closed set of states, irreducible set of states, irreducible MC, absorption probabilities, martingales,
- classification of states of birth and death chains, branching chain, queuing chain, random walk, gambler's ruin chain with absorbing ,
- reflecting and elastic barrier, etc. probability of ruin cases
- expected gain, expected duration of the game.

Unit2: **[15 Hours]**

- Elementary properties of stationary distributions, illustrations such as birth and death chains,
- Ehrenfest chain, particles in box, average number of visits to recurrent state, non null and positive recurrent states,
- probability of absorption in persistent class starting from transient state,
- period of state, existence of uniqueness of stationary distributions, reducible chains, illustrations such as queuing chain finite chains,
- convergence to the stationary distribution. Steady state distribution, ergodic Markov chain, Ergodic theorem.
- Branching Chain: BGW branching process, offspring distribution, mean and variance, generating function for probability of ultimate extinction, nth generation size and related recurrence relations

Unit3: **[15 Hours]**

- Intensity rates, it's relation with transition probabilities. Kolmogorov consistency condition, Markov property in continuous time stochastic processes. Kolmogorov forward and backward equations.
- Poisson process: Postulates and properties of Poisson process, probability distribution of N(t) the number of occurrences of the event in (0,t], Poisson process and probability distribution of interarrival time, generalizations of Poisson process: pure birth process: Yule Furry process. Non-homogeneous Poisson processes
- Renewal process: renewal process in continuous time, renewal function and renewal density, renewal equation, stopping time: wald's equation, elementary renewal theorem and its applications: (i) Age and block replacement policies, (ii) Replacement on failure and block replacement, renewal theorems (Blackwell's and Smith's)

Unit4: **[15 Hours]**

- Birth and death process: (i) Pure-Birth process , Yule Furry Process (ii)Pure death process, particular cases: Birth immigration process. (i) immigration-emigration process, (ii) linear growth process, (iii) linear growth with immigration, (iv) immigration death process.
- Continuous time Markov chains: Markov processes with continuous state space: Introduction to Brownian motion and its properties, Transition probabilitiesBrownian motion process as limiting case of random walk.Wiener process and its properties.

Sr. No.	Name of the Book	Author	Publisher
1	Introduction to probability models	Ross, S. (2000), 7th Edition	Academic Press
2	Stochastic processes	MedhiJ. (1982)	Wiley Eastern
3	Introduction to stochastic processes	Hoel ,P.G.,Port, S.C. ,Stone, C.J. (1972)	
4	Stochastic models: Analysis and applications	Bhat, B.R. (2000)	New Age International
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7	An introduction to stochastic modeling	Taylor, H N and Karlin, S. (1984)	Academic Press
8	Modeling and Analysis of Stochastic Systems	VidyadharG. Kulkarni	CRS Press Publications.
9	Stochastic modeling and its Applications	Tijms S	Wiley Publishers

STA51104: Practical based on Real Analysis, Multivariate Analysis and StochasticProcesses

No. of credit : 04

Sr. No.	Name of Practical	No of Practical
1	Exploratory Multivariate Analysis	1
2	Contour Plots	1
3	Principal Component Analysis	1
4	Factor Analysis	1
5	Cluster Analysis	1
6	Canonical Correlation	1
7	Model Sampling From multivariate Normal Distribution and Computation of M.L.E's of Parameter	2
8	Discriminant Analysis	2
9	Application of Hotelling T square	2
10	Realization of Markov Chain When TPM is given and computation of transition probabilities and stationary distribution of markov chain	1
11	Classification of States (persistent ,transient ,ergodicity)	1
12	The Realization of Poisson process	1
13	Realization of Birth and Death process	1
14	Realization of Gausian and Brownian Motion	1
15	Verify for the Convergence of Sequence	1
16	Verify for the convergence of Series	1
17	Practical based on Rieman integral	1
18	Practical based on Rieman Steilje's integral	1
19	Application of Hessian matrix	1
20	Manual Practical on integration	2
21	Project equivalent to 5 practicals	5
Total Number of practical		30

STA51105: Machine Learning **No. of credit : 02**

Course Outcomes:

After completion of the course, students will be able to:

CO1) Apply appropriate learning algorithm for analyzing data.
CO2) Use appropriate R-packages for data analysis.
CO3) Design learning algorithms for new tasks.
CO4) Self-learn many other ML techniques.
CO5) Be a better data scientist

Unit1: **[15 Hours]**

- Need for and meaning of Machine Learning (ML).
- Various ML tasks.Framework of ML environment.
- Relationship with other fields such as Data Mining, Statistics, Data Science, Big Data Analytics.
- Introduction to Classification task and optimality of Bayes rule.Generative and
- discriminative approaches to classification problems.
- Nearest neighbor classifier,
- Naïve Bayes classifier,
- Linear and non-linear discriminant functions. (15 L)

Unit2: **[15 Hours]**

- SVM Learning.
- Linear separability.Hard and soft margin optimal decision boundaries.
- Kernel trick. Neural Network Learning - basic concepts, Perceptron learning and its limitations, Back-propagation algorithm, Logistic regression,
- Multi class classification with softmax- activation function.

Unit3: **[15 Hours]**

- Decision Tree Learning – Impurity measures, construction of classification tree, tree pruning.
- modifications for regression trees. Ensemble learning-Bagging and boosting, random forests, Cross validation.

Unit4: **[15 Hours]**

- Cluster learning- k-means algorithm, Agglomerative hierarchical clustering.
- Cluster quality. Regression Learning.Linear, non-linear regression.
- Association analysis and some miscellaneous topics.

Sr. No.	Name of the Book	Author	Publisher
1	Data Mining: Concepts and Techniques	Han J., Kamber M., and Pei J (2012)	Elsevier
2	Introduction to Machine Learning	Alex Smola and S.V.N. Vishwanathan (2008), 3rd Edition	Cambridge University Press

3	Data Mining: Practical Machine Learning Tools and Techniques.	Ian H. Witten and Eibe Frank (2005), 2nd Edition	Elsevier

STA51106: Practical based on Machine Learning **No. of credit : 02**

Sr.No.	Title	No of Experiment
1A	Implementation of the K-NN (K nearest neighbor) algorithm for classification problems.	1
1B	Implementation of K-NN (K nearest neighbor) algorithm for Regression problem.	1
2	Implementation of Naïve Bayes Classifier	1
3A	Implementation of Decision tree for classification	1
3B	Implementation of Decision tree for regression	1
4	Ensemble learning-Bagging and boosting	1
5A	SVM learning for classification	1
5B	SVM learning for regression	1
6	Implementation of k means clustering	1
7	Implementation of A priori algorithm	1
8	Project (equivalent to 5 Practicals)	5
Total Number of practical		**15**

STA51107: Numerical Methods **No. of credit : 02**

Course Outcomes:

After completion of the course, students will be able to:

CO1) Demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems.

CO2) Apply numerical methods to obtain approximate solutions to mathematical problems.

CO3) Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and nonlinear equations, and the solution of differential equations**.**

Unit 1 : [10 Hours]

- Riemann and Riemann- Stieltjes Integral, applications in Statistics.

Uni2: [5 Hours]

- **I**mproper integrals of first and second kind for one variable
- Conditions for convergenceof beta and Gamma functions , relation between beta and gamma functions, properties of beta and gamma functions
- Duplication formula. Implict function Theorem / Inverse function theorem and their simple applications.

Uni3: **[**15 Hours]

- (i)Newton–Raphson method for two or more simultaneous transcendental equations, (ii) Newton's bivariate interpolation formula, (iii) Unconstrained optimization : Grid search method, Gradient search : Seepest descent method ,Newton's , method. (iv) Simpson's , Trapezoidal rule for bivariate integrals; (v) Simulation : Linear congruential generator ; Monte Carlo method to evaluate single and multiple integrals. (vi) Jack – Knife estimators. (vii) Boot-Strap method

Sr. No.	Name of the Book	Author	Publisher
1	Principles of Mathematical Analysis	Rudin W.(1985)	McGraw – Hill
2	Mathematical Analysis: A Modern Approach toAdvanced Calculus	Apostol T. M. (1975)	Addison - Wesley
3	Elements of Real Analysis	Bartle R. G. (1976)	Wiley
4	Mathematical Analysis	Bhat, B.R. (2000)	Wiley Eastern Limited2nd edition)

STA51108: Practical based on Numerical Methods **No. of credit : 02**

Sr.No.	Title	No of Experiment
1	Simultaneous Transcendental equations N- R method.	2
2	Grid search , steepest descent and Newton's Method of optimization.	3

3	Bivariate interpolation.	2
4	Computations of double integral	2
5	Numerical integration using simulations.	2
6	Computation of integral by Riemann and Riemenn – Stiltjes sums.	2
7	Boots Trap method	1
8	Jack knife method	1
Total Number of practical		**15**

Semester II

STA52101: Linear Algebra

Course Outcomes:-On completion of the course, the students will be able to:

CO1)Learn about the concept of linear independence of vectors over a field, and the dimension of a vector space.

CO2) Basic concepts of linear transformations, dimension theorem, matrix representation of a linear transformation, and the change of coordinate matrix.

Unit 1 **[9 Hours]**

- Vector space, subspace
- Linear dependence and independence
- Basis of vector space, Dimension of a vector space, orthogonal and orthonormal vectors, orthonormal basis, Gram- Schmidt orthogonalization Matrix algebra, special types of matrices,orthogonal matrix, idempotent matrix partitioned matrices, elementary operations, rank of a matrix, inverse of a matrix

Unit 2 **[9 Hours]**

- Characteristic roots of a matrix, right and left characteristic vectors
- Properties of characteristic roots and vectors, algebraic and geometric multiplicities
- Spectral decomposition, nth power of a matrix, Cayley- Hamilton theorem.

Unit 3 **[12 Hours]**

- g-inverse, Moore-Penrose g-inverse, solution of a system of homogeneous
- and non- homogeneous linear equations. Gauss seidel and Gauss Jacobi iterative methods.
- Quadratic forms, definition, reduction and classification, simultaneous reduction of two quadratic forms, maxima and minima of ratio of quadratic forms.

Sr. No.	Name of the Book	Author	Publisher
1	Matrix Algebra Useful for Statistics	Searle S.A.(1982):	Wiley
2	An introduction to linear Statistical models Volume I,	Graybill (1961):	Mc Graw Hill
3	Linear Statistical Inference and its Applications	Rao C.R. (1973)	Wiley Eastern

STA52102: Bayesian Analysis

Unit1: [15 Hours]

- Subjective and frequentist probability ,
- Bayesian inference set up, prior and posterior distributions,
- loss functions, principles of minimum expected posterior loss, quadratic and other loss functions,
- advantages of being Bayesian ,
- improper priors ,Common problems of Bayesian Inference,
- point estimation, maximum a posteriori estmatior (MAP) ,HPD confidence intervals, credible intervals,
- predictions of future observations, Bayesian testing.

Unit2: [15 Hours]

- Bayesian analysis with subjective priors ,
- classes priors, conjugate class of priors,
- Jeffreys prior, probability matching prior,
- robustness and sensitivity.

Unit3: [15 Hours]

- Bayesian model selection BIC,
- Bayes factors, limit of posterior distributions,
- consistency and asymptotic normality of posterior distributions

Unit4: [15 Hours]

- Bayesian computing, E-M Algorithm ,
- MCMC, MH Algorithms ,
- Gibb' sampling ,
- convergence diagnostics. (Note: Minimum 10 hours of computational practice)

Sr. No.	Name of the Book	Author	Publisher
1	Introduction to Bayesian Statistics	Bolstad W M(2007), 2nd Edition	Wiley
2	Bayesian Ideas and Data Analysis: An introduction for Scientists and Statisticians	Christensen R. Johnson W. Branscum A. and Hanson T. E.(2011)	Chapman and Hall
3	Bayesian Statistical Modeling	Congdon P (2006)	Wiley
4	An Introduction to Bayesian Analysis :Theory and Methods	Ghosh J.K., Delampady M. and T.Samantha(2006)	Springer
5	Bayesian Computation with R	Jim A (2009), 2nd Edition	Springer
6	Bayesian Thinking Modelling and Computation, Handbook of Statistics	Rao C. R. and Day D. (2006), Vol 25	Elsevier

STA52103: Time Series and Econometrics

Course Outcomes:On completion of the course, the students will be able to:

CO1) To learn and develop scientific view to understand the time series data and its analysis.

CO2) To learn stationary and non-stationary, and seasonal and non-seasonal time series modeEstimate model parameters and compare different models developed for the same dataset in terms of their estimation and prediction accuracy.ls.

CO3) Learn to create POWERFUL reports and dashboards with Microsoft Power BI with a few clicks of the mouse

CO4) To learn some basic concepts of econometrics.

Unit1: **[15 Hours]**

- Inference in Econometric Models: Simultaneous equation models – endogenous and exogenous models,

- Problems with OLS estimators, Identification problem and reduced models. Indirect Least Squares Method,
- 2 stage and 3 stage OLS estimation.
- Properties of the estimators.Indirect Inference in Econometric models. (12 L)

Unit2: **[15 Hours]**

- Time - series as a discrete parameter stochastic process.
- Exploratory time Series analysis, Autocovariance and autocorrelation functions and their properties.
- Methods of estimation and elimination of trend and seasonality: Graphical method, Moving average, exponential smoothing and least square method.
- Testing the estimated noise sequence: The sample ACF, the Portmanteau tests, the turning point test, the difference sign test and the rank test.
- Holt -Winters smoothing. Forecasting based on smoothing, adaptive smoothing.

Unit3: **[15 Hours]**

- Stationary processes: General linear processes, moving average (MA), auto regressive (AR) and autoregressive moving average (ARMA) processes.
- Causal and non-causal process, Stationarity and inevitability conditions.
- Non-stationary and seasonal time series models: Auto regressive integrated moving average (ARIMA) models, Seasonal ARIMA (SARIMA) models,
- Transfer function models (Time series regression). (12L)

Unit4: **[15 Hours]**

- Forecasting in time series models, Durbin-Levinson algorithm, innovation algorithm (without proof).
- Estimation of mean, autocovariance and autocorrelation functions, Yule-Walker estimation, Estimation of ARIMA models parameters, maximum likelihood method, large sample theory (without proofs).
- Choice of AR and MA periods, FPE, AIC, AICc, BIC, residual analysis and diagnostic checking.
- Unit-root non stationarity, unit-root tests (Dickey-Fuller).

Sr. No.	Name of the Book	Author	Publisher
1	An Introduction to Time Series Analysis	Brockwell, P.J. and Davis	Springer
2	Time Series Forecasting	Chatfield, C. (2001)	Chapman & hall, London

3	Time Series Analysis using R	Chatfield, C. (2007).	Chapman & hall, London
4	Introduction to Statistical Time Series	Fuller, W. A. (1996)	John Wiley
5	Time Series Analysis.	Hamilton N. Y. (1994).	Princeton University press. Princeton
6	Time Series	Kendall, Sir Maurice and Ord, J. K. (1990), 3rd Edition	Edward Arnold
7	Applied Time Series Econometrics	Lutkepohl, H. and Kratzing, M. (Ed.) (2004).	Cambridge University Press, Cambridge
8	Time Series Analysis & Its Applications	Shumway, R. H.andStoffer D. S. (2010)	Springer, New York
9	Introduction to time series	Tsay, R. S. (2010).	Wiley.

STA52104: Practical based on Linear Algebra, Bayesian Analysis, and Time series and Econometrics

Sr. No.	Name of Practical	No of Practical
1	Matrices :Properties of matrices ,Row Space ,Column space and Null Space	2
2	Inverse of square matrix (Direct method ,g inverse ,MPg inverse,partitioning method)	1
3	Gram Schmidt orthogonalization: Forming an orthogonal matrix of specified order using Gram Schmidt orthogonalization	1
4	Eigenvalue ,Eigen vectors ,spectral decomposition and power of matrix (Spectral Decomposition)	2
5	Solution of System of linear equation using Gauss elimination ,Gauss Jordan elimination ,Gauss Seidel and gauss Jacobi methods	2
6	Classification and reduction of quadratic forms ,Verification of Cayley Hamilton theorem	1

	Estimation of mean and autocovariance of given time series.	1
7	Smoothing the series using various Filters and Estimation of trend and seasonal component	1
8	Calculating and plotting ACF and PACF	1
9	Simulation of AR and MA models and Fitting of AR, MA Models.	1
10	Fitting of ARMA, AIMA and SARIMA model	2
11	Forecasting using Holt Winters method	2
12	Fitting of suitable time series model and calculation of FPE, AIC, AICc, BIC, residual analysis and diagnostic checking.	1
	Testing the stationarity of time series.	1
13	Order selection in time series: use of ACF/PACF and ATC, BIC, fitting of AR, MA models	1
15	Plotting the Prior and posterior density functions and likelihood function on the same graphs paper	1
16	Generating random samples from different posterior distributions.	1
17	Constructing Highest posterior density credible intervals	1
18	Testing of hypothesis by computing Bayes factor	1
19	Practical based on MH algorithm.	1
20	Project (equivalent to 5 Practicals)	5
Total		30

STA52105: Categorical data analysis

Course Outcomes: On completion of the course, the students will be able to:

CO1) Appreciation of difference between linear models and logistic and log-linear models.

CO2) Knowledge of models for categorical data analysis and ability to fit them and interpret the results.

CO3) Awareness of dependence relationships amongst categorical variables.

CO4) Ability to use any related software to fit models for categorical data

Unit 1: **[6 Hours]**

Introduction to Categorical data analysis: categorical response data, Probability distributions for categorical data, statistical inference for discrete data.

Contingency tables: Probability structure for contingency tables, comparing proportions with 2x2 tables, odds ratio, tests for independence, exact inference, extension to three way and larger tables

Unit 2: **[8 Hours]**

Generalized linear models (GLM): GLM for binary data and count data, Statistical inference and model checking, fitting GLMs. Logistic Regression: interpretation, inference, logistic regression withcategorical predictors

Unit 3: **[8 Hours]**

Multiple logistic regression, building and applying logistic regression model, multicategory logit models. Log-linear models for two way and three way tables, inference for log linear models, log linear-logistic connection, independence graphs and collapsibility

Unit 4: **[8 Hours]**

Models for matched pairs: comparing dependent proportions, logistic regression for matched pairs, comparing margins of square contingency tables. Random effects modeling of clustered categorical data, extension to multinomial responses, hierarchical models.

Books Recommended:

Sr. No.	Name of the Book	Author	Publisher
1	Analysis of Categorical Data,	A. Agresti	Wiley, 1990.
2	An Introduction to Categorical Data Analysis	A. Agresti	Wiley, New York

STA62106: Practical based on Sampling Methods

Sr.No.	Title	No of Experiment
1	Practical based on SRSWOR, SRSWR methods	2
2	Practical based on Stratified random sampling, various kinds of allocation, Post stratification, using auxiliary information.	3
3	Practical based on Ratio and regression methods of estimation	2
4	Practical based on pps sampling design	2
5	Practical based on Double sampling	2
6	Practical based on two stage sampling	2
7	Practical based on Systematic sampling	1
8	Practical based on cluster sampling Randomized response technique.	1
Total Number of practical		**15**

STA52107: Sampling Method

Course Outcomes:

At the end of this course, a student will have developed ability to:

CO1) Explain the methods for simple random sampling and estimate the population mean, population total and their variances using simple random sampling methods.

CO2) Explain stratified and systematic sampling methods and estimate the population mean, population total and their variances using these method

CO3) Learn to use ratio and regression method of sampling in proper sampling situation.

Unit1: Introduction to sampling [7 Hours]

- Basic methods of sample selection,
- simple random sampling with replacement (SRSWR),
- simple random sampling without replacement (SRSWOR),
- probability proportional sampling with and without replacement

Unit 2: Introduction to Systematic and stratified Sampling [8 Hours]

- systematic sampling, estimation problems
- Horwitz- Thompson estimator and its properties.
- Stratification: Allocation problems and estimation problems, formation of strata and number of strata, method of collapsed strata. Use of supplementary information for estimation

Unit 3: Ratio and Regression method of sampling [15 Hours]

- ratio and regression estimators with their properties and generalizations
- Jackknife methods. Cluster sampling, multistage-sampling. Double sampling procedures,
- Ratio and regression estimators, stratification. Non-sampling errors, response and non-response errors and their treatments, randomized response.

Books Recommended:

Sr. No.	Name of the Book	Author	Publisher
1	Sample Survey Theory	Des Raj and Chandhok, P. (1998)	Narosa
2	Sampling Theory of Surveys with Applications	Sukhatme P.V, Suktatme, B.V., Sukhatme S. and Asok C. (1984)	Indian Soc. for Agricultural Statistics, New Delhi
3	Sampling Techniques	Cochran, W.G. (1984).	Wiley

STA61108: Practical based on BI

Course Outcomes:

CO1) Easily create a wide range of GRAPHS and VISUALISATIONS using drag and drop technologies

CO2) Learn to create Data Models and use the DAX Formula language to develop POWERFUL calculations

CO3) Learn to create POWERFUL reports and dashboards with Microsoft Power BI with a few clicks of the mouse

CO4) PUBLISH reports and dashboards on the Internet and view using laptops, tablets or smartphones in minutes

Unit1: Power BI Introduction **[12 Hours]**

- **I**ntroduction
- · Data analytics and Microsoft .
- Getting Started with Power BI .
- · Get Data from Various Data Sources .
- · Optimize Performance .
- Resolve Data Errors .
- Data Shaping .
- Enhance the Data Structure .
- · Data Profiling
- Programs on this
  - ★ Import given data into Power BI
  - ★ To carry cleaning of data (Trim,Upper Case,Lower Case,Spacing).

Uni2:Designing a data model in power BI **[15 Hours]**

- Introduction to Data Modeling .
- Working with Tables .
- Dimensions
- Visualization of data

- Programs on this unit
  - ★ To create tables from imported data.
  - ★ To Format table using data modeling techniques.
  - ★ Create Bar Plot, Pie Chart,Donut ,water flow chart from the given data

Uni3: . Create Measures using DAX in power BI **[18 Hours]**

- Introduction to DAX .
- DAX Content .
- Advanced DAX .
- Optimize the data model for Performance .
- Optimize DirectQuery Models .
- Create and manage Aggregations .
- Programs on this unit
  - ★ To carry out arithmetic calculations (addition, subtraction, multiplication, division).
  - ★ To carry out making duplicate columns and carry out arithmetic calculations

Unit 4 : Create Dashboards [15 Hours]

- Create a Dashboard.
- Real-time Dashboards.
- Enhance a Dashboard.

- Programs on this unit
    - ★ Get real life data (Primary or Secondary) and make appropriate dashboard.