Central University of Punjab,
Bathinda

M.Sc. STATISTICS

Session: 2021-2023

Department of Mathematics and Statistics
School of Basic Sciences

M.Sc. (Statistics) Programme

Graduate Attributes:

Students will be able to develop a broad understanding of recent Statistical theories, tools and techniques. Students will apply different Statistical techniques in various fields and will independently plan and carry out research in different areas of Statistics. They will compete at regional/national/international level for research/jobs in the area of statistics.

M.Sc. Statistics (Semester-I)

Course Code	Course Title	Course Type	Credit Hours			Course Credits
			L	T	P	
STA.507	Statistical Methods with Packages	Core	3	0	0	3
STA.508	Statistical Methods with Packages (Practical)	Skill Based	0	0	2	1
MAT.506	Real Analysis	Core	3	0	0	3
MAT.508	Linear Algebra	Core	3	0	0	3
STA.512	Probability Theory	Core	3	0	0	3
STA.523	Sampling Theory	Core	3	0	0	3
STA.524	Sampling Theory (Practical)	Skill Based	0	0	2	1
STA.513	Distribution Theory	Discipline Elective	3	0	0	3
STA.526	Linear Models and Regression					
STA.559	Demography & Vital Statistics					
XYZ	Interdisciplinary (From Other Departments)	IDC	2	0	0	2
Total			**20**	**0**	**4**	**22**

Interdisciplinary courses offered by STA Faculty (For students of other Departments)

STA.510	Basic Statistics	IDC	2	0	0	2

M.Sc. Statistics (Semester II)

Course Code	Course Title	Course Type	Credit Hours			Course Credits
			L	T	P	
STA.521	Statistical Inference	Core	3	0	0	3
STA.522	Statistical Inference (Practical)	Skill Based	0	0	2	1
STA.525	Stochastic Processes	Core	3	0	0	3
STA.555	Quality Control and Time Series	Core	3	0	0	3
STA.556	Quality Control and Time Series (Practical)	Skill Based	0	0	2	1
STA.575	Econometrics	Core	3	0	0	3
STA.576	Econometrics (Practical)	Skill Based	0	0	2	1
ABC	Value Added Course (From Other Departments)	VAC	2	0	0	2
STA.527	Basics of R Programming (Practical)	Skill Based	0	0	2	1
STA.528	Actuarial Statistics	Discipline Elective	3	0	0	3
STA.529	Statistical Methods for Insurance					
STA.511	Operations Research					
Total			**17**	**0**	**8**	**21**

Value added courses offered by Department of Mathematics and Statistics (For PG students of other Departments)

MAT.528	Linear Programming (VAC)	Value Based	2	0	0	2

M.Sc. Statistics (Semester III)

Course Code	Course Title	Course Type	Credit Hours			Course Credits
			L	T	P	
MAT.502	Research Methodology	Compulsory Foundation	4	0	0	4
STA.551	Multivariate Analysis	Core	3	0	0	3
STA.552	Multivariate Analysis (Practical)	Skill Based	0	0	2	1
STA.553	Design and Analysis of Experiment	Skill Based	3	0	0	3
STA.554	Design and Analysis of Experiment (Practical)	Core	0	0	2	1
STA.557	Stochastic Finance & Machine Learning in Insurance	Discipline Elective	3	0	0	3
STA.560	Non-parametric Inference					
STA.574	Statistical Simulation					
STA.558	Review of Statistical Concepts (DEC)	Compulsory Foundation	2	0	0	2
STA.563	Entrepreneurship Skills	Compulsory Foundation	1	0	0	1
STA.600	Research Proposal	Skill Based	4	0	0	4
MAT.568	Basics of LateX (Practical)	Skill Based	0	0	2	1
Total			**20**	**0**	**4**	**23**

MOOCs May be taken up 40% of the total credits (excluding dissertation credits). MOOC may be taken in lieu of any course but content of that course should match a minimum 70%. Mapping is to be done by the respective department and students may be informed accordingly.

M.Sc. Statistics (Semester IV)

Course	Course Title	Course	Credit Hours	Course Credits

Code		Type	L	T	P	
STA.600	Dissertation	Skill Based	0	0	40	20

Students will have an option to carry out dissertation work in industry, national institutes or Universities in the top 100 NIRF ranking.

Group dissertation may be opted, with a group consisting of a maximum of four students. These students may work using single approach or multidisciplinary approach. Research projects can be taken up in collaboration with industry or in a group from within the discipline or across the discipline.

Total Credits for the course: 86

Evaluation Criteria for Core, Discipline Elective, Compulsory Foundation, VAC and IDC

A. Internal Assessment: [25 Marks]
B. Mid Semester Test: Based on Subjective Type Questions [25 Marks]
C. End Semester Exam: Based on 70% Subjective Type Questions and 30% Objective Type Questions [50 Marks]

Discipline Enrichment Course:

A. Mid Semester Test: Based on Objective Type Questions [50 Marks]
B. End Semester Exam: Based on Objective Type Questions [50 Marks]

Entrepreneurship Course:

A. Mid Semester Test: Based on Objective Type Questions [25 Marks]
B. End Semester Exam: Based on Objective Type Questions [25 Marks]

Dissertation:

A. Third semester (Based on proposal)

a) Dissertation proposal and presentation: Supervisor [50 marks]
b) Dissertation proposal and presentation: HoD and Senior most faculty [50 marks]

B. Fourth semester (Based on Dissertation)

a) Continuous assessment, report, presentations, viva voce: Supervisor [50 marks]
b) Continuous assessment, report, presentations, viva voce: HoD, Senior most faculty, and External expert [50 marks]

Evaluation Criteria for Practical classes

A. Practical file: [15 Marks]
B. Practical Exam: [75 Marks]
C. Viva-Voce Examination: [10 Marks]

Semester I

Course Title: Statistical Methods with Packages
Course Code: STA.507
Total Lectures: 45

L	T	P	Credits
3	0	0	3

Learning outcomes: The students will be able to

- Learn the different methods of data presentation.
- Understand about the measures of central tendency.
- Explore the exact sampling distributions.
- Exercise the application of testing in real-life problems.
- Knowing the concept of chi-square goodness of fit.

Unit I **12 Hours**

Descriptive Statistics: Meaning, need and importance of statistics. Attributes and variables. Measurement and measurement scales. Collection and tabulation of data. Diagrammatic representation of frequency distribution: histogram, frequency polygon, frequency curve, ogives, stem and leaf plot, pie chart. Measures of central tendency, dispersion (including box and whisker plot), skewness and kurtosis. Linear regression and correlation (Karl Pearson's and Spearman's) and residual plots.

Activity: Students will construct various statistical plots using real data. Students will also explore the concepts of the measures of central tendency

Unit II **12 Hours**

Population, random sample, parameter, statistic and sampling distributions. Normal, Chi-square, t and F distributions and their relations. Sample mean and sample variance associated with a random sample from a normal distribution: their independence and distributions, concepts of standard errors.

Activity: Students will do the exact sampling distribution.

Unit III **11 Hours**

Statistical hypotheses, Type I and II errors, level of significance, test of significance, concept of p-value. Tests of significance for the parameters of normal distribution (one sample and two sample problems) and the relevant confidence intervals.

Activity: Students will explore the testing of hypotheses in practical applications.

Unit IV **10 Hours**

Chi-square test of goodness of fit and independence of attributes. Test of significance for correlation coefficient (one and two sample problem). Testing variance of normal distribution, testing of proportion (one and two sample problem), testing of correlation coefficient (one sample and two sample problem).

Activity: Students will explore the concept of goodness of fit.

Transaction mode: Lecture/Demonstration/Co Operative learning /programming/Practical/Group discussion/Team teaching/ Experimentation/Tutorial/Problem solving/Self-learning.

Suggested Readings:

1. A. M. Goon, M. K. Gupta and B. Dasgupta, *Fundamentals of Statistics*, Vol I and II, 2005.
2. R. V. Hogg, J. McKean and A. Craig, *Introduction to Mathematical Statistics*, 7th Edition, Pearson, 2012.
3. W. W. Daniel and C. L. Cross, *Biostatistics: A Foundation for Analysis in the Health Sciences*, 10th Edition, Wiley & Sons, 2013.

Course Title: Statistical Methods with Packages (Practical)
Course Code: STA.508
Total Hours: 30

L	T	P	Credits
0	0	2	1

Topics should include graphic representation of statistical data, descriptive statistics, correlation, linear regression model.

Learning Outcome: The students will be able

- Understand the basic techniques for graphical representation of data.
- Explain the concepts of dependence is bivariate data.
- Understand the basic packages used in statistical methodologies.

Laboratory Work: Programming exercises on statistical software tools like R.

1. To explore the various graphical representation of data .
2. To find the sample mean and sample variance from data.
3. To find the various descriptive statistics of a given data.
4. To demonstrate the various concept of dependence in a bivariate data.
5. To discuss the concept of correlation in a given data.
6. To fitting of simple linear regression models.
7. To fitting of multiple linear regression models.
8. Data fitting for distribution.
9. To display Random number generation.
10. Testing of hypothesis

Transaction mode: Lecture/Demonstration/Co Operative learning /programming/Practical/Group discussion/Team teaching/ Experimentation/Tutorial/Problem solving/Self-learning.

Suggested Readings:

1. A. M. Goon, M. K. Gupta and B. Dasgupta, *Fundamentals*

of Statistics, Vol I and II, 2005.
2. R. V. Hogg, J. McKean and A. Craig, *Introduction to Mathematical Statistics*, 7th Edition, Pearson, 2012.
3. W. W. Daniel and C. L. Cross, *Biostatistics: A Foundation for Analysis in the Health Sciences*, 10th Edition, Wiley & Sons, 2013.

Course Title: Real Analysis
Course Code: MAT.506
Total Hours: 45

L	T	P	Credits
3	0	0	3

Learning outcomes:

The students will be able to

- Apply the knowledge of set theory and metric spaces with properties.
- Illustrate various properties of compact sets and connected sets.
- Explain concepts of convergent sequences and continuity in metric spaces.
- Apply the knowledge of Riemann Stieltjes Integrals.

Unit-I **12 Hours**

Metric spaces: Definition and examples, Open and closed sets, Compact sets, Elementary properties of compact sets, k- cells, Compactness of k-cells, Compact subsets of Euclidean space $\Re^k$, Bolzano Weierstrass theorem, Heine Borel theorem, Perfect sets, Cantor set, Separated sets, Connected sets in a metric space, Connected subsets of real line.

Activity: Students will solve some problems which will be based on concepts of compact sets and connected sets

Unit-II **11 Hours**

Sequences in Metric spaces: Convergent sequences, Subsequences, Cauchy sequences, Complete metric space with examples, Cantor's intersection theorem (Statement only), Category of a set and Baire's category theorem. Banach contraction principle.

Activity: Students will solve some problems which will be based on application of sequences, category theorem and Banach contraction theorem.

Unit-III **12 Hours**

Continuity: Limits of functions (in Metric spaces), Continuous functions, Continuity and compactness, Continuity and connectedness, Discontinuities, Uniform continuity.

Riemann Stieltje's Integral: Definition and existence of Riemann Stieltje's integral, Properties of integral. Integration and Differentiation. Fundamental Theorem of Calculus, 1st and 2nd Mean Value Theorems of Riemann Stieltje's integral.

Activity: Students will do examples/exercises related to continuity and its characterizations. Students will explore how Riemann Stieltje's integral is generalization of Riemann integral.

Unit-IV **10 Hours**

Sequences and series of functions: Problem of interchange of limit processes for sequences of functions, Uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation.

Activity: Students will explore how uniform convergence is related to integration and differentiation.

TRANSACTION MODE: Lecture/Demonstration/Project Method/ Co Operative learning/ Seminar/Group discussion/Team teaching /Tutorial/Problem solving/E-team teaching/Self-learning.

Suggested Readings:

1. T. M. Apostol, *Mathematical Analysis*, Addition –Wesley, USA, 1981.
2. R. G. Bartle, *The Elements of Real Analysis*, John Willey and Sons, New York, 1976.
3. A. Kumar and S. Kumaresan, *A Basic Course in Real Analysis*, Narosa, Publishing House, New Delhi, 2014.
4. W. Rudin, *Principles of Mathematical Analysis*, 3rd Edition, McGraw Hill, Kogakusha, International student Edition, 1976.
5. E. C. Titchmarsh, *The Theory of functions,* Oxford University Press, Oxford, 2002.

Course Title: Linear Algebra
Course Code: MAT.508
Total Hours: 45

L	T	P	Credits
3	0	0	3

Learning outcomes:

The students will be able to

- Review the basic notions in linear algebra that are often used in mathematics and other sciences
- Define Vector spaces, Subspaces and related results.
- Define Linear transformations and characteristic polynomials with examples.
- Illustrate various properties of canonical forms.
- Study of Inner product spaces
- Explain concepts of the Gram-Schmidt orthogonalization process.

Unit I **12 Hours**

Vector spaces, Subspaces: Definition and Examples, Linear dependence and independence, Basis and dimensions, Coordinates, Linear transformations, Algebra of linear transformations, Isomorphism, Matrix representation of a linear transformation.

Activity: Students will construct different vector spaces like a set of all continuous functions, set of all polynomials. They will define Linear transformation on these spaces.

Unit II **12 Hours**

Change of basis, Rank and nullity of a linear transformation. Linear functionals, Dual spaces, Transpose of a linear transformation. Annihilating Polynomials: Characteristic polynomial and minimal polynomial of a linear transformation, Characteristic values and Characteristic vectors of a linear transformation, Cayley Hamilton theorem.

Activity: Students will explore the geometrical and physical meaning of Characteristic values and characteristics vectors.

Unit III **12 Hours**

Diagonalizing matrices, Diagonalizing real symmetric matrices, Characteristic polynomials and minimal polynomials of block matrices, Canonical forms: Jordan canonical forms, rational canonical forms. Quotient spaces, Bilinear forms, Symmetric and skew- Symmetric bilinear forms, Sylvester's theorem, quadratic forms, Hermitian forms.

Activity: Students will solve the problems related to applications of canonical forms of matrices.

Unit IV **09 Hours**

Inner product spaces. Norms and distances, Orthonormal basis, Orthogonality, Schwarz inequality, The Gram-Schmidt orthogonalization process. Orthogonal and positive definite matrices.

Activity: Students will explore the application of defining norm and the inner product on vector spaces.

TRANSACTION MODE: Lecture/Demonstration/Project Method/ Co Operative learning/ Seminar/Group discussion/Team teaching /Tutorial/Problem solving/E-team teaching/Self-learning.

Suggested Readings:

1. J. Gilbert and L. Gilbert, *Linear Algebra and Matrix Theory,* Cengage Learning, 2004.
2. K. Hoffman and R. Kunze: *Linear Algebra,* 2nd Edition, Pearson Education (Asia) Pvt. Ltd/ Prentice Hall of India, 2004.
3. V. Bist and V. Sahai, *Linear Algebra,* Narosa, Delhi, 2002.
4. S Lang, Linear Algebra, Undergraduate texts in mathematics, Springer, 1989.

Course Title: Probability Theory
Course Code: STA.512
Total Hours: 45

L	T	P	Credits
3	0	0	3

Learning Outcomes:
The students will be able to

- Understand the concept of sigma field, probability measure and probability space.
- Explore the concept of distribution and random variables.
- Establish the various moments inequalities.
- Learn the concept of convergence of sequences of random variables.

Unit I **11 Hours**

Classes of sets, field and sigma fields, limit of sequences of sets, sigma field generated by a class of subsets, Borel fields. Probability measure, probability space, continuity of a probability measure.

Activity: Students will explore the concept of sigma fields and construct probability measures.

Unit II **11 Hours**

Real and vector-valued random variables, Induced probability space

Probability distribution, Distribution functions of discrete, continuous and mixed type random variables, decomposition of a distribution.

Activity: Students will construct some new probability distributions. They will also be able to make a differentiation between discrete, continuous and mixed type random variables.

Unit III **12 Hours**

Expectation of random variable and its properties. Linear properties of Expectations, Inequalities: Jensen's, Chebychevs, Markov, Hölders and Lyapounov inequalities. Independence of events and random variables, Borel zero-one law, Borel-Cantelli Lemma, Kolmogorov zero-one law.

Activity: Students will explore the concept of expectation and establish various important inequalities based on moments.

Unit IV **16 Hours**

Various modes of convergence of sequences of random variables (in probability, almost surely, in rth mean), Implication between modes of convergence. Slutsky's theorem. Law of large number, Weak law of large number, Strong law of large number (without proof), Central Limit Theorem.

Activity: Students will learn about various modes of convergence of sequences of random variables. With an application of convergence of random variables, they will establish the WLLN and SLLN.

Transaction mode: Lecture/Demonstration/Co Operative learning / programming/Practical/Group discussion/Team teaching/ Experimentation/Tutorial/Problem solving/Self-learning.

Suggested Readings:

1. K. L. Chung, A Course in Probability Theory, 3rd Edition, Academic Press, 2001.
2. P. Billingsley, Probability and Measure, 3rd Edition, Wiley Series in Probability and Mathematical Statistics. 2008.
3. P. L. Meyer, Introductory Probability and Statistical Applications, 2nd Edition, Oxford & Lbh, 2017.
4. S. M. Ross, Introduction to Probability Models, 11th Edition, 2014.
5. V. K. Rohtagi and A. K. M. E. Saleh, An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern, 2010.

Course Title: Sampling Theory
Course Code: STA.523
Total Hours: 45

L	T	P	Credits
3	0	0	3

Learning Outcomes:

The students will be able to

- Explain various sampling techniques.
- Classify among SRSWOR, SRSWR, stratified etc.
- Make use of Two-stage sampling and double sampling techniques.
- Justify PPS WR/WOR methods.
- Discuss Yates, Grundy and Desraj estimators as well as sampling and non-sampling errors.

Unit I **11 Hours**

Introduction to usual notations used in sampling. Basic finite population sampling techniques: SRSWOR, SRSWR, stratified, systematic and related results on estimation of population mean/ total. Relative precision of different sampling techniques. Allocation problem in stratified sampling.

Activity: Students will solve problems related to different types of sampling techniques for estimation of population parameters.

Unit II **12 Hours**

Ratio and regression estimators based on SRSWOR method of sampling. Two-stage sampling with equal size of first stage units. Double sampling for ratio and regression methods of estimation. Cluster sampling - equal clusters.

Activity: Students will solve problems related to ratio regression, Two stage sampling method and clustering

Unit III **12 Hours**

PPS WR/WOR methods [cumulative total, Lahiri's schemes]

and related estimators of a finite population mean : [Thompson-Horwitz, Yates and Grundy estimator, Desraj estimators for a general sample size and Murthy's estimator for a sample of size 2].

Activity: Students will solve problems related to PPS method using different estimators.

Unit IV **10 Hours**

Sampling and Non-sampling errors with special reference to non-response problems. National sample surveys office (NSSO) and role ofvarious statistical organizations in national development.

Activity: Students will get understanding about different statistical organizations and their roles.

Transaction mode: Lecture/Co Operative learning/ Practical/ Group discussion/Team teaching /Tutorial/Problem solving/Self-learning.

Suggested Readings:

1. A. Chaudhuri, *Essentials of Survey Sampling*, Prentice Hall of India, 2010.
2. A. Chaudhari and H. Stenger, *Survey Sampling Theory and Methods*, 2nd Edition, Chapman and Hall, 2005.
3. D. Raj and P. Chandak, *Sampling Theory*, Narosa, 1988.
4. D. Singh and F.S. Chaudhary, *Theory and Analysis Of Sample Survey Designs*, John Wiley & Sons, 1986.
5. P. Mukhopadyay, *Theory and Methods of Survey Sampling*, 2nd Edition, Prentice Hall of India, 2008.
6. P.V. Sukhatme and P.V. Sukhatme, *Sampling Theory of Surveys with Applications*, Asia Publishing House, New edition, 1970.
7. S. K. Thompson, *Sampling*, John Wiley and Sons, New York, 2002.
8. W. G. Cochran, *Sampling Techniques*, John Wiley & Sons, New York, 1977.

Course Title: Sampling Theory (Practical)
Course Code: STA.524
Total Hours: 30

L	T	P	Credits
0	0	2	1

Learning Outcome:

The students will be able

- Explain various methods of sampling and estimation of population parameters.

- Understand the concept of efficiency of various sampling methods

Laboratory Work: Programming exercises on statistical software tools like R.

1. To find an estimate of population's means for SRSWOR from observations.
2. To find an estimate of population total for SRSWOR from observations.
3. To find an estimate of population's means for SRSWR from observations.
4. To find an estimate of population total for SRSWR from observations.
5. To compare the efficiency of SRSWR and SRSWOR from observations.
6. To find an estimate of population mean for stratified sampling technique from observations.
7. To find an estimation of population total for stratified sampling technique from observations.
8. Relative precision of stratified and other sampling techniques.
9. Relative precision of systematic and other sampling techniques
10. Derive regression estimator based on SRSWOR.
11. Derive ratio estimator based on SRSWOR.
12. Derive values for Double sampling under ratio and regression methods of estimation.

Transaction mode: Lecture/Co Operative learning/ Practical/ Group discussion/Team teaching /Tutorial/Problem solving/Self-learning.

Course Title: Distribution Theory
Course Code: STA.513
Total Hours: 45

L	T	P	Credits
3	0	0	3

Learning Outcomes: The students will be able to

- Explain random experiments, probability distributions.
- Classify various probability distributions.
- Make use of discrete and continuous distributions.
- Justify compound, truncated and mixture distributions.
- Discuss order statistics and convolution of two distributions.

Unit I **12 Hours**

Discrete distributions: Uniform, Bernoulli, Binomial, geometric, Negative Binomial, hyper-geometric, Poisson, Continuous Distributions: Uniform, normal, exponential, gamma, Beta, Cauchy, Weibull, Pareto, Lognormal distributions their properties and applications.

Activity: Students will learn various forms of probability distributions. They will solve various problems related to applications part of these distributions.

Unit II **11 Hours**

Discrete and continuous bivariate random variables: Definitions, computation of probabilities of various events, marginal, conditional, product moments and correlations. The p. d. f. of a bivariate normal distribution, marginal and conditional distributions, conditional expectation and conditional variance.

Activity: Students will explore characteristics of various discrete and continuous bivariate distributions and solve problems related to them,

Unit III **11 Hours**

Moment generating and probability generating functions. Functions of random variables and their distributions using Jacobian of transformation and other tools. Compound, truncated and mixture distributions. Convolutions of two distributions.

Activity: Students will explore moment generating function and probability generating function and solve problems related to them.

Unit IV **11 Hours**

Order statistics and joint, marginal and conditional distributions (univariate and bivariate continuous case only). The distribution of sample range.

Activity: Students will explore about Order statistics and its properties. They solve various problems related with order statistics.

Transaction mode: Lecture/Co Operative learning/ Practical/ Group discussion/Team teaching /Tutorial/Problem solving/Self-learning.

Suggested Readings:

1. E. J. Dudewicz and S. N. Mishra, *Modern Mathematical Statistics*, Wiley International Student Edition, 1988.
2. G. Gupta and D. Gupta, *An Outline of Statistical Theory*, Vol. I, World Press, 1991.
3. H.A. David and H. N. Nagaraja, *Order Statistics*. John Wiley & Sons, Inc., 1970.
4. I. Miller and M. Miller, *Mathematical Statistics*, 6th Edition, Oxford &IBH Pub., 1999.
5. P. Mukhopadhyay: *Mathematical Statistics*, New central Book Agency(P) Ltd. Calcutta, 1996.
6. P. L. Meyer, *Introductory Probability and Statistical Applications*, 2nd Edition, Oxford & Lbh, 2017.
7. S. M. Ross, *Introduction to Probability Models*, 11th Edition, 2014.
8. V. K. Rohtagi and A. K. M. E. Saleh, *An Introduction to Probability Theory and Mathematical Statistics*, Wiley Eastern, 2010.

Course Title: Linear Models and Regression

L	T	P	Credits
3	0	0	3

Course Code: STA.526

Total Hours: 45

Learning Outcomes: The students will be able to

- Explain linear model.
- Classify between point and interval estimates.
- Make use of g-inverse for estimation of parameters in linear models.
- Justify ANOVA, ANCOVA, Logit, Probit model
- Discuss Bivariate, Multiple and polynomials regression.

Unit I **11 Hours**

Linear model, least squares estimates, best linear unbiased estimates, Gauss-Markoff set-up, normal equations, Point and interval estimates construction of confidence intervals of the parameters of linear model.

Activity: Students will explore about Gauff Markoff Setup and solve various problems related to point and interval estimation.

Unit II **11 Hours**

Interval estimation for regression coefficients β_0, β_1, σ^2 and Interval estimation of the mean response. Use of g-inverse, statements and applications of fundamental theorems of least squares.

Activity: Students will construct confidence interval for various parameters of linear regression models.

Unit III **11 Hours**

Introduction to fixed, mixed and random effect models. Tests of significance and interval estimates based on least squares theory in one-way and two-way classified data.

Activity: Students will learn about various forms of models and test for the significance of their parameters.

Unit IV **12 Hours**

Analysis of variance (ANOVA*) and* analysis *of* covariance (ANCOVA). Fundamental concept of generalized linear model (GLM), exponential family of random variables. Link functions such as Logit, Probit, binomial. Residuals and their plots as tests for departure from assumptions of fitness of the model normality, homogeneity of variances.

Activity: Students will explore generalized linear models and ANCOVA. Students will solve problems related to testing of the assumptions of various models.

Transaction mode: Lecture/Co Operative learning/ Practical/ Group discussion/Team teaching /Tutorial/Problem solving/Self-learning.

Suggested Readings:

1. A. Sen and M. Srivastava, *Regression Analysis: Theory, Methods, and Applications,* illustrated Edition, Springer, 2014.
2. C. R. Rao, *Linear Statistical Inference and its Applications*, 2nd Edition, Wiley, 2009.
3. D. C. Montgomery, E. A. Peck and G. G. Vining, Introduction to Linear Regression Analysis, 5th Edition, Wiley, 2013.
4. F. A. Graybill, *An Introduction to Linear Statistical Models*, Vol. 1, McGraw-Hill Book, 1961.
5. N. R. Draper and H. Smith, *Applied Regression Analysis*, 3rd Edition, Wiley, 2014.
6. R. D. Cook and S. Weisberg, *Residual and Influence in Regression*, Chapman & Hall, 1982.
7. S. Weisberg, *Applied Linear Regression*, 4th Edition, Wiley, 2013.

Course Title: Demography and Vital Statistics
Course Code: STA.559
Total Hours: 45

L	T	P	Credits
3	0	0	3

Learning outcomes:
The students will be able to

- Understand the concept of population theories.
- Explain stochastic models for reproduction.
- Explain different measures of mortality.
- Discuss stochastic models for migration.
- Get in-depth understanding of methods for population projection.

Unit I **12 Hours**

Population Theories: Coverage and content errors in demographic data, use of balancing equations and Chandrasekharan-Deming formula to check completeness of registration data, Adjustment of age data use of Myer and UN indices Population composition, dependency ratio.

Activity: Students will explore various methods to check the completeness of registration data.

Unit II **11 Hours**

Measures of fertility: stochastic models for reproduction, distribution of time to first birth, inter-live birth intervals and of number of births, estimation of parameters, estimation of parity progression ratio from open birth interval data.

Activity: Students will explore various measures of fertility and solve various examples related to them.

Unit III **11 Hours**

Measures of Mortality: Construction of abridged life tables, Distribution of life table functions and their estimation. Stable and quasi-stable populations, intrinsic growth rate. Models for population growth and their fitting to population data. Stochastic models for population growth.

Activity: Students will explore various measure of mortality and solve various examples related to fitting models to population data.

Unit IV **11 Hours**

Stochastic models for migration and for social and occupational mobility based on Markov chains. Estimation of measures of mobility. Methods for population projection.

Activity: Students will explore various stochastic models for population projection.

Transaction mode: Lecture/Co Operative learning/ Practical/ Group discussion/Team teaching /Tutorial/Problem solving/Self-learning.

Suggested Readings:

1. D. I. Bartholomew, *Stochastic Models for Social Process*, John Wiley, 1982.
2. M. Spiegelman, *Introduction to Demography Analysis*, Harvard University press, 1969.
3. N. Keyfitz, *Applied Mathematical Demography*, Springer Verlag, 1977.
4. N. Keyfitz, J. A. Beckman, *Demography through Problems*, S-Verlag New York, 1984.
5. P. R. Cox, *Demography*, Cambridge University press, 1970.
6. R. Ramkumar, *Technical Demography*, New Age International, 1986.
7. S. Biswas, *Stochastic Process in Demography and Applications*, Wiley Eastern Ltd., New Delhi, 1988.

Course Title: Basic Statistics (IDC)
Course Code: STA.510
Total Hours: 30

L	T	P	Credits
2	0	0	2

Learning outcomes:

The student will be able to

- Explain descriptive statistics, probability distributions.
- Classify measures of central tendency and dispersion.

- Make use of basic approaches to probability.
- Justify axiomatic approach to probability.
- Discuss application of discrete and continuous random variables.

Unit I **07 Hours**

Descriptive Statistics: Meaning, need and importance of statistics. Attributes and variables. Measurement and measurement scales. Collection and tabulation of data. Diagrammatic representation of frequency distribution: histogram, frequency polygon, frequency curve, ogives, stem and leaf plot, pie chart.

Activity: Students will construct important statistical plots with the help of real data.

Unit II **08 Hours**

Measures of central tendency, dispersion (including box and whisker plot), skewness and kurtosis. Data on two attributes, independence and association of attributes in 2x2 tables. Simple linear regression and correlation (Karl Pearson's and Spearman's) and residual plots.

Activity: Students will learn the concept of dependence via correlation and regression analysis.

Unit III **07 Hours**

Random experiments, sample spaces (finite and infinite), events, algebra of events, three basic approaches to probability, combinatorial problems, conditional probability, Bayes' formula.

Activity: Students will explore the concept of random experiments and learn the use of probability in daily life.

Unit IV **08 Hours**

Random variables (discrete and continuous). Distribution Function and its properties, mean and variance. Discrete Distributions: Bernoulli, Binomial, Poisson, geometric. Continuous Distributions: Uniform, exponential, normal.

Activity: Students will explore the concept of discrete and continuous distributions will apply these models in practical applications.

Transaction mode: Lecture/Co Operative learning/ Practical/ Group discussion/Team teaching /Tutorial/Problem solving/Self-learning.

Suggested Readings:

1. F. E. Croxton and D. J. Cowden, *Applied General Statistics*, 2nd Edition, Pitman, 1962.
2. P. G. Hoel, *Introduction to Mathematical Statistics*, 4th Edition, New York, John Wiley and Sons, 1971.
3. W. W. Daniel and C. L. Cross, *Biostatistics: A Foundation*

for Analysisin the Health Sciences, 10th Edition, Wiley & Sons, 2013.

Semester II

L	T	P	Credits
3	0	0	3

Course Title: Statistical Inference
Course Code: STA.521
Total Hours: 45

Learning outcomes:
The students will be able to

- Learn different estimation techniques.
- Identify a good estimator.
- Learn the concept of MVUE and UMVUE.
- Establish various properties of likelihood estimators.
- Understand the concept of statistical inference under Bayesian framework.
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Unit I **12 Hours**

Statistic and its sampling distributions, Concept of mean squared errors. Basic concepts of point estimation: Unbiasedness, consistency and efficiency of estimators. Examples from some standard discrete and continuous distributions. Sufficiency and minimal sufficiency, Exponential family of distributions, Factorization criteria, Completeness.

Activity: Students will explore the basic concept of parametric estimation. They will learn how to extract a good estimator among the huge class of estimators.

Unit II **12 Hours**

Minimum and uniformly minimum variance unbiased estimation, Rao-Blackwell and Lehmann-Scheffe theorems. Ancillary statistic, Basu's theorem and its applications. Fisher information measure, Cramer-Rao inequality, Chapman-Robin inequality, Bhattacharya bounds.

Activity: Students will learn the concept of Fisher information measure and will construct some important lower bounds for variance.

Unit III **11 Hours**

Methods of estimation: Method of moments, Maximum likelihood estimators, Properties of maximum likelihood estimators, Least square estimation, Minimum chi- square method.

Activity: Students will explore various methods of parameter estimation and will establish its statistical properties.

Unit IV **10 Hours**

Introduction to Bayesian Statistics and its applications: Loss function, Prior distribution, Bayes' theorem, Posterior distribution, Bayes' risk, Bayes' principle, Bayesian

estimation, Properties of Bayesian estimator.

Activity: Students will learn basic concepts of Bayes' estimation.

Transaction mode: Lecture/Co Operative learning/ Practical/ Group discussion/Team teaching /Tutorial/Problem solving/Self-learning.

Suggested Readings:

1. A. K. M. E. Saleh and V. K. Rohatgi, *An Introduction to Probability and Statistics*, 2nd Edition, Wiley, 2008.
2. B. K. Kale, *A First Course on Parametric Inference*, Narosa Publishing House, 1999.
3. C. R. Rao, *Linear Statistical Inference and its Applications*, 2nd Edition, Wiley, 2002.
4. E. J. Dudewicz and S. N. Mishra, *Modern Mathematical Statistics*, Wiley International Student Edition, 1988.
5. E. L. Lehmann, *Theory of Point, Estimation*, Student Edition, John Wiley & Sons, 1986.
6. G. Casella and R. L. Berger, *Statistical Inference*, 2nd Edition, Duxbury Thomson Learning, 2008.

Course Title: Statistical Inference (Practical)
Course Code: STA.522
Total Hours: 30

L	T	P	Credits
0	0	2	1

Laboratory experiments will be set in context with the materials covered in theory classes of Statistical Inference-I.

Learning Outcome: The students will be able

- Understand the basic techniques used in parametric estimation.
- Explain the concepts of selection of a better estimator based on sample.
- Understand the basic packages used in inferential statistics.

Laboratory Work:

1. To find an estimate in normal population.
2. To demonstrate consistence using data.
3. To demonstrate methods of moments using data.
4. To calculate maximum likelihood estimation in single parametric model.
5. To obtain maximum likelihood estimation in multiparametric model.
6. To find an estimate of population mean for stratified sampling technique from observations.
7. To find least squares estimates in regression model.
8. To find Bayes estimates in desecrate data.

Transaction mode: Lecture/Co Operative learning/ Practical/ Group discussion/Team teaching /Tutorial/Problem solving/Self-learning.

Suggested Readings:

1. A. K. M. E. Saleh and V. K. Rohatgi, *An Introduction to Probability and Statistics*, 2nd Edition, Wiley, 2008.
2. B. K. Kale, *A First Course on Parametric Inference*, Narosa Publishing House, 1999.
3. C. R. Rao, *Linear Statistical Inference and its Applications*, 2nd Edition, Wiley, 2002.
4. E. J. Dudewicz and S. N. Mishra, *Modern Mathematical Statistics*, Wiley International Student Edition, 1988.
5. E. L. Lehmann, *Theory of Point, Estimation*, Student Edition, John Wiley & Sons, 1986.
6. G. Casella and R. L. Berger, *Statistical Inference*, 2nd Edition, Duxbury Thomson Learning, 2008.

Course Title: Stochastic Processes
Course Code: STA.525
Total Hours: 45

L	T	P	Credits
3	0	0	3

Learning Outcomes:
The students will be able to

- Explain Stochastic Processes.
- Classify among various forms of stochastic processes.
- Make use of random walk and counting process.
- Justify Markov Chain
- Discuss Renewal and elementary renewal process.

Unit I **12 Hours**

Introduction to Stochastic Processes. Classification of stochastic processes according to state space and time domain into discrete/continuous time, discrete/continuous state spaces, elementary problems, Random walk and Gambler's ruin problems, Counting process. Applications of stochastic processes. Stationarity of stochastic processes, Weakly stationary and strongly stationary processes.

Activity: Students will classify among various forms of stochastic processes. They will solve real life problems using the properties of stochastic processes.

Unit II **13 Hours**

Markov chains: Definition and examples of Markov Chain, Transition probability matrix, classification of states, communicating classes, recurrence: non-recurrence, Irreducibility, Stationary distribution and its interpretation. Chapman-Kolmogorov equations, n-step transition probability matrices and their limits, stationary distribution.

Activity: Students will solve problems related to Markov

chains and derive the stationarity of the distribution.

Unit III **10 Hours**

Statistical Inference for Markov Chains: Estimation of transition probabilities.

Discrete state space continuous time Markov Processes: Poisson process, Simple Birth Process, Simple Death Process, Simple Birth- Death process.

Activity: Students will explore about the various forms of stochastic processes and estimate their transition probabilities.

Unit IV **10 Hours**

Continuous State Continuous Time Markov Processes: Brownian motion process, Wiener Process and its properties.

Activity: Students will solve problems related to continuous state and continuous time stochastic processes.

Transaction mode: Lecture/Co Operative learning/ Practical/ Group discussion/Team teaching /Tutorial/Problem solving/Self-learning.

Suggested Readings:

1. B. R. Bhat, *Stochastic Models: Analysis and Applications*, New Age International India, 2000.
2. J. Medhi, *Stochastic Processes*, 2nd Ed ,Wiley Eastern Ltd., 1994.
3. N. T. Bailey, *The Elements of Stochastic Processes*, John Wiley & Sons, Inc., New York, 1965.
4. S. M. Ross, *Stochastic Processes,* Wiley Publications, 1996.
5. S. Karlin and H. M. Taylor, *A First Course in Stochastic Processes*, Vol. 1, Academic Press, 1975.

Course Title: Quality Control and Time Series

L	T	P	Credits
3	0	0	3

Course Code: STA.555

Total Hours: 45

Learning outcomes:

The students will be able to

- Understand the concept of quality technology and
  - assurance, productivity.
- Explain $\bar{X}$ and R charts, analysis of pattern on control charts, control chart for attributes- np, p, c and u charts
- Explain CUSUM, Group control charts, O. C. curve and ARL of control charts.
- Discuss Dodge's continuous sampling inspection plans .
- Get in-depth understanding of Time Series models.

Unit I **11 Hours**

The meaning of quality, quality assurance, technology and productivity. Statistical methods for quality control and improvement. Chance and assignable causes of quality variation, general theory of control charts, control charts for variables: $\bar{X}$ and R charts, analysis of pattern on control charts, control chart for attributes- np, p, c and u charts.

Activity: Students will understand about quality of the product. They will construct various charts to detect pattern in the production process.

Unit II **11 Hours**

Multiple stream processes: Group control charts. Specification limits and tolerance limits, O.C and ARL of control charts, CUSUM charts.

Activity: Students will explore various multiple stream processes and solve problems related to them.

Unit III **12 Hours**

Review of sampling inspection techniques, single, double, multiple and sequential sampling plans and their properties, methods for estimating (n, c) using large sample techniques, Dodge's continuous sampling inspection plans for inspection by variables for one-sided and two-sided specifications.

Activity: Students will use various sampling inspection techniques to make an inference about the acceptance or rejection of the lot of final product.

Unit IV **11 Hours**

Time series as discrete parameter stochastic process. Auto covariance and auto correlation functions and their properties. Moving average (MA), Auto regressive (AR), ARMA and ARIMA models. Box-Jenkins models. Choice of AR and MA periods. Estimation of ARIMA model parameters, correlogram analysis.

Activity: Students will understand various time series models and solve problems to understand their applications.

Transaction mode: Lecture/Co Operative learning/ Practical/ Group discussion/Team teaching /Tutorial/Problem solving/Self-learning.

Suggested Readings:

1. D. C. Montgomery and L. A. Johnson, *Forecasting and Time Series Analysis*, Mc Graw Hill, New York, 1976.
2. D. C. Montgomery, *Introduction to Statistical Quality Control*, 5th Edition., John Wiley & Sons, 2005.
3. G. B. Wetherill, *Sampling Inspection and Quality Control*, Halsted Press, 1977.
4. P. J. Brockwell and A. Daris Richard, *Introduction to Time*

Series And Forecasting, 2nd Edition. Springer-Verlag, New York, Inc. (Springer Texts in Statistics), 2002.

5. S. Biswas, *Statistics of Quality Control, Sampling Inspection and Reliability*, New Age International Publishers Eastern Ltd, 1996.

Course Title: Quality Control and Time Series (Practical)
Course Code: STA.556
Total Hours: 30

L	T	P	Credits
0	0	2	1

Learning outcomes:

The students will be able to

- Explain various charts and how to construct them.
- Understand the concept of multiple stream processes.
- Understand the concept of various time series models.

Laboratory Work: Experiments are from the topics of Quality Control and Time Series using SPSS/R.

1. Construct $\bar{X}$ and R charts.
2. Construct control chart for attributes- np.
3. Construct control chart for p.
4. Construct control chart for c.
5. Construct control chart for u.
6. Construct CUSUM charts.
7. understand application of single sampling plan.
8. understand application of double sampling plan.
9. compare multiple and sequential sampling plans.
10. understand methods for estimating (n, c) using large sample techniques

Transaction mode: Lecture/Co Operative learning/ Practical/ Group discussion/Team teaching /Tutorial/Problem solving/Self-learning.

Course Title: Econometrics
Course Code: STA.575
Total Hours: 45

L	T	P	Credits
3	0	0	3

Learning outcomes:

The students will be able to

- Understand the concept of OLS and GLS in general linear models (GLM).
- Explain problem of autocorrelation, multicollinearity in GLM.

- Explain Ridge regression, Linear regression with stochastic regressors.
- Discuss Simultaneous linear equations and identification problem.
- Get in-depth understanding of 2SLS estimators, k-class estimators. 3SLS estimation.

Unit I **12 Hours**

Nature of econometrics. The general linear model (GLM) and its assumptions. Ordinary least squares (OLS) estimation and prediction. Significance tests and confidence intervals, linear restrictions. Use of dummy variables and seasonal adjustment. Generalized least squares (GLS) estimation and prediction. Heteroscedastic disturbances.

Activity: Students will explore various forms of least square estimation techniques and their assumptions.

Unit II **12 Hours**

Auto correlation, its consequences and tests. Estimation and prediction. Multicollinearity problem, its implications and tools for handling the problem. Linear regression with stochastic regressors. Instrumental variable estimation, errors in variables. Autoregressive linear regression.

Activity: Students will check whether the model satisfies the assumptions of linear regression model. Students will explore various other forms of regression and solve problems related to them.

Unit III **10 Hours**

Simultaneous linear equations model, examples. Identification problem. Restrictions on structural parameters –rank and order conditions. Restriction on variance and co-variances.

Activity: Students will solve problems related to Simultaneous Linear equations.

Unit IV **11 Hours**

Estimation in simultaneous equations model. Recursive systems, 2 SLS estimators, k-class estimators. 3SLS estimation. Full information maximum likelihood method. Prediction and simultaneous confidence intervals.

Activity: Students will explore two stage and three stage linear estimators and solve problems related to them.

Transaction mode: Lecture/Demonstration/ Co Operative learning/ programming / Practical/ Group discussion/Team teaching/Experimentation/Tutorial/Problem solving/Self-learning.

Suggested Readings:

1. A. Koutsyannis, *Theory of Econometrics, Mc Millian, 2004.*
2. D. N. Gujarati, *Basic Econometrics*, 4th Edition, McGraw–Hill, 2004.

3. G. C. Judge, R. C. Hill, W. E. Griffiths, H. Lutkepohl and T. C. Lee, *Introduction to the Theory and Practice of Econometrics,* 2nd Edition, John Wiley & Sons, 1988.
4. J. Kmenta, *Elements of Econometrics*, 2nd Edition, Mac Millan, 1986.
5. J. Johnston, *Econometric Methods*, Mc Graw Hill, 1991.
6. W. H. Greene, *Econometric Analysis,* Prentice Hall, 2003.

Course Title: Econometrics (Practical)
Course Code: STA.576
Total Hours: 30

L	T	P	Credits
0	0	2	1

Learning Outcome.
The students will be able to
- Explain various forms of least square methods
- Illustrate methods to test the assumptions of the model
- Discuss Simultaneous equation model and SLS methods

Laboratory Work. Problems related to Econometrics using SPSS/R.

1. Estimate the coefficient of the variables
2. Construct confidence intervals for the coefficients
3. Test for the autocorrelation of the model
4. Test for the normality assumption of the model
5. Test for the heterogeneous of the dataset.

Transaction mode: Lecture/Co Operative learning/ Practical/ Group discussion/Team teaching /Tutorial/Problem solving/Self-learning.

Course Title: Basics of R Programming (Practical)
Course Code: STA.527
Total Hours: 30

L	T	P	Credits
0	0	2	1

Learning Outcome.
The students will be able to
- Explain various mathematical operators
- Illustrate mathematical function in R
- Discuss methods to handle dataset in R

Laboratory Work. Program related to R programming.

1. Learn the basic procedure for installation of the R software.
2. Use mathematical operators, relational operators.
3. Understand if-else function, nested loop
4. Understand for loop, while loops, break nest statement
5. Understand mathematical functions in R, random numbers in R
6. Apply Matrix operations in R
7. Apply List operators

8. Implement the concept of usage of various packages in R.
9. Develop skills to handle dataset in R.
10. Develop skills to construct graphical display, histogram, boxplot

Transaction mode: Lecture/Co Operative learning/ Practical/ Group discussion/Team teaching /Tutorial/Problem solving/Self-learning.

Suggested Reading

1. J. P. Lander, *R for Everyone, Advanced Analytics and Graphics,* Ist Edition, Pearson Education, 2014.
2. M. Gardener, *Beginning R: The Statistical Programming Language*, Wiley, 2013.

Course Title: Actuarial Statistics
Course Code: STA.528
Total Hours: 45

L	T	P	Credits
3	0	0	3

Learning outcomes: The students will be able to

- Understand the concept of probability models and life tables.
- Explain risk models for individual claims and distribution of aggregate claims.
- Explain survival, multiple, joint life and last survivor functions.
- Discuss various forms of rate of interest and their applications.
- Get in-depth understanding of assurance and annuity contracts

Unit I **10 Hours**

Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor.

Activity: Students will solve problems related to different types of interest and discounting factor.

Unit II **09 Hours**

Life tables functions like $\boldsymbol{l_x}$, $\boldsymbol{d_x}$ and probability of survival and Probability of death and their select equivalents.

Activity: Students will solve problems how to evaluate survival and death probability from life table

Unit III **10 Hours**

Define the distribution and density function of continuous future lifetime and curtate future lifetime random variable. Define force of mortality, survival function and derive relationship between them.

Activity: Students will explore the concept of future lifetime distribution, force of mortality and solve problems related to them.

Unit IV **16 Hours**

Assurance and annuity contracts: definitions of benefits and premiums, various types of assurances and annuities, present value, formulae for mean and variance of various continuous and discrete payments.

Activity: Students will learn about various types of assurance and annuity. Students will solve problems related how to derive mean and variance of these contracts.

Transaction mode: Lecture/Co Operative learning/ Practical/ Group discussion/Team teaching /Tutorial/Problem solving/Self-learning.

Suggested Readings:

1 D. S. Borowaik and A. F. Shapiro, *Financial and Actuarial Statistics: AnIntroduction*, Marcel Dekker Inc., New York-Basel, 2005.

2 N. L. Bowers, H. U. Gerber, J. C. Hickman, D. A. Jones and C. J. Nesbitt, *Actuarial Mathematics*, 2nd Edition, Society of Actuaries, USA,1997.

3 P. J. Boland, *Statistical and Probabilistic Methods in Actuarial Science*,Chapman and Hall/CRC, 2007.

4 S. A. Klugman, H. H. Panjer, G. E. Willmot and G. G. Venter, *Loss Models:From Data to Decisions*. 3rd Edition, Wiley-Interscience, 2008.

5 S. D. Promislow, *Fundamentals of Actuarial Mathematics*, 2nd Edition,Wiley, 2011.

Course Title: Statistical Methods for Insurance

L	T	P	Credits
3	0	0	3

Course Code: STA.529

Total Hours: 45

Learning outcomes:

The students will be able to

- Understand the concept of Insurance.
- Explain Insurance contracts.
- Classify insurance in life and non-life insurance.
- Discuss ruin theory.
- Get in-depth understanding of Bayesian inference and credibility theory.

Unit I **11 Hours**

Review of Loss distributions: Classical loss distributions, heavy-tailed distributions, reinsurance and loss distributions. Reinsurance and effect of inflation.

Activity: Students will learn about loss distribution used in insurance sector.

Unit II **12 Hours**

Risk models for aggregate claims: Collective risk model and individual risk model, premiums and reserves for aggregate claims, reinsurance for aggregate claims.

Activity: Students will learn various types of risk models and solve problems related to them.

Unit III **11 Hours**

Ruin theory: Surplus process in discrete time and continuous time, probability of ruin in finite and infinite time, adjustment coefficient, Lundberg inequality, applications in reinsurance.

Activity: Students will learn the concept of ruin theory and solve application part of ruin theory in insurance sector.

Unit IV **11 Hours**

Introduction to Bayesian inference, Credibility Theory, Full credibility for claim frequency, claim severity and aggregate loss. Bayesian credibility, Empirical Bayes credibility.

Activity: Students will learn about the concept of Bayesian inference and credibility theory and solve problems related to them.

Suggested Readings:

1. D. C. M. Dickson, *Insurance Risk and Ruin*, Cambridge University Press, Cambridge,2005.
2. E. S. Harrington and R. Gregory, *Risk Management and Insurance*: 2nd ed., Tata McGraw Hill Publicating Company Ltd. New Delhi,1998.
3. J. Grandell, *Aspects of Risk Theory*, Springer-Verlag, New York, 1990.
4. N. L. Bowers, H. U. Gerber, J. C. Hickman, D. A. Jones, and C. J. Nesbitt, *Actuarial Mathematics*, Second Edition, The Society of Actuaries. Sahaumburg, Illinois, 1984.
5. P. J. Boland, *Statistical and Probabilistic Methods in Actuarial Science*. Chapman & Hall, London, 2007.
6. S. Ramasubramanian, *Lectures on Insurance Models*, Hindustan Book Agency Texts and Readings in Mathematics, 2009.
7. T. Mikosch, *Non-Life Insurance Mathematics- An Introduction with a Poisson Process*, Springer, Berlin, 2004.

Course Title: Operations Research

Course Code: STA.511

Total Hours: 45

L	T	P	Credits
3	0	0	3

Learning outcomes:

The students will be able to

- Discuss the concept of convex sets and linear programming problems with formulation.
- Apply different methods to solve linear programming problems.
- explore the concept of Duality theory and Sensitivity analysis.

- Explain transportation problems and assignment problems with their mathematical formulation.
- Apply methods to test the optimality of transportation problems.
- Develop understanding of Queuing and inventory models.

Unit-I **11 Hours**

Mathematical formulation of linear programming problem, Linear Programming and examples, Convex Sets, Hyper plane, Open and Closed half-spaces, Feasible, Basic Feasible and Optimal Solutions, Extreme Point & graphical methods.

Activity: Students will formulate linear programming problems and find solutions with graphical methods.

Unit-II **12 Hours**

Simplex method, Big-M method, Two phase method, Determination of Optimal solutions, Unrestricted variables. Duality theory, Dual linear Programming Problems, Fundamental properties of dual problems, Complementary slackness, Unbounded solution in Primal. Dual Simplex Algorithm.

Activity: Students will do problems to find solutions through Simplex method, Big-M method and two phase method. They will do exercise of dual linear programming problems.

Unit-III **12 Hours**

Sensitivity analysis: Discrete changes in the cost vector, requirement vector and coefficient matrix.

The General transportation problem, Duality in transportation problem, Loops in transportation tables, Solution of transportation problem, Test for optimality, Degeneracy, Transportation algorithm (MODI method), Minimization transportation problem.

Activity: Students will do exercises on Sensitivity analysis and transportation problems.

Unit -IV **10 Hours**

Assignment Problems: Mathematical formulation of assignment problem, Hungarian method for solving assignment problems, Traveling salesman problem. Sequencing Problem: General assumptions and basic terms used in sequencing. Processing n jobs through 2 machines, Processing n jobs through 3 machines.

Activity: Students will do exercises on Assignment problem and sequencing problem

TRANSACTION MODE: Lecture/Demonstration/Project Method/ Co Operative learning/ Seminar/Group discussion/Team teaching /Tutorial/Problem solving/E-team teaching/Self-learning.

Suggested Readings:

1. G. Hadley, *Linear Programming*, Narosa Publishing House, New Delhi, 1987.

2. H. A. Taha, *Operations Research - An Introduction*, Macmillan Publishing Company Inc., New York, 2006.
3. K. Swarup, P. K. Gupta, and M. Mohan, *Operations Research*, Sultan Chand & Sons, New Delhi, 2001.
4. N. S. Kambo, *Mathematical Programming Techniques*, Affiliated East- West Press Pvt. Ltd., 1984, Revised Edition, New Delhi, 2005.
5. S. M. Sinha, *Mathematical Programming, Theory and Methods,* Delhi: Elsevier, 2006.

Course Title: Linear Programming (VAC)

Course Code: MAT.528

Total Hours: 30

L	T	P	Credits
2	0	0	2

Learning outcomes:

The students will be able to

- Discuss the linear programming problem with formulation.
- Apply different methods to solve linear programming problem.
- Understand the concept of Duality theory and Sensitivity analysis.
- Explain transportation problem and assignment problem with their mathematical formulation.

Unit-I **08 Hours**

Formulation of linear programming problems (LPP).Graphical solution to LPPs. Cases of unique and multiple optimal solutions.

Activity: Students will do formulation of Linear programming problem and find the solutions using graphical method.

Unit-II **08 Hours**

Feasible solution, basic feasible solutions, Optimal solution, Convex sets, Solution of LPP with Simplex methods.

Activity: Students will solve linear programming problems with simplex method.

Unit-III **06 Hours**

The dual problem. Formulation of the dual. Dual Simplex method.

Activity: Students will do exercises related to dual linear programming problems.

Unit-IV **08 Hours**

Transportation and Assignment Problem: Transportation problems, Formulation of transportation problem, Feasible and optimal solution of transportation problems. Assignment problems.

Activity: Students will do exercises on transportation problems and assignment problems.

TRANSACTION MODE: Lecture/Demonstration/Project Method/ Co Operative learning/ Seminar/Group discussion/Team teaching /Tutorial/Problem solving/E-team teaching/Self-learning.

Recommended Books:

1. H. A. Taha, *Operations Research - An Introduction,* Macmillan Publishing Company Inc., New York, 2006.
2. K .Swarup, P. K. Gupta and Man Mohan, *Operations Research*, Sultan Chand & Sons, New Delhi, 2001.
3. F. S. Hillier and G. J. Lieberman, *Introduction to Operations Research*, McGraw-Hill, New York, 2001.

Semester III

Course Title: Research Methodology
Course Code: STA.502
Total Hours: 60

L	T	P	Credits
4	0	0	4

Learning outcomes:
The students will be able to

- Explain the various terms like objective, meaning of research, significance research etc. which is used in research.
- Review the basic concepts of literature survey and formulation research problems.
- Basic concepts of the research design.
- Review the basic concepts of the research writing problems.

Unit-I **14 Hours**

Introduction: Meaning, Objectives, Characteristics, Significance, and Types of Research; Research Approaches, Research Methods vs. Research Methodology, Research Process, and Criteria of Good Research.

Activity: Students will gain theoretical and practical knowledge of a specific area of research.

Unit-II **16 Hours**

Literature Survey and Review: Meaning of Literature Survey and Review, Sources of Literature, Methods of Literature Review, and Techniques of Writing the Reviewed Literature. **Formulating Research Problem:** Understanding a Research Problem, Selecting the Research Problem, Steps in Formulation of a Research Problem, Formulation of Research Objectives, and Construction of Hypothesis.

Activity: Students will gain a literature survey and formulate research problems of a specific area of research.

Unit-III **14 Hours**

Research Design: Meaning of and Need for Research Design, Characteristics of a Good Research Design, Different Research Designs, Basic Principles of Experimental Designs, Data Collection, Processing, and Interpretation.

Activity: Students will explore the concept of research design and data collection of a research problem of a specific area of research.

Unit-IV **16 Hours**

Report Writing: Types of Reports – Technical and Popular Reports, Significance of Report Writing, Different Steps in Writing Report, Art of Writing Research Proposals, Research Papers, Project Reports, and Dissertations/Thesis; Basics of Citation and Bibliography/Reference Preparation Styles; Report Presentation: Oral and Poster Presentations of Research Reports.

Activity: Students will explore the concept of the report writing and

report presentation of a research problem.

TRANSACTION MODE: Lecture/Demonstration/Project Method/ Co Operative learning/ Seminar/Group discussion/Team teaching/Tutorial/Problem solving/E-team teaching/Self-learning.

Suggested Readings:

1. Anderson, J. (2001): *Thesis and Assignment Writing*, 4th ed., Wiley, USA
2. Dawson, Catherine, (2014): *Practical Research Methods,* New Delhi, UBS Publishers' Distributors.
3. Gray, David E. (2004): *Doing Research in the Real World*. London, UK: Sage Publications.
4. Kothari, C.R. and G. Garg (2014): *Research Methodology*: Methods and Techniques, 3rd ed., New Age International Pvt. Ltd. Publisher
5. Kumar, R. (2014): *Research Methodology – A Step-By-Step Guide for Beginners*, 4th ed., Sage Publications.

Course Title: Multivariate Analysis
Course Code: STA.551
Total Hours: 45

L	T	P	Credits
3	0	0	3

Learning Outcomes:

The students will be able to

- Learn various important properties of multivariate normal distribution.
- Analyze multivariate data.
- Understand multivariate hypothesis tests and infer appropriate conclusions.
- Use the Wishart distribution in real applications.
- Explore the principles of data reduction technique

Unit I **11 Hours**

Multivariate normal distribution: Definition, conditional & marginal distributions, characteristic function. Maximum likelihood estimators of parameters. Distributions of sample mean vector and variance-covariance matrix and their independence.Null distribution of partial and multiple correlation coefficient. Application in testing and interval estimation.

Activity: Students will explore the concept of multivariate normal distribution and will obtain its MLEs. Students will also apply multivariate normal population in testing and interval estimation.

Unit II **12 Hours**

Hotelling's T^2 , its distribution and applications. One sample, two sample and application in tests on mean equality of the components of a mean vector in a multivariate normal

population. Mahalanobis D^2 and its sampling distribution.

Activity: Students will learn the generalization of Studen's t-distribution and will use it in one sample and two sample problems.

Unit III **11 Hours**

Wishart distribution and its properties. Distribution of sample generalized variance. Classification and discriminant procedure for discriminating between two multivariate normal populations, Sample discriminant function and related tests. Probabilities of misclassification and their estimation.

Activity: Students will learn about classification and discriminant procedure for discriminating between two multivariate normal populations.

Unit IV **11 Hours**

Generalised variance, Wilk's criterion and Multivariate Analysis of Variance [MANOVA] of one-way classified data. Testing independence of sets of variates and equality of covariance matrices. Principle components, dimension reduction, canonical variables and canonical correlation: definition, use, estimation and computation.

Activity: Students will explore the concept of data reduction and also learn about canonical correlation.

Transaction mode: Lecture/Demonstration/ Co Operative learning/ programming / Practical/ Group discussion/Team teaching/Experimentation/Tutorial/Problem solving/Self-learning.

Suggested Readings:

1 A. M. Kshirsagar, *Multivariate Analysis*, Illustrated Edition, Marcel Dekker, 1972.

2 N. C. Giri, *Multivariate Statistical Inference*. 1st Edition, Academic Press, 1977.

3 R. A. Johnson and D. Wichern, *Applied Multivariate Statistical Analysis*, 6th Edition, Pearson, 2008.

4 T. W. Anderson, *An Introduction to Multivariate Statistical Analysis*, 3rd Edition, John Wiley & Sons, 2009.

5 W. K. Hardly and L. Simor, *Applied Multivariate Statistical Analysis,* 4th Edition,Springer-Verlag Berlin Heidelberg, 2015.

Course Title: Multivariate Analysis (Practical)

Course Code: STA.552

Total Hours: 30

L	T	P	Credits
0	0	2	1

Laboratory experiments will be set in context with the materials covered in theory.

Learning Outcome:

The students will be able

- Understand the basic techniques used in multivariate modelling.

- Explain the concepts of multiple correlation in data.
- Understand the principle of data reduction.

Laboratory Work: Students will be able to

1. Generation of multivariate normal data of the given dependence.
2. To demonstration of various types of graphs in multivariate data.
3. To construct variance-covariance matrix using a multivariate data.
4. To construct correlation matrix of a data.
5. To construction of confidence interval in multivariate normal population.
6. To explore the concept of data reduction via PCA.
7. To demonstrate factor analysis.
8. To explore MANOVA.

Transaction mode: Lecture/Demonstration/ Co Operative learning/ programming / Practical/ Group discussion/Team teaching/Experimentation/Tutorial/Problem solving/Self-learning.

Suggested Readings:

1.A. M. Kshirsagar, *Multivariate Analysis*, Illustrated Edition, Marcel Dekker, 1972.

2. N. C. Giri, *Multivariate Statistical Inference*. 1st Edition, Academic Press, 1977.
3. R. A. Johnson and D. Wichern, *Applied Multivariate Statistical Analysis*, 6th Edition, Pearson, 2008.
4. T. W. Anderson, *An Introduction to Multivariate Statistical Analysis*, 3rd Edition, John Wiley & Sons, 2009.
5. W. K. Hardly and L. Simor, *Applied Multivariate Statistical Analysis,* 4th Edition,Springer-Verlag Berlin Heidelberg, 2015.

Course Title: Design and Analysis of Experiment

L	T	P	Credits
3	0	0	3

Course Code: STA.553
Total Hours: 45
Learning Outcomes: The students will be able to

- Discuss three basic principle of design of experiments.
- Apply the concept of balancing.
- Understand the concept of missing plot techniques.
- Develop understanding of Balanced Incomplete Block Design, Split-Plot Design and Strip-Plot Design.

Unit I **12 Hours**

Three basic principles of design of experiments: Randomization, replication and local control. Fixed effect and random effect model. Design useful for elimination of heterogeneity, Completely randomized, randomized complete block design.

Activity: Students will learn about three basic principle of design of experiments. They will also solve problems related to CRD and RCBD.

Unit II **11 Hours**

Balanced incomplete block designs and their applications. Asymptotic relative efficiency of various designs, Missing plot technique. Latin squares, Graeco Latin squares design.

Activity: Students will understand the concept of BIBD and solve problems related to Latin square and Graeco Latin Square Design.

Unit III **11 Hours**

Factorial designs, 2^2 and 2^3 factorial designs, confounding, fractional replication.

Activity: Students will understand the concept of Factorial designs and solve problems related to them.

Unit IV **11 Hours**

Nested Designs: Split-plot Design, Strip-plot Design.

Activity: Students will learn about Split-plot design and strip plot design and understand their application in real life.

Transaction mode: Lecture/Demonstration/ Co Operative learning/ programming / Practical/ Group discussion/Team teaching/Experimentation/Tutorial/Problem solving/Self-learning.

Suggested Readings:

1. D. C. Montgomery, *Design and Analysis of Experiment*, 7th Edition, John& sons, Wiley, 2008.

2. D. Raghavarao, *Construction and Combinatorial Problems in Design ofExperiments*, Wiley, 1971.
3. M. C. Chakarbarti, *Mathematics of Design and Analysis of Experiments*, Asia Publishing House, 1970.
4. M. N. Dass and N. C. Giri, *Design and Analysis of Experiments*, 2nd Edition, Wiley, 1986.
5. O. Kempthorne, *Design and Analysis of Experiments, 2nd Edition, Vol I-II*, Wiley, 2007.
6. W. G. Cochran and G. M. Cox, *Design of Experiments*, 2nd Edition, John Wiley & Sons, 2003.

Course Title: Design and Analysis of Experiment (Practical)

L	T	P	Credits
0	0	2	1

Course Code: STA.554

Total Hours: 30

Learning Outcome:

The students will be able to

- Explain various models related to design of experiments
- Understand the statistical analysis of various designs
- Discuss the comparison of various design among themselves.

Laboratory Work: Practical will be set in context with the materials covered in theory using R/SPSS.

- Use one-way ANOVA for testing of mean
- Conduct an experiment of fitting fixed effect model
- Conduct an experiment of fitting mixed effect
- Conduct an experiment for testing for equality of blocks.
- Conduct an experiment for fitting of BIBD
- Conduct an experiment for fitting of LSD
- Conduct an experiment for fitting of Split Plot Design
- Conduct an experiment for fitting of Strip Plot Design

Transaction mode: Lecture/Demonstration/ Co Operative learning/programming / Practical/ Group discussion/Team teaching/Experimentation/Tutorial/Problem solving/Self-learning.

Course Title: Stochastic Finance and Machine Learning in Insurance

L	T	P	Credits
3	0	0	3

Course Code: STA.557

Total Hours: 45

Learning Outcomes:

The students will be able to

- Understand the mechanism of options markets.
- Explain Brownian motion and Weiner Process.
- Explain Black- Scholes Model.
- Discuss various forms of Clustering.
- Get in-depth understanding of Machine learning algorithms.

Unit I **12 Hours**

Mechanism of Options markets, Types of Options, Option positions, Derivatives, Underlying Assets, Specification of stock options, Stock option pricing, Factors affecting option prices, Upper and lower bounds for option prices.

Activity: Students will understand various types of options and its position. They will also explore the concept of derivatives and its role in stock market.

Unit II **11 Hours**

Trading strategies involving options, Binomial model: One-step and two-step models, Binomial trees. Risk neutral valuation.

Brownian Motion, Weiner Process, Quadratic Variation, Arithmetic and Geometric Brownian motion.

Activity: Students will explore the concept of Binomial model and Brownian motion and its applications by solving problems.

Unit III **11 Hours**

Review of basic properties and related martingales, Applications to insurance problems, Ito Lemma, Ito integral, Applying Ito Lemma. Black-Scholes model: Distribution of rate of returns, volatility, risk neutral pricing.

Activity: Students will understand the concept of martingales and application to insurance sector.

Unit IV **11 Hours**

Basics: Introduction to Machine Learning - Different Forms of Learning Classification: Classification tree, SVM, Instance Based Classification, LDA.

Activity: Students will have hand on experience of various machine learning algorithm and its applications through examples.

Suggested Readings

1. C. Bishop, *Pattern Recognition and Machine Learning*. Springer, 2010.
2. E. S. Steven, *Stochastic Calculus for Finance I: The Binomial Asset Pricing Models*, Springer, 2005.
3 J. C. Hull and S. Basu, *Options, Futures and Other Derivatives*, 3rd Prentice Hall of India Private Ltd., New Delhi, 2010.
4 J. Han and M. Kamber, *Data Mining: Concept and Techniques,* 3rd Edition, Elsevier, USA, 2012.
5. M. S. Joshi, *The Concept and Practice of Mathematical Finance*, 2nd Edition, Cambridge University Press, 2008.
6. R. O. Duda, P. E. Hart and D. G. Stork, *Pattern Classification,* 2nd edition, Wiley-Blackwell, 2000.

7. S. M Ross, *An Elementary Introduction to Mathematical Finance*, Cambridge University Press, 2005.
8. T. Hastie, R. Tibshirani and J. Friedman, *Elements of Statistical Learning*, 9th Edition, Springer, 2017.
9. T. Mitchell, *Machine Learning*. Mc-Graw Hill, 2017.

Course Title: Non-parametric Inference

L	T	P	Credits
3	0	0	3

Course Code: STA.560
Total Hours: 45
Learning Outcomes:
The students will be able to

- Explain estimable parametric function.
- Apply the concept of empirical distribution function.
- Understand test for randomness.
- Discuss about Rank Statistics and its limiting distribution.

Unit I **11 Hours**

Estimable parametric functions, kernel, symmetric kernel, one sample U-Statistic. Two sample U-Statistic, asymptotic distribution of U-Statistics, UMVUE property of U-Statistics. Probability Inverse Transformation method and its application. Empirical distribution function, confidence intervals based on order statistics for quantiles, tolerance regions.
Activity: Students will understand the concepts of empirical distribution and U-Statistic.

Unit II **11 Hours**

Tests for randomness: Tests based on the total number of runs and runs up and down. Rank-order statistics. One sample and paired-sample techniques: sign test and signed-rank test. Goodness of fit problem: Chi-square and Kolmogorov-Smirnov tests. Independence in bivariate sample: Kendall's and Spearman's rank correlation.
Activity: Students will understand the various concepts non-parametric tests.

Unit III **11 Hours**

The General Two sample Problem: Wald Wolfwitz run test and Kolmogorov –Smirnov two sample test. Linear Rank Statistics: Linear Rank Statistics and its limiting distribution, Rank test, MP and LMP rank tests.
Activity: Students will understand the problems of rank test.

Unit IV **12 Hours**

General two sample location and scale problem: Tests for two-sample location problem: Wilcoxon-Mann-Whitney, Terry-Hoeffding, Kruskal-Wallis, Jonckheere- Terpstra tests. Concepts of Jackknifing, method of Quenouille for reducing bias, Bootstrap methods.
Activity: Students will understand the concepts of bootstrap.

Transaction mode: Lecture/Demonstration/ Co Operative learning/ programming / Practical/ Group discussion/Team teaching/Experimentation/Tutorial/Problem solving/Self-learning.

Suggested Readings:

1. A. C. Davison and D. V. Hinkley, *Bootstrap Methods and their Applications*, Cambridge University Press, 1997.
2. J. D. Gibbons and S. Chakraborti, *Nonparametrics Statistical Inference*, 2nd Edition, Marcel Dekker, Inc, 2003.
3. L. Wasserman, *All of Nonparametric Statistics*, 1st Edition, Springer, 2005.
4. M. L. Puri and P. K. Sen, *Nonparametric Methods in Multivariate Analysis*, John Wiley and Sons, 1971.
5. R. H. Randles and D. A. Wolfe, *Introduction to the Theory of Nonparametric Statistics*, Wiley, 1979.
6. W. W. Daniel, *Applied Nonparametric Statistics*, 2nd Edition, Duxbury, 20

Course Title: Statistical Simulation

L	T	P	Credits
3	0	0	3

Course Code: STA.574

Total Hours: 45

Learning Outcomes:

The students will be able to

- Explain deterministic and stochastic processes.
- Apply the concept of random number generation.
- Understand Monte Carlo integration.
- Discuss about variance reduction techniques.

Unit I **11 Hours**

Simulation: An introduction, need of simulation, physical versus digital simulation, Buffon's needle problem. Deterministic and stochastic processes. Use of simulation in defense and inventory problems.

Activity: Students will understand the concepts of deterministic and stochastic processes.

Unit II **11 Hours**

Random Number Generation**:** Congruential generators, statistical tests for pseudo random numbers.

Activity: Students will learn about random number generation.

Unit III **12 Hours**

Random Variate Generation: Inverse transforms method, composition method, acceptance rejection method. Generating random variates from continuous and discrete distributions. Generation of random vectors from multivariate normal distribution.

Activity: Students will learn about random sample generation some well known family of distributions.

Unit IV **11 Hours**

Monte Carlo integration and variance reduction techniques : Hit or miss Monte Carlo method, sample mean Monte Carlo method, Jacknife Method.

Activity: Students will understand the concept of Monte Carlo method.

Transaction mode: Lecture/Demonstration/ Co Operative learning/ programming / Practical/ Group discussion/Team teaching /Experimentation/Tutorial/Problem solving/Self-learning.

Suggested Readings:

1. G. Gordon, *System Simulation*, Prentice Hall of India, New Delhi, 2001.
2. P. A. W. Lewis and E. J. Orav, *Simulation Methodology for Statisticians*, Operations Analysis and Engineering, Wadsworth & Brooks Cole Advanced Books & Software. Volume I, 1988.
3. R. Y. Rubinstein, *Simulation and Monte Carlo Method*, John Wiley & Sons, 1981.
4. T. T. Julius and R. C. Gonzalesz, *Pattern Recognition Principles*, Addison – Wesley Publishing Company, 1997.

Course Title: Review of Statistical Concepts (DEC)

L	T	P	Credits
2	0	0	2

Course Code: STA.558

Total Hours: 30

Learning outcomes:

Students will be able to

- Review the basic concepts of probability.
- Understand the basic concepts of testing and inferential statistics.
- Apply the techniques of statistics for solving problems.
- Review the concepts in Stochastic Processes.

Unit I **08 Hours**

Linear Algebra: Vector spaces, subspaces, linear dependence, basis, dimension, algebra of linear transformations. Algebra of matrices, rank and determinant of matrices, linear equations. Eigenvalues and eigenvectors, Cayley-Hamilton theorem. Matrix representation of linear transformations. Change of basis, canonical forms, diagonal forms, triangular forms, Jordan forms. Inner product spaces, orthonormal basis. Quadratic forms, reduction and classification of quadratic forms.

Activity: Students will solve problems based on NET/GATE questions.

Unit II **07 Hours**

Descriptive statistics, exploratory data analysis.

Sample space, discrete probability, independent events, Bayes theorem. Random variables and distribution functions (univariate and multivariate); Expectation and moments. Independent random variables, marginal and conditional distributions.

Markov chains with finite and countable state space, classification of states, limiting behaviour of n-step transition probabilities,

stationary distribution.

Methods of estimation. Properties of estimators. Confidence intervals. Tests of hypotheses: most powerful and uniformly most powerful tests, Likelihood ratio tests. Analysis of discrete data and chi-square test of goodness of fit. Large sample tests.

Activity: Students will solve problems based on NET/GATE questions.

Unit III **08 Hours**

Gauss-Markov models, estimability of parameters, Best linear unbiased estimators, tests for linear hypotheses and confidence intervals. Analysis of variance and covariance. Fixed, random and mixed effects models. Simple and multiple linear regression.

Elementary regression diagnostics. Logistic regression.

Activity: Students will solve problems based on NET/GATE questions.

Unit IV **07 Hours**

Multivariate normal distribution, Wishart distribution and their properties. Distribution of quadratic forms. Inference for parameters, partial and multiple correlation coefficients and related tests.

Simple random sampling, stratified sampling and systematic sampling. Probability proportional to size sampling. Ratio and regression methods.

Completely randomized, randomized blocks and Latin-square designs.

Activity: Students will solve problems based on NET/GATE questions.

Transaction mode: Lecture/Demonstration/ Co Operative learning/ programming / Practical/ Group discussion/Team teaching/Experimentation/Tutorial/Problem solving/Self-learning.

Recommended Books:

1. A. K. M. E. Saleh and V. K. Rohatgi, *An Introduction to Probability and Statistics*, 2nd Edition, Wiley, 2008.
2. A. M. Goon, M. K. Gupta and B. Dasgupta, *An Outline of Statistical Theory*, Vol. 2, The World Press Pvt. Ltd., Calcutta, 2003.
3. D. C. Montgomery, *Design and Analysis of Experiment*, Wiley, 2004.
4. G. B. Wetherill, *Sampling Inspection and Quality Control*, Halsted Press, 1977.
5. G. Casella and R. L. Berger, *Statistical Inference*, 2nd Edition, Duxbury, Thomson Learning, 2008.
6. J. Medhi, *Stochastic Processes*, 2nd Ed ,Wiley Eastern Ltd., 1994.
7. K. Hoffman and R. Kunze: *Linear Algebra* 2nd Edition, Pearson Education (Asia) Pvt. Ltd/ Prentice Hall of India, 2004.
8. N. R. Draper and H. Smith, *Applied Regression Analysis*, 3rd Ed., Wiley, 1998.
9. P. L. Meyer, *Introductory Probability and Statistical Applications*,

Oxford &IBH Pub., 1975.
10. P. Mukhopadyay, *Theory and Methods of Survey Sampling*, Prentice Hallof India, 1998.
11. R. A. Johnson and D. Wichern, *Applied Multivariate Statistical Analysis*, 5th Edition, Pearson, 2005.
12. S. D. Sharma, *Operations Research,* Kedarnath Amarnath, Meerut, 2009.
13. S. M. Ross, *Introduction to Probability Models*, 11th Edition, 2014.
14. S. M. Ross, *Stochastic Processes,* Wiley Publications, 1996.
15. S. Weisberg, *Applied Linear Regression*, Wiley, 1985.
16. T. W. Anderson, *An Introduction to Multivariate Statistical Analysis*, 2nd Edition, Wiley, 1983.

Course Title: Entrepreneurship Skills
Course Code: STA.563
Total Hours: 15

L	T	P	Credits
1	0	0	1

Learning Outcomes:

The students will be able to:

- Understand the basic concepts of entrepreneur, entrepreneurship and its importance.
- Aware of the issues, challenges and opportunities in entrepreneurship.
- Develop capabilities of preparing proposals for starting small businesses.
- Know the availability of various institutional supports for making a new start-up.

Unit – 1 **3 Hours**

Introduction to entrepreneur and entrepreneurship; Characteristics of an entrepreneur; Characteristics of entrepreneurship; entrepreneurial traits and skills; innovation and entrepreneurship; Types of entrepreneurial ventures; enterprise and society in Indian context; Importance of women entrepreneurship

Unit – 2 **5 Hours**

Promotion of a venture – Why to start a small business; How to start a small business; opportunity analysis, external environmental analysis, legal requirements for establishing a new unit, raising of funds, and establishing the venture - Project report preparation – format for a preliminary project report, format for a detailed/final project report.

Unit – 3 **4 Hours**

Mathematics and Statistics as a tool for innovation, current challenges to be tackled in marketing, health and environmental sectors, figuring out scientific needs of the society, mathematics and statistics in cross-disciplinary industries, examples of successful mathematics and statistics spin-offs, funding from scientific and governmental bodies.

Unit – 4 **3 Hours**

Communicating with data and statistics, hypothesis testing and modeling, importance of units and measurement, from idea to research to product design and development, scope of innovation in: theoretical physics, String theory, mathematical modeling, optimization

problems, Image Processing, Architecture, Machine Learning, Econometrics and many more.

Suggested Readings:

1. Arora, Renu (2008). Entrepreneurship and Small Business, Dhanpat Rai & Sons Publications.
2. Chandra, Prasaaan (2018). Project Preparation, Appraisal, Implementation, Tata Mc-Graw Hills.
3. Desai, Vasant (2019). Management of a Small Scale Industry, Himalaya Publishing House.
4. Jain, P. C. (2015). Handbook of New Entrepreneurs, Oxford University Press.
5. Srivastava, S. B. (2009). A Practical Guide to Industrial Entrepreneurs, Sultan Chand & Sons.

Course Title: Research Proposal
Course Code: STA.600
Total Hours: 120

L	T	P	Credits
0	0	8	4

Learning outcomes:

The students will be able to

- develop interest in theoretical and practical research.
- decide their area of research as per their competency.
- get theoretical and practical knowledge of a specific area of research.
- prepare themselves for quality research in any mathematical discipline and allied areas.

Evaluation Criteria:

Dissertation Proposal				
	Marks	**Proposal (30)**	**Presentation (10)**	**Viva-Voce (10)**
Supervisor	**50**			
HoD and Senior faculty member	**50**			

Transaction mode: Lecture/Demonstration/ Co Operative learning/ programming / Practical/ Group discussion/Team teaching/Experimentation/Tutorial/Problem solving/Self-learning.

Course Title: Basics of LateX (Practical)

L	T	P	Credits
0	0	2	1

Code: MAT.568
Total Hours: 30

Learning outcomes:
The students will be able to

1. Installation of the LaTeX software in Windows and Linux and understanding LaTeX compilation and LaTeX editors.
2. Basic syntax used in LaTeX.
3. Writing mathematical equations, Matrices, Tables, Inclusion of graphics into LaTeX file.
4. Page configurations**:** Title, Abstract, Keywords, Chapter, Sections and Subsections.
5. References and their citations.
6. Labeling of equations, Table of contents, List of figures.
7. Use of Packages**:** amsmath, amssymb, amsthm, amsfonts, graphic.
8. Use of document classes**:** Article, Report, Book, Beamer.
9. Applications of LaTeX in writing reports, books, research papers and thesis.

Transaction mode: Lecture/Demonstration/ Co Operative learning/ programming / Practical/ Group discussion/Team teaching/Experimentation/Tutorial/Problem solving/Self-learning.

Suggested Readings:

1 D. F. Griffiths and D. J. Higham, *Learning LaTeX,* 2nd Edition, Philadelphia, Pennsylvania, SIAM, 1997.

2 L. Lamport. LATEX: A Document Preparation System, User's Guide and Reference Manual. 2nd Edition, Addison Wesley, New York, 1994.

3 M. Goossens, F. M. Michel, and S. Alexander, The LaTeX companion, 2nd Edition, Addison-Wesley, 1994.

Semester IV

Course Title: Dissertation

Course Code: STA.600

Total Hours: 300

L	T	P	Credits
0	0	0	20

Learning outcomes:.

The students will be able to

- gain Theoretical and Practical knowledge of a specific area of research.
- have a good understanding of the subject to pursue research in reputed Institutions of higher learning.
- apply theoretical and practical knowledge to real life situations.
- prepare themselves for collaborative research in India and abroad.
- get Phd positions in reputed universities/institutes at regional/ national/ international level.

Evaluation Criteria:

Dissertation						
	Continuous Assessment		Report	Presentation	Viva-Voce	Total Marks
	Regularity in work	Mid-term evaluative				
Supervisor	**10**	**10**	**20**	**05**	**05**	**50**
HoD, Senior faculty member and external expert	**-**	**-**	**30**	**10**	**10**	**50**

Evaluation pattern similar to fourth semester dissertation will apply for internship where supervisor will award 50% marks and external co-supervisor, HoD and senior-most faculty will award 50% marks.

Transaction mode: Lecture/Demonstration/ Co Operative learning/ programming / Practical/ Group discussion/Team teaching / Experimentation /Tutorial / Problem solving/Self-learning.