Dr. Babasaheb Ambedkar Marathwada University

Department of Statistics

Structure and Curriculum

for

M.A./M. Sc. (Statistics) Programme

(Choice Based Credit and Grading System)

(Academic Autonomy)

(Effective from June 2021)

Structure and Curriculum for M.Sc. (Statistics) Programme
(Choice Based Credit System)

The M.A./M.Sc. (Statistics) programme is divided into four semesters with 114 credits which includes 8 practical courses (16 Credits), research project work (24 credits), service course (04 credits) and Constitution of India (02 Credits). Remaining credits are distributed for core and elective courses.

Preamble of the syllabus:

M. A. / M. Sc. Statistics programme is of 114 credits spread over four semesters. The programme emphasizes both theory and applications of statistics and is structured to provide knowledge and skills in depth necessary for the employability of students in industry, other organizations, as well as in academics. The program has some unique features such as independent projects, a large number of elective courses, pre-requisite system and extensive computer training of statistical computations including standard software packages such as MINITAB, R, SPSS and SYSTAT. The department has the academic autonomy and it has been utilized to add the new and need based elective courses. New courses such as Statistical Analysis of Clinical Trials, Actuarial Statistics, Industrial Statistics, Statistical Simulation, Data Mining, Demography, Econometrics, Time Series Analysis have been introduced. The independent project work is one of the important components of this program. The syllabus of the first year (two semesters) covers most of the core courses. In the second year syllabus there are five core courses and nine optional courses. The syllabus has been framed to have a good balance of theory, methods and applications of statistics. It is possible for the students of any other disciplines to study fundamentals of Statistics in service course entitled Statistical Methods.

Eligibility:

Those who have completed B.A./B. Sc. with Statistics / Mathematics as an optional subject from any recognized University/ Institution are eligible for admission. However preference will be given to B.Sc. with Statistics as one of the optional subject. Common written entrance test will be conducted and admissions will be on the basis of merit of written test or as and when decided by Department / University.

Intake Capacity: 30 (Reservation as per University rules)

Admission / Promotion Process:

In response to the advertisement for registration, interested students will have to register themselves. Admission will be done on the basis of Common Entrance Test (CET) and performance of students at their qualifying graduate level examination (Marks obtained in the subject of Statistics at B. Sc level. Once the student is admitted he / she will be promoted to the

2nd year (3rd semester) if he / she qualify all courses 1st semester and 50 % of theory courses of 2nd semester. Students will have to register themselves for every consecutive semester. Dropout students will be allowed to register for respective semester as and when the concerned courses are offered by the department, however he / she should not exceed more than twice the duration of the course from the date of first registration at parent department. The admission of the concern student will be automatically cancelled if he / she fails to complete the M. Sc. degree within a period of maximum four years / eight semesters.

Choice Based Credit and Grading System (CBCGS):

The choice based credit and grading system has been adopted by this department. This provides flexibility to make the system more responsive to the changing needs of our students, the professionals and society. It gives greater freedom to students to determine their own pace of study. The credit based system also facilitates the transfer of credits.

- Students will have to earn 114 credits for the award of M.Sc. (Statistics) degree.
- 2 credits will have to obtain from the course constitution of India.
- 24 credits will have to obtain from the research project.

Credit-to- contact hour Mapping:

One contact hour per week is assigned 1 credit for theory and 0.5 credits for laboratory courses/ research project. Thus a 4 - credit theory course corresponds to 4 contact hours per week and same analogy will be applicable for laboratory courses / research project.

Attendance:

Students must have 75 % of attendance in each core, foundation, elective, laboratory and research project course for appearing examination otherwise he / she will not be strictly allowed for appearing the examination of each course. However, students having 65 % attendance with medical certificate may request Head of the Department for the condonation of attendance.

Departmental Committee:

The existing Departmental Committee (DC) will monitor the smooth functioning of M. Sc. programme.

Results Grievances / Redressal Committee

Grievances / redressal committee will be constituted in the department to resolve all grievances relating to the evaluation. The committee shall consist of Head of the department, the concerned teacher of a particular course and senior faculty member of Department of Committee. The decision of Grievances / redressal committee will be final.

Evaluation Methods:

- The assessment will be based on 20: 80 ratios of continuous internal assessment (CIA) and semester end examination (SEE).

Continuous Internal Assessment (CIA):

- Two internal tests of 20 marks each. Finally the marks will be converted out of 20 marks. The setting of the question papers and the assessment will be done by the concerned teacher or as per rules of the University.

Semester End Examination (SEE):

- The semester end theory examination for each theory course will be of 80 marks. The total marks shall be 100 for 4 credit theory course (80 marks semester end exam + 20 marks CIA) and 50 for 2 credit theory course (40 marks semester end exam + 10 marks CIA).

- Semester end examination (SEE) time table will be declared by the departmental committee (as per the university annual calendar). The setting of the question papers and the assessment will be done by the concerned teacher or as per rules of the University. For Practical exams evaluation will be done by external examiners. However, in case of non-availability of external examiner for either paper setting or assessment or both, department committee will be empowered to take appropriate decision.

- Pattern of semester end question paper will be as below:

    - The semester end examination of theory course will have two parts (20+60 = 80 Marks)
    - Part A will be consisting of 20 marks (multiple choice questions / fill in the blanks/ short answers) as compulsory questions and it should cover entire course curriculum.
    - Part B will carry 7 questions (01 question from each of 05 units and 02 questions randomly from the syllabus). Students will have to attempt 05 questions out of 07 (60 Marks).
    - 20 to 30% weightage can be given to problems/ numerical wherein use of non-programmable scientific calculator may be allowed.
    - Number of sub questions (with allotment of marks) in a question may be decided by the examiner.

- The semester end practical examination will be conducted at the end of each semester along with the theory examination.

- At the end of each semester the Head of the Department shall send all results to the Controller of Examination for further processing.

- Every student will have privilege for revaluation of answer sheets or recounting of marks for each semester end examination. However, students will have to submit an application to the grievances committee of the department.

Earning Credits:

At the end of every semester, a letter grade will be awarded in each course for which a student had registered. A student's performance will be measured by the number of credits that he/she earned by the weighted Grade Point Average (GPA). The SGPA (Semester Grade Point Average) will be awarded after completion of respective semester and the CGPA (Cumulative Grade Point Average) will be awarded at the end of the 4th semester.

Grading System:

- The grading reflects a student-own proficiency in the course. A ten point rating scale shall be used for the evaluation of the performance of the students to provide letter grade for each course and overall grade for the Master Programme. Grade points are based on the total number of marks obtained by him / her in all heads of the examination of the course. The grade points and their equivalent range of marks are shown in Table-I

Table – I: Ten point grade and grade description

Marks Obtained (%)	Grade Point	Letter Grade	Description
90-100	9.00- 10	O	Outstanding
80-89	8.00-8.90	A^{++}	Exceptional
70-79	7.00-7.90	A^{+}	Excellent
60-69	6.00-6.90	A	Very Good
55-59	5.50-5.90	B^{+}	Good
50-54	5.00-5.40	B	Fair
45-49	4.50-4.90	C^{++}	Average (Above)
41-44	4.1-4.49	C	Average
40	4.0	P	Pass
< 40	0.0	F	Fail (Unsatisfactory
	0.0	AB	Absent

- Non appearance in any examination / assessment shall be treated as the students have secured zero marks in that subject examination / assessment.

- Minimum P grade (4.00 grade points) shall be the limit to clear / pass the course / subject. A student with F grade will be considered as 'failed" in the concerned course and he / she has to clear the course by appearing in the next successive semester examinations.

- Every student shall be awarded grade points out of maximum 10 points in each subject (based on 10 point scale). Based on the grade points obtained in each subject, Semester Grade Point Average (SGPA) and then Cumulative Grade Point Average (CGPA) shall be computed. Results will be announced at the end of each semester and CGPA will be given on the completion of M. Sc. programme.

Computation of SGPA (Semester Grade Point Average) and CGPA (Cumulative Grade Point Average)

Grade in each subject / course will be calculated based on the summation of marks obtained in internal and semester end examination.
The computation of SGPA and CGPA will be as below

- Semester Grade Point Average (SGPA) is the weighted average points obtained by the students in a semester and will be computed as follows

$$SGPA = \frac{\text{Sum (Course Credit X Number of Grade Points in concern Course Gained by the Student}}{\text{Sum (Course Credit)}}$$

  The SGPA will be mentioned on the mark sheet at the end of every semester.

- The Cumulative Grade Point Average (CGPA) will be used to describe the overall performance of a student in all semester of the course and will be computed as under.

$$CGPA = \frac{\text{Sum (All four Semester SGPA)}}{\text{Total Number of Semester}}$$

The SGPA and CGPA shall be rounded off to the second place of decimal.

Grade Card

Results will be declared by the Departmental Committee and the grade card (containing the grades obtained by the student along with SGPA) will be issued by the university after completion of every semester. The grade card will be consisting of following details.

- Title of the courses along with code opted by the student.
- Credits associated with the course.
- Grades and grade points secured by the student.
- Total credits earned by the student in a particular semester.
- Total credits earned by the students till that semester.
- SGPA of the student.
- CGPA of the student (at the end of the 4^{th} semester).

Cumulative Grade Card

Course	Course Title	Teaching hours/week	Marks	Credits
STA- 400	Constitution of India	2 hours	50	2
STA- 401	Mathematical and Statistical Analysis (Foundation course)	4 hours	100	4

STA- 402	Distribution Theory (core course)	4 hours	100	4
STA- 403	Probability Theory (core course)	4 hours	100	4
STA- 404	Statistical Inference –I (core course)	4 hours	100	4
STA- 405	Statistical Computation (R and Python)	4 hours	100	4
STA- 406	Practical – I (using software)	4 hours	50	2
STA- 407	Practical – II (using software)	4 hours	50	2
	Total	**---**	**650**	**26**

The grade card sheet showing details grades secured by the student in each subject in all semester along with overall CGPA will be issued by the University at the end of 4th semester.

Semester I

Semester II

Course	Course Title	Teaching time/week	Marks	Credits
STA- 408	Design and Analysis of Experiments-I (core)	4 hours	100	4
STA- 409	Stochastic Processes (core)	4 hours	100	4
STA- 410	Sampling Techniques (core)	4 hours	100	4
STA- 411	Regression Analysis (core)	4 hours	100	4
STA- 412	Statistical Inference –II (core)	4 hours	100	4
STA- 413	Practical – III (using software)	2 hours	50	2
STA- 414	Practical – IV (using software)	2 hours	50	2
	Total	**----**	**600**	**24**

Semester III

Course	Course Title	Teaching hours/week	Marks	Credits
	Core Courses			
STA- 501	Design & Analysis of Expt.-II (**Core)**	4 hours	100	4
STA- 502	Multivariate Analysis **(core)**	4 hours	100	4
	Any Three Electives			
STA- 503	Time Series Analysis (**Elective)**	4 hours	100	4
STA- 504	Industrial Statistics (**Elective)**	4 hours	100	4
STA- 505	Operations Research –I **(Elective)**	4 hours	100	4
STA- 506	Econometrics (**Elective)**	4 hours	100	4
	Service course			
STA- 507	Statistical Methods **(Service Course)** **	4 hours	100	4
STA-508	Research Project/Dissertation part –I	4 hours	100	4
STA-509	Practical – V (using software)	4 hours	50	2
STA-510	Practical – VI (using software)	4 hours	50	2
	Total	**----**	**800***	**32***

Note: *Student shall choose any three Electives.

** This course is offered to students of other departments only. However students of this department will choose one service course from any other department.

Semester IV

Course	Course Title	Teaching hours/week	Marks	Credits
	Core			
STA- 512	Reliability Theory **(Core)**	4 hours	100	4
	Any Three Electives			
STA- 513	Actuarial Statistics **(Elective)**	4 hours	100	4
STA- 514	Statistical Analysis of Clinical Trials **(Elective)**	4 hours	100	4
STA- 515	Operations Research –II **(Elective)**	4 hours	100	4
STA- 516	Statistical Simulations **(Elective)**	4 hours	100	4
STA- 517	Data Mining **(Elective)**	4 hours	100	4
STA- 518	Seminar/ Project Dissertation part-II	4 hours	100	4
STA- 519	Practical – VII (using software)	4 hours	50	2
STA- 520	Practical -VIII (using software)	4 hours	50	2
	Total	**-----**	**600***	**24***

Grand Total of Marks: 2650 **Total Credits: 106**

Note: ***** Student shall choose any three Electives from the list.

Grand Total of Marks: 2850 **Total Credits: 114**

Note: ***** Student shall choose any three Electives.

- Students of Semester III shall choose any three electives in consultation with HOD. Combination of electives for SEM III and SEM IV will be as follows.

Remarks

- There should not be more than 8 students in a batch for M. Sc. Practical course
- Every student has to undertake one Research project independently in first semester and same will be continued upto 4^{th} semester.
- Out of 60 lectures in each theory course about 10 lectures will include assignments, tutorials and class tests.

]\

Course Personal Outcome

Students enrolled in the

PO-No.	Component	Outcomes
PO-1	Basic Knowledge	Capable of applying basic subject knowledge learned during the programme.
PO-2	In-depth Knowledge	Capable of applying advanced subject knowledge learned during the programme..
PO-3	Critical thinking and Problem-Solving abilities	Capable of applying acquired knowledge to solve the practical problems and interpret results.
PO-4	Creativity and innovation	Capable to identify and model, formulate and analyze the scientific problems and to apply modern technologies to real life problems.
PO-5	Research aptitude and global competency	All round development of students to apply knowledge in research, industries and to find solutions to current problems in various fields.
PO-6	multidisciplinary education	Capability to apply the learned tools and techniques with the multidisciplinary approach across the fields.
PO-7	Skills enhancement	Ability to think analytically, independently and draw logical conclusions by applying statistical techniques
PO-8	Teamwork abilities	capability to learn and work in a group. Develop various skills which will help in expressing ideas and views clearly and effectively
PO-10	Ethical thinking and social awareness	Inculcate the professional and ethical attitude and ability to relate with social problems.

STA-400: Constitution of India

SEM I **Max Marks: 50**

Credits: 02

Syllabus as per Department of Law, Dr. B.A.M.U.

STA-401 Mathematical and Statistical Analysis

Course Outcomes

CO1: Learn mathematical methods involving matrices, determinants, Eigen values and Eigen vectors and quadratic forms.

CO2: The concept on generalized inverse, Moore – Penrose generalized inverse and all basic properties. Hermitian matrices and its properties.

CO3: Identify diagonalizable and non-diagonalisable matrices, orthogonally diagonalizable symmetric matrices.

Unit-I : Introduction to n dimensional Euclidean space and metric space, system of real numbers, countable and uncountable sets, countability of rational numbers, uncountability of real numbers, supremum and infimum of set of real numbers, interior point, limit point of a set, open set, closed set. Bolzano-Weierstrass theorem, Heine-Borel theorem (Statement only), Application of these theorems.

(12L)

Unit-II : Real valued function, continuity and discontinuity, uniform continuity, power series, convergence, Cauchy's general principle of convergence for series, uniform convergence, properties of uniform convergence.**Unit-I :**field, Vector space, subspace of vector space ,theorems and examples related to vector space and subspaces , linear dependence & independence withtheorems and examples related to vector, linear combination, linear span and basis with theorem and example.

(12 L)

Unit-III field, Vector space, subspace of vector space ,theorems and examples related to vector space and subspaces , linear dependence & independence withtheorems and examples related to vector, linear combination, linear span and basis with theorem and example.

(12 L)

Unit-IV : inner product space ,dimension of vector space ,example of inner product spaces , Norms of vector space, algebra of linear transformations, its properties and theorems Orthonormal basis and orthogonal projection of vector, Gram–Schmidt orthogonalization process, Kronecker product.

(12 L)

Unit-V: Introduction of matrix, Generalized inverse, Moore – Penrose generalized inverse and all basic properties. Hermitian matrices and its properties. Quadratic forms: definition, reduction and classification of quadratic forms, index and signature of quadratic form, triangular reduction of positive definite matrix, maxima and minima of ratio of quadratic forms. Characteristic roots and vectors, Caley – Hamilton theorem and applications , minimal polynomial ,similar matrices, algebraic and geometric multiplicity of a characteristic root

Text books :

1) Malik S.A. and Arora S. (1991) : Mathematical Analysis. Wiley Eastern Ltd. 2nd Edn.
2) Deshpande J.V. (1981) : Textbook of Mathematical Analysis. Tata MC-Graw Hill.
3) Searle, S.R.(1982) : Matrix algebra useful for statistics. John Wiley and sons Inc
4) Biswas S.(1984) : Topics in algebra of matrices. Academic publications

Reference books:

1) Apostoal T.M. (1985) ; Mathematical Analysis. Narosa, Indian Ed.
2) Hadley G.(1987) : Linear Algebra. Narosa Publishing house.
3) Hoffiman K.and Kunze.R. (1971) : Linear algebra. 2nd Ed Prentice hall Inc.
4) Bartle G.R. & Sherbert D.R. (2000) : Introduction to Real analysis. John wiley & Sons
5). Hadley G.(1987) : Linear Algebra. Narosa Publishing house.

STA-402: DISTRIBUTION THEORY

Course Outcome:

Objective:

Learning Distribution theory is to understand the mathematical properties and applications of probability distributions, enabling individuals to analyse and model random phenomena, make statistical inferences, and solve real-world problems in various fields

After completing this course students will be able to:

CO1: Find various properties of discrete and continuous distributions

CO2: Fit distributions to real life data sets

CO3: Derivation of distributions of different forms of random variables

SEM: I **Max Mark: 100**

Credit: 04

Unit I: - Basic Distribution Theory: Random experiment and its sample space, events, probability axioms, Random variable, Discrete random variables, continuous random variables, **Convolution of random variables**. Definition of distribution and types of distribution: p.d.f, p.m.f, c.d.f. of random variables, m.g.f, p.g.f., characteristic function of random variables, Moments: raw moments, central moments & factorial moments, joint distribution, conditional distribution, marginal distribution, **mixture distributions.** (12L)

Unit II :- Discrete Distributions : Bernoulli, Binomial, Poisson, geometric, negative binomial, , Hyper geometric, uniform and **multinomial** distribution. Their m.g.f, p.g.f, c.d.f., characteristics function, moments, properties and fitting of above distributions. **Compound Poisson distribution and truncated Poisson distributions**. (12L)

Unit III: - Continuous Distributions: Exponential, Normal, Gamma, Beta, Uniform, Lognormal, Weibull, Cauchy, Pareto distribution, **Dirichlet Distribution,** Their m.g.f, p.g.f, c.d.f., characteristics function, moments and properties of above distributions. (12L)

Unit IV: Sampling distributions: central and non central Chi-square, t- and F-distribution. Their m.g.f, p.g.f, c.d.f., characteristics function, moments and properties. **Bivariate normal distribution:** c.d.f., marginal distribution, conditional distribution and its properties. (12L)

Unit V : Order Statistics: kth order statistics, their density functions, distribution function and its properties. **Inequalities**: Markov, Holder, Jensen and *Lyapunov's* inequality, **Compound and truncated distributions.** (12L)

Text Books

1) Rohtagi V.K. (2012**):** An Introduction to Probability Theory and Mathematical Statistics**,** Wiley eastern, 2nd ed.
2) Anirban Dasgupta (2010) Fundamentals of Probability: A First Course. Springer Texts in Statistics
3) Hogg, R.V. and Craig, A.T. (1978). Introduction to Mathematical Statistics, (5th Ed. Pearsons Education).
4) Hogg, R.V. and Tanis E.(2002) An. Probability and Statistical Inference (6th Ed. Pearsons Education).

Reference Books

1) Mukhopadhy .P (1996): Mathematical Statistics, New central book agency,
2) Dudewicz E.J.and Mishra S.N. (1988): Modern Mathematical statistics, Wiley Int. student's Edition.
3) Johnson, S. and Kotz, (1972). Distributions in Statistics, (Vol..I, II and III, Houghton and Miffin).

STA- 403: PROBABILITY THEORY

Course Outcome:

After completing this course students will be able to:
CO1: Learn the concepts of random variables, different measures & their properties.
CO2: The concept of measurable functions and Integration of measurable functions.
CO3: Describe the advanced techniques of Probability theory including Laws of large numbers
CO4: To learn about convergence, evaluating inequalities. Learn the central limit theorem.

SEM-I **Marks: 100**
Credits: 04

Unit-I: Fields and sigma fields: Random experiment, Sample space and events. Sequence of sets, limit supremum and limit infimum of sequence of sets. Classes of sets, fields, Sigma-fields, Minimal fields, Borel fields. (12L)

Unit-II: Random Variables: Point function and set function, Inverse function. Measurable function, Borel function. **Measures:** Measure (Definition and simple properties). Probability measure, Properties of a measure. Continuity of a probability measure. Caratheodory Extension

theorem (without proof). Counting measure, Conditional Probability measure, Counting measure, Lebesgue measure, Lebesgue stiltjes measure. (12L)

Unit-III : Distribution Functions: Distribution functions of a r.v. and its properties. Jordan decomposition theorem, Mixture of distribution functions. Distribution functions of vector valued r.v.s. Empirical distribution functions. **Expectation and Moments:** Expectation of a r.v. Properties of expectation, Expectation of Complex r.v. Moments, Moment generating function. (12L)

Unit-IV : Convergence of Sequence of Random variables: Convergence in distribution, Convergence in probability, Almost sure convergence and convergence in quadratic mean and their inter-relations. Slutsky's theorem, Monotone convergence theorem, Fatou's Lemma, Dominated convergence theorem.
Characteristic function: Definition and simple properties, Some inequalities. Uniqueness theorem (statement only), Levy's continuity theorem (Statement only). **Independence:** Independence of events, sequence of independent events, independent classes of events, independence of r.v.s, Borel zero-one law. (12L)

Unit V: Law of Large Numbers : Weak law of large numbers (WLLN), Strong law of large numbers (SLLN), Chebyshev's WLLN, Khinchin's WLLN, Kolmogorov's SLLN (only statement), **Central Limit Theorem (CLT) :**CLT, Lindeberg-Levy, Lindeberg-Feller (sufficient condition only) and their applications, Liapounov's theorem, Multivariate CLT. (12 L)

Text Books:

1. Bhat, B.R. (2000), Modern Probability Theory, New Age International Pub.
2. Basu, A.K. (1999), Measure Theory and Probability , Prentice Hall of India.
3. Athreya K. B. and Lahiri S. (2006). Probability Theory Vol. 41, Trim series, (Hindustan Book Agency).
4. Billingsley, P. (1986). Probability and Measure, John Wiley

Reference Books:

1. Ash, Robert (1972): Real Analysis and Probability, Academic Press.
2. Kingman, J.F.C. and Taylor, S.J. (1996). Introduction to measure and probability, Cambridge University Press. Feller, W. (1969). Introduction to Probability and its Applications Vol.II (Wiley Eastern Ltd.)
3. Gnedenko, B. V. (1988). Probability Theory (Mir. Pub.)
4. Gut, Allan (2005), Probability: A Graduate Course. (Springer, New York)

STA- 404: STATISTICAL INFERENCE – I

After completing the course the students will be able to:
CO1: To identify the distributions belonging to different families of distributions.

CO2: To explain and demonstrate the conceptual understanding of a minimum variance unbiased estimation.

CO3: To explain and evaluate estimates with optimal properties from a given sample with appropriate distributional assumptions.

CO4: To explain and obtain tests and confidence intervals with optimal property.

SEM-I **Marks : 100**
Credits : 04

Unit-I : Theory of estimation: Introduction, Characteristics of estimators : unbiasedness, Consistency, Efficiency, Sufficiency. factorization theorem, minimal sufficiency , minimal sufficient statistic, construction of minimal sufficient statistics, special classes of distributions admitting complete sufficient statistics. (12L)

Unit-II : Likelihood function, Examples from standard discrete and continuous distributions (such as Bernoulli, Poisson, Negative Binomial, Normal, exponential, Gamma, Pareto etc.), Methods of estimation : Maximum likelihood method, Methods of moments. (12 L)

Unit-III :, Concept of completeness, bounded completeness, MVUE Uniqueness Rao – Blackwell theorem. Lehman –scheffs theorem. Application to standard families of distribution Regular families, Fisher information, Cramer Rao inequality. (12 L)
Unit-IV : Testing of hypothesis : Concept of critical regions, types of hypothesis, test functions, two kinds of errors, level of significance, power function, Neyman- Pearson lemma (with Proof) for test function, MP and UMP test, UMP test for one sided alternative for one parameter exponential class of densities and extension to the distribution having monotone likelihood ratio property. (12 L)

Unit-V: Interval estimation, confidence level, construction of confidence intervals using pivots, shortest expected length confidence interval, uniformly most accurate one sided confidence interval. Types of scales. Non – parametric tests: Sign test, Run test, Mann- Whitney Wilcoxon U test, Median test.Kruskal-Wallis Test. (12 L)

Text Books :

1) Kale B.K. and Murlidharan(2015) : A first course on parametric inference, Narosa Publishing House.
2) Rohatgi V. and Ehsanes Saleh A. K. MD (2012): An introduction to Probability and Mathematical Statistics, Wiley Eastern Ltd., New Delhi Student Edition.
3) Casella G. & beregar R.L.(2002) : Statistical Inference,2nd edition.

4) Dudewitz E.J. and Mishra S.N. (1988) : Modern Mathematical Statistics, John Wiley.

Reference Books :

1) George Casella, Roger L. Berger(2001): Statistical Inference,2nd edition, Duxbury Advanced Press.
2) Lehmann E.L. (1988) : (latest) Theory of Point Estimation (Student edition),John Wiley.
3) Lehmann E.L. (1986) :Testing Statistical hypothesis (Student edition),John Wiley.
4) Rao C.R. (2012) : Linear Statistical Inference and its Application, Wiley series, John Wiley & Sons, Inc.
5) Zacks.S.(1971) : Theory of Statistical Inference, John Wiley and sons, New York.

STA- 405: Statistical Computation (R and Python)

CO1**:** Describe package, syntax, codes for R programming
CO2: Develop R Programs for statistical problems, models and methods
CO2: Describe package, syntax, codes for R programming
CO4: Develop R Programs for statistical problems, models and methods

SEM. -I **Max marks: 100**
Credits: 04

Introduction: History, Features, Setting up path, Basic Syntax, Variable and Data Types, Operator.
Input-Output: Printing on screen, Reading data from keyboard, Opening and closing file, Reading and writing files, Functions
Conditional Statements: If, If- else, Nested if-else.
Looping: For, While, Nested loops.
Control Statements: Break, Continue, Pass.
String Manipulation: Accessing Strings, Basic Operations, String slices, Function and Methods.
Lists: Introduction, Accessing list, Operations, Working with lists, Function and Methods.
Tuple: Introduction, Accessing tuples , Operations, Working, Functions and Methods.
Dictionaries: Introduction, Accessing values in dictionaries,
Functions: Defining a function, Calling a function, Types of functions, Function Arguments, Anonymous functions, Global and local variables.
Modules: Importing module, Math module, Random module, Packages, Composition.

Text Books :

1. Python Crash Course, Eric Matthes (No Starch Press, 2016.
2. Think Python: How to Think Like a Computer Scientist, 2nd edition Allen B. Downey (O'Reilly, 2015)

STA-406: PRACTICAL – I (Using Software)

SEM: I **Max Mark: 50**
Credit: 02

List of practical (Mathematical and Statistical Analysis)

Sr. No.	Title of Practical
1	Basics of R-Programming and Python.
2	Matrix operations
3	Computation of the rank, inverse of Matrix and solving linear equations.
4	Computation of characteristic roots and characteristic vectors of a matrix
5	Reduction of quadric forms to diagonal forms by : i) Orthogonal Method ii) Elementary transformation.
6	Gram-Schemidt orthogonalization
7	Fitting of discrete distributions (Binomial, Poisson, Geometric, Negative Binomial)
8	Fitting of Continuous distributions (Normal, Exponential, Lognormal, Uniform, Gamma, Beta)
9	Generation of random numbers from discrete distributions
10	Generation of random numbers from discrete distributions

STA-407: PRACTICAL – II (Using Software)

SEM: I **Max Mark: 50**
Credit: 02

List of practical (Distribution theory + Stat. inference)

Sr. No.	Title of Practical
1	Testing of Hypotheses (based on t and F distribution)
2	Testing of Hypotheses (based on Z and Chi square distribution)
3	Testing of Normality using Shapiro-Wilk test, Kolmogorov Smirnoff test
4	Non-Parametric Testing: Sign, run, Mann Whitney
5	Non-Parametric Testing: Wilcoxon Signed Rank Test, median, Kruskal-Wallis Test
6	MLE Method
7	Method of Moments
8	Construction of confidence interval
9	UMP Test
10	WLLN, SLLN and Central Limit Theorem

STA – 408: Design and Analysis of Experiment -I

Course outcome:

After completing this course students will be able to:

CO1: Identify where to use ANOVA and ANCOVA. Perform analysis and interpret the results
CO2: Distinguish between CRD, RBD and LSD. Perform their analysis. Determine the estimates of missing observations
CO3: Analyse factorial designs and interpret the results
CO4: Construct complete and partially confounded factorial designs and perform their analysis.

SEM II **Max Marks: 100**
Credits: 04

Unit I : Analysis of variance (ANOVA): Introduction to design of experiments, need of design of experiments, fundamental principles of design of experiments, contrast ,orthogonal contrast, one way and two way ANOVA, **non parametric methods of ANOVA**. (12L)

Unit II: Basic Designs: Completely Randomized Design (CRD): Layout and randomization, Statistical analysis, Derivation of various formulae, advantage and disadvantages. Randomized Block Design (RBD): Layout and randomization, Statistical analysis, Derivation of various formulae, advantage and disadvantages of RBD over CRD. Latin square Design (LSD): Layout and randomization, Statistical analysis, Derivation of various formulae, advantage and disadvantages of LSD over RBD. **Model adequacy checking of the above designs**. (12L)

Unit III: Missing values and ANOCOVA: Missing plot techniques in RBD and LSD with one and two missing observations, ANOCOVA for one way and two way. Efficiency of RBD related to CRD, Efficiency of LSD related to RBD. (12L**)**

Unit IV: Multiple comparison test: due to Tukey, Scheffe , Bonferroni Method, Random, fixed and mixed effect models. Estimation of error functions, BLUE and its related theorems, Gauss Markov theorem. (12L)

Unit V: Concept of factorial experiment, 2^2, 2^3 , $\mathbf{2^n}$ factorial experiments and their Statistical analysis by Yates method and Fishers algebraic method. (12L)

Text Books:-

1) Montgomery D.C. (2004): Design and Analysis of Experiments , John and Wiley
2) Das M.N and Giri (2006): Design and Analysis of Experiments, Eastern Wiley
3) Joshi D.D. (1987): Linear Estimators and Design of Experiments, Wiley eastern
4) Kshirsagar A.M. (1983) : A course in Linear Models. Marcel Dekker Inc New York.

Reference Books:-

1) Giri N. (1986): Analysis of Variance, South Asia publication.

2) Peterson R.G. Design and Analysis of Experiments, Marcel Dekker Inc New York
3) Alok Dey (1986): Theory of Block Design, Eastern Wiley

STA-409: STOCHASTIC PROCESSES

CO1: IDENTIFY STOCHASTIC PROCESSES
CO2: FIND EXTINCTION PROBABILITY
CO3: PREDICT THE FUTURE PROBABILITIES OF THE EVENT USING TRANSITION PROBABILITY MATRIX
CO4: FORECAST VALUE USING TIME SERIES ANALYSIS

SEM-II **Marks : 100**
Credits :04

Unit I : Introduction to Stochastic Process : Classification of stochastic processes according to state space and time domain, countable state Markov chains (MC's), Chapman-Kolmogorov equations, calculation of n-step transition probability & it's limits, classification of states. Stationary distribution, random walk and gambler's ruin problem, limiting probability, counting process, application from social ,biological& physical sciences. (12 L)

Unit-II : Poisson Process : Properties of Poisson process with results associated with these properties, Generalization of Poisson process, Compound Poisson process.
Birth & Death Process**:** Continuous time Markov chain, Pure Birth Process, Birth & Death Process, Kolmogorov Backward Equation, Kolmogorov Forward Equation, A machine repair model, application to queues and storage problem. (12 L)

Unit-III : Special case of Stochastic Process:
Branching Process : introduction, Galton-Watson Branching Process, Probability of extinction, distribution of population size. Generalization of G-W process, Age dependent branching process. Time Series, moving average process, autoregressive process. (12L)

UNIT IV: **Brownian Motion Process (BMP Wiener Process)**: Brownian Motion Process as a limit of random walk, problems on standard BMP. Stationary Process: Covariance Stationary, Weakly & strongly stationary process,. Renewal Process: Renewal Reward Process, The average age of a renewal process, The average excess of a renewal process, Regenerate process, alternating renewal Process. (12 L)

Unit-V : Continuous Time & Continuous State Space Markov Process :
Kolmogorov-Feller differential equations, diffusion Processes with wiener process and Orenstein-Uhlenbeck Process as particular cases. First passage time and other problems. (12 L)

Text Books :

1. Bhat, B.R. (2000) Stochastic Models : Analysis and Applications. New Age International Publications, New Delhi.
2. Medhi, J. (1982) Stochastic Process, Wiley Eastern.
3. Ross, S.M. (2000) Introduction of Probability Models, 7thedn. (Academic Press).

Reference Books :

1. Adke, S.R. and Manjunath, S.M. (1984) An Introduction to finite Markov processes. Wiley Eastern.
2. Karlin, S. and Taylor, H.M. (2012) A first course in Stochastic Processes, Vol.1, Academic Press.

STA-410: Sampling Theory and Methods

CO1: To identify the suitable sampling technique as per requirement
CO2: To draw the sample size according to different sampling schemes
CO3: To find variance and various properties of the samples drawn
CO4: To Analyze survey data by using estimation procedures under different sampling methods.

SEM-II **Marks: 100**
Credits: 04

Unit-I : Introduction to sampling: review of basic concepts of sampling theory , population, sample, sampling unit, sampling frame, sampling fraction, unbiasedness, sampling variance, sampling and non sampling errors, efficiency, accuracy and precision. Determination of sample size. **Types of sampling**: probability and non probability sampling, **Simple random sampling**: SRSWR and SRSWOR, advantages and disadvantages, estimation of mean and variance. (12 L)

Unit-II: Stratified random sampling: Introduction, principles of stratification, advantages of stratification, proportional allocation, Optimum allocation, Neyman allocation. Estimation of mean and variance. **Systematic sampling**: Introduction, selection procedure, advantages and disadvantages, estimation of mean and variance. Comparison of SRSWOR, Stratified random sampling and systematic sampling. (12 L)

Unit-III: Cluster sampling: Introduction, estimation of population mean and variance. Theorem on estimation of sample mean and mean square error. Relative efficiency of cluster sampling in terms of intra class correlation coefficient. (12 L)

Unit-IV: PPS sampling: Introduction, Unequal probability sampling with replacement and without replacement (including Lahiri's scheme) and related estimations of a finite population mean. Ordered and unordered estimators, Desraj's ordered estimators, Horvitz – Thompson , Murthy's and Prabhu Ajgaonkar's unordered estimators. (12L)

Unit-V: Two stage sampling: Introduction, two stage sampling with equal first stage units, estimation of mean and variance, optimum allocation.
Ratio method of estimation: Introduction, estimation of mean and variance, bias of ratio estimator. Ratio estimate in stratified sampling.
Regression method of estimation: Introduction, mean and variance of the simple regression estimate. Comparison of simple regression estimate with ratio estimate. Regression estimates in Stratified sampling. (12 L)

Text Books :

1) Sukhatme et al (1984) :Sampling Theory of Surveys with Applications, lowa State University Press and IARS.
2) Murthy M.N. (1977) : Sampling Theory and Methods, Statistical Publishing .
3) Singh, D. And Choudhary F.S. (2009) Theory and Analysis of Sample Survey Designs, New age International Publishers .Society, Calcutta.
4) Mukhopadhyay P.(1996): Inferential problems in Survey Sampling. New Age International.
5) Cochran(1977), W.G.: Sampling Techniques. (3^{rd} / Edition,)Wiley.
6) Des Raj and Chandak (1998) :Sampling Theory ,Narosa.

Reference Books :

1) Hedayat A.S. and Sinha B.K.(1991): Design and Inference in Finite Population Sampling. Wiley.
2) Choudhary, A. and Mukerjee, R. (1988): Randomized Response Theory and Techniques, New York: Marcel Dekker Inc.

STA-411: REGRESSION ANALYSIS

COURSE OUTCOME

After completing this course students will be able to:

CO1: To fit linear regression models and interpret the results.

CO2: Check the model adequacy

CO3: Explore advanced regression techniques such as polynomial regression, logistic regression, and ridge regression, robust regression.

CO4: To apply model selection techniques

CO5: Apply regression analysis to real-world datasets and solve practical problems in various domains.

SEM II **Max Mark: 100**
Credit: 04

Unit I : Basics of Regression Analysis: Define correlation, and regression, simple linear regression/ & multiple regressions /coefficient of determination, adjusted coefficient of determination, Variable selection method. (12L)

Unit II : Residual and Outliers: Residual and their plots as tests for departure from assumptions such as fitness of the model, normality homogeneity of variances and determination of outliers, Influential observations, leverage outliers Robust , L_1 regression and M- estimator, estimation of predication error by cross validation and boot strap method. (12L)

Unit III : Non linear Regression: Definition, Non -linear least squares estimation, , maximum likelihood estimation, Non -linear least square transformation to a linear model, , fitting of polynomial models in one and two variables and Orthogonal polynomial models , parameter estimation in a non linear system, (12L)

Unit IV: Logistic regression: Introduction, Fitting the Logistic regression model, testing for the significance of the coefficients, Introduction to multiple Logistic regression, the multiple Logistic regression model, fitting the multiple logistic regression model, testing for the significance of the model for Logistic regression, analysis of binary and grouped data by using logistic models, log – linear model, test of hypothesis, Wald test, LR test. (12L)

Unit V: Multicollinearity: Introduction, Ridge regression and ridge trace, principal component regression, Mallow's Cp-statistics. Autocorrelation, Auto regressive model, ARIMA model. (12L)

Text book:

1) Montogomery D.C. et al (2012): Introduction to linear regression Analysis. Wiley.
2) Draper N.R and Smith H (1998): Applied Regression analysis 3rd Ed. Wiley.

Reference Books:

1) Weisbers S (1985): Applied linear Regression, Wiley.
2) Cook R.D.F Weisberg S. (1982): Residual & influence in regression, Chapman & hall
3) Gunst N.R .and Mason R.I. (1980): Regression analysis and its Applications of Data Oriented Approach, Marcel and Dekker.

STA-412: STATISTICAL INFERENCE-II

COURSE OUTCOME

After completing this course students will be able to:

CO1: Verify membership of distributions to different families of distribution

CO2: Find estimators using methods such as moments, maximum likelihood, Newton- Raphson, Method of scoring

CO3: Fit truncated and censored distributions

CO4: use bootstrapping methods in regression.

SEM: II **Max.Marks: 100**
Credits : 04

Unit I : Consistent estimation of real and vector valued parameter. Invariance of Consistent estimator under continuous transformation. Consistency of estimators by method of moments and method of percentiles, mean squared error criterion, asymptotic relative efficiency, error probabilities and their rates of convergence, minimum sample size required to attain given level of accuracy. (12 L)

Unit II : Consistent Asymptotic Normal(CAN) estimator, invariance of CAN estimator under differentiable transformation. One parameter exponential family, multi parameter exponential family. CAN property of estimators obtained by moment and MLE method in one parameter exponential family, Extension to multi parameter exponential family (12 L)

Unit III : one-parameter Cramer family, Method of maximum likelihood CAN estimators for one-parameter Cramer family, Cramer-Huzurbazar theorem (statement only), Solution of likelihood equations, method of scoring, Newton-Raphson and other interactive procedures, Fisher lower Bound to Asymptotic variance, extension to multiparameter case (without proof) multinomial distribution with cell probabilities depending on a parameter. (12 L)

Unit IV: MLE in censored and truncated distributons. Likelihood Ratio Test(LRT), Asymptotic distribution of LRT statistic, Wald's Test, RAO's Score test , Pearson's chi-square test of Goodness of fit, Bartlett's test for homogeneity of variances. Variance stabilizing transformations. (12 L)

Unit V: Bootstrap Distribution and the Meaning of Consistency, Delta Theorem for the Bootstrap, Failure of the Bootstrap, Bootstrap Confidence Intervals, Bootstrap in Regression, Bootstrap for dependent data. Jackkinfe estimates of bias. Deleted – d Jackknife and von Mises Functionals (12 L)

Text Books :

1) Kale B.K. and Murlidharan(2015) : A first course on parametric inference, Narosa Publishing House.
2) Rohatgi V. and Ehsanes Saleh A. K. MD (2012): An introduction to Probability and Mathematical Statistics, Wiley Eastern Ltd., New Delhi Student Edition.
3) Casella G. & beregar R.L.(2002) : Statistical Inference,2nd edition.
4) Dudewitz E.J. and Mishra S.N. (1988) : Modern Mathematical Statistics, John Wiley.

Reference Books :

5)George Casella, Roger L. Berger(2001): Statistical Inference,2nd edition, Duxbury Advanced Press.
6) Lehmann E.L. (2000): Theory of Point Estimation (Student edition),John Wiley.
7) Lehmann E.L. (1986):Testing Statistical hypothesis (Student edition),John Wiley.
8) Rao C.R. (2012): Linear Statistical Inference and its Application, Wiley series, John Wiley & Sons, Inc.
9) Zacks.S.(1971) : Theory of Statistical Inference, John Wiley and sons, New York.

STA-413: PRACTICAL – III

SEM: II **Max Mark: 50**

Credit: 02

List of practical (Based on Statistical Inference-II, Stochastic Process and Sample survey using Software)

Sr. No.	Title of Practical
1	Newton Raphson method for estimation of parameters
2	Computation of Correlation coefficients
3	Testing of homogeneity of variances
4	Construction of transition probability matrix and calculation of n- step transition probabilities
5	Generation of random numbers using SRSWOR/ SRSWR
6	Estimation of mean and variance with unequal probabilities
7	Construction of H- T estimator and estimator variance : a) Lahari's scheme b) Murthy's estimator
8	Estimation of mean and variance in stratified sampling under Neyman – Proportion and optimum allocation.
9	Estimation of mean and variance in : a) Systematic sampling b) Cluster sampling c) Two stage sampling
10	Ratio and regression method of estimation in SRS.

STA-414: PRACTICAL- IV

Course Outcome

After completing this course students will be able to:

CO1: Analyze basic designs like CRD, RBD, and LSD with R Programming or Python

CO2: To estimate missing values in designs using R programming and Python.

CO3: To fit linear and non-linear regression using different methods and implementation of variable selection method using R programming and Python.

CO4: Deal with extreme observation and multicollinearity by Robust Regression and Ridge Regression using R programming and Python.

SEM:II **Max Mark: 50**

Credit: 02

List of practical (Based on D.O.E-I + Regression Analysis)

Sr. No.	Title of Practical
1	Analysis of variance in CRD
2	Analysis of variance in RBD
3	Analysis of variance in LSD
4	Analysis of variance in (one) missing plot techniques RBD and LSD
5	Analysis of Covariance
6	Fitting of Simple and Multiple Regression
7	Fitting of orthogonal polynomials
8	Variable selection methods

9	Fitting of Logistic regression
10	Robust, Ridge regression

STA-501: DESIGN AND ANALYSIS OF EXPERIMENTS-II

CO1: CONSTRUCT BLOCK FOR TOTAL AND PARTIAL CONFOUNDING. IDENTIFY CONFOUNDED EFFECT
CO2: ANALYZE 3^N FACTORIAL DESIGN
CO3: ANALYZE BIBD AND PBIBD

SEM III **Max. Marks: 100**
Credits: 04

Unit I : Factorial experiments: Symmetrical Factorial Experimentsts of type 3^2 , 3^3 and their layout, Randomization, Yates method for estimation of factorial effect totals in 3^2 , 3^3 Factorial experiments and Statistical Analysis. Asymmetrical factorial experiments of m x n x p types and their layout, Randomization and Statistical Analysis. Situations when these experiments are used. (12 L)

Unit II : Confounding in factorial experiments, Complete and Partial confounding, **Construction of designs for** 2^n **and** 3^n **confounded factorial designs**, Analysis of confounded factorial designs. **Fractional Factorial Designs, resolution III, IV and V design**. (12 L)

Unit III : Split plot design : Introduction, Layout and Randomization, Statistical analysis of split plot design. **Strip plot design:** What is Strip plot design? Layout and Randomization, Statistical analysis of strip plot design. Practical Situations when these designs are used. (12 L)

Unit IV : Incomplete Block Designs: Balanced Incomplete Block design (BIBD), General block design and its information matrix, Criteria for Connectedness, Balance and Orthogonally, **Optimality of block design, A, D, G, E, V optimality of designs**. Construction of Balanced Incomplete Block Designs (BIBD), Relationship among parameters of BIBD, Inter and Intra block analysis of BIBD. Resolvable designs. (12 L)

Unit V: Partially Balanced Incomplete Blocks Designs (PBIBD): Relationships among parameter PBIBD. Construction of PBIBD. Concept of Youden Square Design. **Generalized block designs. Response surface methodology (RSM):** linear and quadratic models, Plackett-Burman design. **(12 L)**

Text Books:-

1) Montgomery D.C. (2004): Design and Analysis of Experiments , John and Wiley
2) Das M.N and Giri (2006): Design and Analysis of Experiments, Eastern Wiley
3)Joshi D.D. (1987): Linear Estimators and Design of Experiments, Wiley eastern
4)Kshirsagar A.M. (1983) : A course in Linear Models. Marcel Dekker Inc New York.

Reference Books:-

1) Giri N. (1986): Analysis of Variance, South Asia publication.
2) Peterson R.G. Design and Analysis of Experiments, Marcel Dekker Inc New York
3) Alok Dey (1986): Theory of Block Design, Eastern Wiley

STA- 502: MULTIVARIATE ANALYSIS

COURSE OUTCOME

After completing this course students will be able to:

CO1: Determine various properties of multivariate normal distribution
CO2: Application of Hotteling's T^2, construction of hypothesis and tests of significance
CO3: Form PCA, its properties, use of PCA to solve real life problems
CO4: Classify observations and construct clusters

SEM: III **Marks: 100**
Credits: 04

Unit I: **Multivariate normal distribution (MVND):** Singular and nonsingular multivariate normal distribution. Characteristic function of MVND, conditional distribution and marginal distribution of MVND. Distribution of linear combination. : .Central & non-central chi square distribution, quadratic forms of normal random variables, its distribution, necessary and sufficient condition for a quadratic from to have χ^2 distribution, condition for independence of two quadratic forms, maximum likelihood estimator of parameters of MVND. (12L)

Unit II : Wishart distribution: Wishart matrix, derivation of Wishart distribution, its characteristic function and properties. **Partial and multiple correlation coefficients**, their properties and sampling distribution. (12L)

Unit III: Tests of Hypothesis about mean vector of a multivariate normal population: Hotelling's T^2 statistics, its application, likelihood ratio test. Mahalanobis D^2 statistic and its relation with T^2 statistic. **Comparisons of several multivariate means:** One way MANOVA, two way MANOVA. (12L)

Unit IV: Principal Component Analysis: Principal components for covariance matrices, Properties of Principal components. **Factor Analysis**: The orthogonal factor model, The principal component method of estimation. **Canonical Correlation:** canonical correlation and canonical variates. (12L)

Unit V: Classification and Discrimination: Classification minimizing Expected cost of misclassification, Classification of normal populations with equal and unequal covariance matrices. Test for homogeneity of covariance matrices. Tests associated with discriminant functions. Calculation of misclassification Probabilities. **Cluster analysis**: Similarity measures, hierarchical methods: Single linkage method, Complete linkage Method, Average Linkage Method, Ward's method. Non- hierarchical clustering methods: K means method. (12L)

Text Books:

1) Anderson T.W.(1983), Introduction to multivariate analysis (John Wiley)
2) Richard A. Johnson, Dean W. Wichern(2002), Applied Multivariate Statistical Analysis. (Prentice hall Inc.)
3) Kshirsagar A.M. (1972), Multivariate Analysis. (Marcel Dekker)
4)K.C. Bhuyan (2005), Multivariate Analysis and its application, New Central book agency Ltd

Reference Books:

1). C. R. Rao (2002), Linear Statistical Inference and its applications. (Wiley Eastern)
2) Morrison D.F. (1976), Multivariate Statistical Methods. (McGraw Hill)
3) Murihead R.J.(1982), Aspects of Multivariate Statistical Theory (J. Wiley)
4) Seber G.A.F. (1984), Multivariate Observations(Wiley)
5) Sharma S. (1996), Applied multivariate techniques. (Wiley)
6) Srivastva M.S. and Khattri (1979), An introduction to Multivariate Statistics. (North Holland)

STA 503: TIME SERIES ANALYSIS

Course outcome

After completing this course students will be able to:

CO1: Find common patterns, and trends in time series data.

CO2: Fit the models ARIMA, SARIMA, exponential smoothing methods, and state-space models to time series data.

CO3: Select appropriate models for time series data and evaluating model performance using metrics like AIC and BIC.

CO4: Explore advanced topics in time series analysis such as ARCH, GARCH and multivariate time series analysis, for forecasting.

SEM III **Max Marks : 100**

Credits : 04

Unit-I : Forecasting : Introduction to time series analysis, Concept of forecasting and its application in manufacturing industrial situations, different methods of forecasting: Moving average, exponential weighted moving average (exponential smoothing) forecasting in presence of linear trends using least square methods, forecasting in presence of seasonal effects. Methods of De-seasonalisation of data.
(12 L)

Unit-II: Time series as discrete parameter stochastic process. Features of time series Data :Trend, Seasonality, auto covariance and auto correlation function and their properties, Two exploratory time – series analysis
(12 L)

Unit-III: Test for randomness of a series against trend and seasonality M.A and exponential smoothing, Hot winters smoothing, forecasting based on smoothing, adaptive smoothing.(12 L)

Unit-IV: Study of stationary process – (a)moving average (M.A), (b)auto regressive (AR), (c)ARMA and (d)ARIMA model box – Jenkins model Discussion (without proof) of estimation of means, auto covariance and auto correlation function under large sample theory.Choice of AR

and MA periods.Estimation of ARIMA model parameters.Forecasting, residual analysis and diagnostic checking.

Unit-V: Introduction to spectral analysis of weekly stationary process. Periodogram and correlogram analysis. Non – stationary and seasonal time models :Unit – root non –stationarits, unit– root test, integrated ARMA (ARIMA) models seasonal ARIMA (SARIMA) models. (12 L)

Text Books :

1. Anderson T.W :The statistical analysis of time series, Wiley.
2. Montgomery DC and Johnson LA :Forecasting and time series analysis, Mcgrew Hill.

Reference Books

1. Kendall and Ord :Time series (3rd Edition), Edward Arnold.
2. Brockwell P.J and Daris R.A :Time series : Theory and methods springer – verlag.
3. Box G.E.P and Jenkins G.M :Time series analysis – forecasting and control, holdan – day, san Francisco.

STA 504 : INDUSTRIAL STATISTICS

CO1: To explain different concepts of statistical quality control, statistical process control and total quality control.
CO2: To construct different control charts and to identify the trends.
CO3: To construct control charts for variables and attributes.
CO4: To construct sampling plans for attributes and variables.
CO5: To explain Six Sigma and ISO standards.

SEM-III **Marks : 100**
Credits : 04

Unit-I: Basic concepts of SPC and SQC,: Concept of quality, Quality improvement , quality philosophy , PDSA cycle . Total Quality Management, Taguchi design. Concept of stable industrial process, Systematic variation, random variation, General theory and review of control charts for attribute and variable data, O.C. and A.R.L. of control charts. Confirming run length(CRL) chart for Attribute. (12 L)

Unit-II: Moving average and Exponentially weighted moving average (EWMA) charts. CUSUM charts using V – masks and decision intervals. Comparison of Shewhart control charts with CUSUM chart. General idea on economic designing of control charts. Process capability and performance indices $C_{p,}$ and $C_{pk,}$. Estimation and confidence intervals of estimation of C_p . (12 L)

Unit-III: Acceptance sampling plans for attributes: Problem of lot acceptance - good and bad lots, producer's and consumer's risks; Single, Double and multiple sampling plans of attributes and their properties. O. C. function, concepts of AQL, LTPD, AOQL, ATI and ASN functions. (12 L)

Unit-IV : Acceptance sampling plans for variables: Designing variable acceptance sampling plans . AOQL based sampling plans: Continuous sampling plans of Dodge type and Wald – Walfowitz type and their properties, Lieberman and Solomon plan. Skip lot sampling plan, Shanin

lot plot method, chain sampling and sequential sampling plan. AQL based sampling plans: Plans to control process fraction defective, MIL- STD -105E plan and its switching procedure.

(12 L)

Unit-V: Quality systems: Concept of six sigma. Define –measure- anlayze – improve – control (DMAIC) approach. Concepts of lean six sigma. Precision and accuracy in measurement systems . Estimation of measurement uncertainty. Quality management: ISO 9000 standards, 9001, 14001 standards (12 L)

Text Books :

1) Montoegmory, D.C (1985) : Statistical Process Control, John Wiley.
2) Montoegmory, D.C (2007) :Introduction to Statistical Quality Control, Wiley.
3) Logothetis N. (1992) :Managing Total Quality, Prentice Hall of India.
4) Suddhendu Biswas (2003) : Statistics of Quality Control, New Central Book Agency.
5) Wetherill G.B. and Brown D.W. Statistical Process Control, theory and practice chapman and Hall.

Reference Books :

1) Mahajan M. S. (2013) : Statistical Quality Control. Dhanpat Rai & Co. (P) LTD. Delhi.
2) Phadke, M.S.(1989) : Quality Engineering through Robust Design Pretic Hall.
3) Oakland J.S. (1989) : Total Quality management, Butterworth Heinemann.
4) Mittag H.J. and Rinne.H. (1993) :Statistical process control John Wiley.

STA- 505: OPERATIONS RESEARCH – I

COURSE OUTCOME

After completing this course students will be able to:

CO1: Recognize the fundamentals and formulation of linear programming problems, as well as their limitations; use graphical methods to solve linear programming problems.

CO2: Use the simplex approach to resolve practical issues.

CO3: Learn assignment, transportation, sensitivity analysis, duality theory, revised simplex method, and artificial variable techniques.

CO4: Apply to real-world problems using integer programming.

CO5: Manage inventory of diverse items with and without shortages.

SEM. III **Max marks: 100**
Credits: 04

Unit I : Review of L.P.P., algorithm of simplex big M method, Transportation problem and assignment problem. Theorem of simplex method, Revised simplex method, theory of duality, complementary Slackness properties. (12L)

Unit II : Nonlinear programming problem: General Nonlinear programming problem, Convex and concave functions, test for concavity and convexity, Lagrange's method for optimality, Kuhn-Tucker condition, Quadratic programming problem-Beals and Wolfes algorithm for solving Q.P.P. (12L)

Unit III : Inventory Problem: Introduction, Reason for carrying inventory, ABC and VED analysis, JIT concept, EOQ formula of Haris, Inventory models with and without shortages,

Inventory models with uniform and instantaneous demand, EOQ formula for single price break, two price break and n price break. Multi item inventory subject to constraint. (12L)

Unit IV : Probabilistic inventory models: Single period probabilistic inventory model with a) Instantaneous demand and discrete units, b) Instantaneous demand and continuous units, c) continuous demand and discrete units, d) continuous demand and continuous units, (s,S) policy for inventory and its derivation in case of exponential demand, Mulitchelon inventory models, Definition of perishable, different kinds of perishability, Basic inventory model for perishability. (12L)

Unit V: Post optimality analysis (changing one component of b-vector and c-vector. Integer programming problem cutting plane algorithm, branch and bound method. (12L)

Text books:

1) Hiller and Lieberman Operations Research concepts and cases, Tata macgraw Hill
2) A. Ravindran, D.T. Phillips, J.J. Solberg. (2001) Operations Research Principles and practices, 2nd ed. John wiley and sons.
3) Taha H.A.(1976) Operations Research, An introduction, 2nd ed., Macmillan, New York.

References:

1) Sharma J.K (2003) Operations Research theory and application, Macmillan business books.
2) Prem kumar Gupta and D. S Hira Operations Research, S. Chand Publication
3) Hadely G.(1969) Linear programming, Addison Wesley.
Wagner H. M. (1975) Principles of Operations Research, 2nd ed. Prentice Hall, Englewood cliffs.

STA 506: ECONOMETRICS

SEM III **Max Marks : 100**
Credits : 04

Unit-I : Nature of Econometrics. The General linear model (GLM) & its extensions. Ordinary least squares (OLS) estimation & prediction. Use of dummy variables and seasonal adjustment. Generalized least squares (GLS) estimation & prediction. Heteroscedastic distribution. Pure and mixed estimation. Grouping of observations and of equation. (12 L)

Unit-II : Auto-correlation, its consequence and tests, the BLUS procedure, Estimation & prediction, Multicollinearity problem, its implications & tools for handling the problem. Ridge regression. (12 L)

Unit-III : Linear regression with stochastic regressors, instrumental variable estimation Errors in variables, Autoregressive linear regression. Distributed lag models, use of principal components, canonical and discriminant analysis in econometrics. (12 L)

Unit-IV : Simultaneous linear equations models. Examples, Identification problem. Restrictions on structural parameters - rank & order conditions. Restrictions on variables and co-variances. (12 L)

Unit-V : Estimation in simultaneous equations model Recursive systems, 2 SLS Estimators Limited information estimators, k- class estimators, 3 SLS estimation, Full information maximum likelihood method, Prediction and simultaneous confidence intervals, Monte Carlo studies and simulation. (12 L)

Text Books :

1. Chow G.C. (1983), Econometrics, McGraw Hill, New York.
2. Gujarati D.N. (1995) Basic Econometrics (2nd Ed.) McGraw Hill, New Delhi.
3. Johnson J. (1991) Econometric Methods, McGraw Hill Book Co. London.

Reference Books

1.Kennedy. P. (1998), A Guide to Econometrics (4th Ed.) MLT Press. New York.
2. Kmenta. J. (1997) Elements of Econoementrics (Reprint Edition), University of Michigan Press, New York.
1. Koutsoyiannis, A (1977), Theory of Econometrics (2nd Ed) The MacMillan Press Ltd. London.
2. Maddala, G.S. (Ed.) (1993) Econometrics Methods and Application (2Vols), Albershot, UK.
3. Theil, H. (1981) Introduction to Econometrics, Prentics Hall of India New Delhi.

STA-507: STATISTICAL METHODS (SERVICE COURSE)

SEM: III **Max.Marks: 100**
Credits : 04

Unit-I: Statistical Measures : Measures of central tendency : Arithmetic Mean, Geometric Mean, Harmonic Mean, Median and Mode; Measures of Variation : Range, Mean Deviation, Standard Deviation, Coefficient of Variation, Quartiles, Percentiles, Measures of Skewness and Kurtosis. Types of data: Qualitative and Quantitative data. Scale of Measurements (Nominal, Ordinal, Interval and Ratio) (12 L)

Unit-II: Probability and Distributions: Concept of Probability, Laws of Probability (Statements only); Random Variable; Probability Distributions: Binomial, Poisson and Normal distributions (properties and applications). (12 L)

Unit-III: Sampling Techniques: Concept and definitions, Types of sampling: Purposive and Random Sampling, Methods of selecting random numbers. Simple Random Sampling, Stratified Random Sampling and Systematic Random Sampling. (12 L)

Unit- IV : Tests of Significance : Basic concepts; Types of Hypothesis, Types of Error, Critical Region; Large sample tests for proportions and means; small sample tests; Application of t, chi-square, F-tests; Non-Parametric Test : Wilcoxon Signed Rank Test, Median Test and Mann-Whitney U-Test. (12 L)

Unit-V: Correlation and Regression: Types of Correlation, Simple Correlation, Karl Pearson's Correlation, Multiple Correlation and Partial Correlations, Properties of Correlation Coefficient, Test of Significance of Correlation Coefficient. Regression: Regression Coefficient, Properties of Regression Coefficient, Fitting of Regression Curve (Linear and Non-linear), Multiple Regression, Coefficient of Multiple Determination (R^2), Stepwise/Step down Regression Analysis.
(12 L)

Text Books:

1) Gupta S.C. and Kapoor V.K. (2010): Fundamentals of Mathematical Statistics, Sultan Chand and Sons , New Delhi.
2) Gupta S.P. (2006): Statistical Methods, Sultan Chand and Sons , New Delhi.
3) Rao, C. R. (1973): Linear Statistical Inference and its Applications , A Wiley – Inter science Publications , JOHN WILEY & SONS, INC.

Reference Books:

1) Gupta S.C. and Kapoor V.K. (2010): Fundamentals of Applied Statistics, Sultan Chand and Sons, New Delhi.
2) Richard B. Ellis(1975): Statistical Inference Basic Concepts, Prentice-Hall, Inc., Englehood Cliffs, New Jersey.
3) E.L. Lehmann (1966): Testing Statistical Hypotheses, New York. John Wiley & Sons, Inc., London, Sydney.

STA-508: RESEARCH PROJECT/DISSERTATION PART -I

SEM: III **Max. Marks: 100**
Credits: 04

The students are expected to do the following research work :

i) Framing of objectives and hypothesis
ii) Preparation of Questionnaires, sample surveys and field work
iii) Filtration and data classification
iv) Seminar

STA 509: PRACTICAL - V
(Based on D.O.E - II)

After completing this course students will be able to:

CO1: Analyse and interpret advanced design like Factorial, Split plot, Strip plot, BIBD and PBIBD with R Programming and Python.

CO2: Analyse total and partial Confounding in design and their practical implementation using R Programming and Python.

CO3: Find Seasonal indices with R Programming and Python.

CO4: Model time series data using techniques such as ARIMA, SARIMA, exponential smoothing methods and their practical uses with R Programming and Python.

CO5: Implement advanced time series models like ARCH, and GARCH using R Programming and Python.

SEM: III **Max Marks : 50**

Credits :02

STA 510: PRACTICAL – VI

Course outcome

After completing this course students will be able to:

1	Analysis of asymmetrical factorial experiments.
2	Analysis of symmetrical factorial experiments.
3	Analysis of Split plot and Strip plot design
4	Analysis of complete and partial confounding
5	Analysis of BIBD
6	Analysis of PBIBD
7	Ratio to moving Average Method, Ratio to Trend Method
8	Link Relative Method, Exponential Smoothing method
9	Time Series
10	Time Series

- To tackle real-life problems related to Linear Programming Problem, Transportation Problem, Assignment Problem.
- To Construct Network Diagrams and network analysis.

SEM: III **Max Marks : 50**
Credits :02

(Operation Research and Industrial Statistics-I)

Sr. No.	Name of the Practical
1	Simplex and Dual Simplex Method
2	Big-M, Penalty Method , Two phase method
3	Transportation Problem, Assignment Problem
4	Inventory models- deterministic, price break models, Sequencing Problem
5	Control Chart for variables and Attributes
6	Acceptance sampling plans for Variables & Attributes
7	Model sampling from multivariate normal distribution,
8	Principal Component Analysis
9	Classification and Discriminent Analysis
10	Hotelling's T^2 Statistics, MANOVA

Note.: Practicals based on other elective courses will be allotted accordingly if they opt.

STA 512: Reliability Theory

Course Outcomes

CO1: Discusses about reliability system connected in Series, Parallel, and k out of N systems and reliability functions.
CO2: Estimate life length distributions, using complete or censored data.
CO3: Learn ageing properties of a system.

SEM: - IV **Marks: 100**
Credits: 04

Unit-I: Reliability: Definition and basic concept, need, achievements, reliability improvement, reliability function, Estimation of survival function, measurement of reliability: concept of failure, Failure rate, mean time to failure (MTTF), mean time between failures (MTBF), Hazard function, hazard rate function, reliability and probability failure, constant failure rate model, Bath tub failure rate,

Unit-II: System Reliability: Reliability block diagrams, Reliability of series, parallel, and mixed configuration, k -out-of –n structure, analysis of complex system-enumeration method, structure function, coherent function, structure function of coherent, bridge structure, Minimal cuts, minimal

paths. General characteristics of coherent systems, systems of independent components, reliability of coherent system, bonds on system reliability.

Unit-III : Maintainability and Availability: Objectives of maintenance, types of maintenance, maintainability, factors affecting maintainability, system down time, reliability and maintainability trade-off, maintainability tools and specific maintainability design considerations, availability - inherent, achieved and operational availability, , System Availability Assessment, Inspection and repair availability model, modeling of a repairable system by NHPP. (12L)

IV: Censoring Analysis:

Concept of censoring, Types of censoring, concept of time, failure and random censoring. Reliability estimation based on failure times in various censored life tests and in tests with and without replacement of failed items in Life Distribution: – Exponential, Lognormal, Gamma, and Weibull distribution. (12L)

Unit-V: Parametric families of distributions of direct importance in Reliability: a notion of aging, Notions of ageing: IFR, DFR, IFRA, DFRA, DMRL.the exponential distribution, the Poission process, the Poission distribution, parametric families of life distributions with monotone failure rate,

Text Books:

1) Sinha S.K.(1986): Reliability and Life Testing, Wiley Estern Limited.
2) Barlow R.E. And Proschan F. (1985): Statistical Theory of methods reliability and Life Testing Holt Rinehart and Winston.
3) K. Muralidharan and A. Syamsundar (2012): Statistical Methods for Quality, Reliability and Maintainability, PHI Learning PVT, India
4) Elandt-Johnson R.E., Johnson N.L. (1980): Survival Model and Data Analysis, John Wiley and Sons.

Reference Books:

1) Bain L.J. And Engethaardt (1991): Statistical Analysis of Reliability and Life Testing models Marcel Derkker.
2) Mahajan M. S. (2013) : Statistical Quality Control. Dhanpat Rai & Co. (P) LTD.
3) Montegomery D.C.(1996): Introduction to Statistical Quality Control, Wiley.

Nelson W.(1982) : Applied Life Data Analysis John Wiley.

STA- 513: ACTUARIAL STATISTICS

C01: To construct life tables
C02: To find present value of money
CO3: To explain the concepts of annuity, for different types of life and term insurance
CO4: To calculate premiums for different insurance products.

SEM: IV **Marks: 100**
Credits: 04

Unit I : Introduction to insurance business and Utility theory: Introduction to insurance business, working of insurance business. Expected value principle, Utility, Utility Functions, Expected utility, Concepts of reinsurance. (12 L)

Unit II : Future life time distributions : Introduction, Future lifetime random variable and its distribution and survival function, Force of mortality, Mortality laws: De Moivre's law, Gompertz's law, Makehan"s law and Weibull law. (12L)

Unit III: **Life Tables:** Introduction, International actuarial notations, distribution function and survival function of time until death t(x). Curtate future life time random variable, Life tables, construction of life tables. (12 L)

Unit IV: Interest: Cash flow models, time value of money, Accumulation and amount function. The effective rate of interest, simple and compound interest. Present value, Nominal and effective rates of interest, discounting & accumulating factors, (12L)

Unit V: Annuities: Continuous life annuities, discrete life annuities, life annuities with monthly payments, apportionable annuities. **Premiums:** Fully continuous & discrete premiums, mthly payment premiums apportionable premiums. (12L)

Text Books:

1) Deshmukh S.R. (2009): Actuarial Statistics: Introduction using R, University press, Hyderabad.
2) Deshmukh S.R. (2012): Multiple decrement models in Insurance, Springer.
3) N.L. Bowers, H.U. Gerber, J.C. Hickman, D.A. jones and C.J. Nesbit(1986), Actuarial mathematics, Society of Actuaries, Itacasa, IIIinois, U.S.A.
4) Dixit S.P. Modi C.S. & Joshi R.V. (2000): Mathematical basis of life Assurance. Published by Insurance Institute of India, Mumbai .
5) Stephen G. Kelison (2007): Theory of Interest, Mc Graw-Hill Irwin Publication. New York.

Reference Books:

1) Neill A. (1977), life contingencies, Hienemann.
2) Donald D.W.A. (1984): Compound interest & Annuities Certain Published for faculty of Actuaries, and the faculties of actuaries London.
3) McCutcheen J.J.& Scott W.F. (1989): Financial Mathematics, Butterworth Heinemann.

STA 514: STATISTICAL ANALYSIS OF CLINICAL TRIALS

Course outcome

After completing this course students will be able to

CO1: Estimate of Pharmacokinetic parameters

CO2: construct, analyze different designs and interpret results
CO3: Find power and sample size

SEM-IV **Marks: 100**
Credits: 04

Unit I: Introduction to clinical trials: The need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, pharmacokinetic parameters, clinically important differences, assessment of bioequivalence, decision rules and regulatory aspects, overview of Phase I-IV trials, classification of clinical trials: multi-center trails, Active control trials, Combination trials, Equivalence trial. (12L)

Unit II: Designs of clinical trials: Parallel Design, cross-over designs, cross-sectional design, longitudinal designs, Randomization techniques for group allocation. Statistical Inferences for effects from a standard 2 X 2 cross over design: The carry over effects, the direct drug effect, the period effect. Repeated measure analysis. (12L)

Unit III: Optimal Crossover designs: review of balanced incomplete block design, Balaam's design, four sequence two period design, two sequence dual design , optimal four period designs, analysis for average bio availability, assessment of intra subject variabilities for optimal designs. (12L)

Unit IV: Statistical methods for average bio availability: The classical Confidence Interval, interval hypothesis testing, Schuirmann's test, Anderson and Hauck's test, non parametric methods, Wicoxon Mann Whitney test. Power of Anderson and hauck's test procedure, power approach for assessing bioequivalence, sample size for point and interval hypothesis. (12L)

Unit V: Power and Sample Size Determination: Hypotheses and Type I and Type II errors, Power and relative efficiency, sample size determination. **The assessment of Inter and Intra subject variabilities:** Point and Interval estimates, interclass correlation, test for equality of variabilities, Pitman Morgan's adjudted F test, test based on Spearman's rank correlation coefficient. (12L)

Text Books:

1. Chow S.C. and Liu J. P.(2009). Design and Analysis of Bioavailability and bioequivalence, 3rd edition, CRC press
2. Chow S.C. and Liu J. P.(2004). Design and Analysis of Clinical Trials, 2nd edition, Marcel Dekkar.
3. L.M. Friedman, C.Furburg, D.L. Demets (1998) Fundamentals of Clinical Trials, Springer Verlag.
4. J.L. Fleiss (1989). The design and Analysis of Clinical Experiments. Wiley and Sons.
5. Daowen Zhang (2009) Statistical Principles of Clinical Trials (Lecture Notes).
6. Fieller Nick (2007). Medical Statistics: Clinical Trials
7. David Machin, Simon Day, Text book of Clinical Trials
8. Umakant Sahoo, Dipti Sawant. Clinical Trial Monitoring: A professional Handbook

Reference Books :

1. S.Piantadosi (1997) Clinical Trails : A methodological Perspective. Wiley and Sons.
2. C.Jennison and B.W. Turnbull (1999). Group sequential methods with application to Clinical Trails CRC Press.

STA- 515: OPERATIONS RESEARCH – II

Course Objective

- This course teaches advanced operations research methods used in systems engineering and management. It equips students with the necessary tools to represent decision-making problems mathematically, with a focus on uncertainty and risk.
- To learn the basics in the field of game theory.
- To know how project management techniques help in planning and scheduling a project.

After completing this course students will be able to:
CO1: Use dynamic programming to solve multistage problems.
CO2: Learn basic concepts of queuing models and solve the steady state equations for various queuing models.
CO3: Find shortest path in a network
CO4: Apply game theory and investment analysis in practical situations.

SEM. IV **Max marks: 100**
Credits: 04

Unit I : Dynamic programming problem, Optimal decision policy, Dynamic programming under certainty, deterministic and probabilistic, Simulation: Introduction, process of simulation, simulation models, Monte-Carlo simulation. (12L)

Unit II : Queuing theory: Introduction, Characteristic of system, Probability distribution in queuing system, Steady state solution of M/M/l and M/M/C with associated distribution such as queue length waiting time, and steady state solution of $M/E_k/l$ and M/G/1, Pollaczek-Khintchine formula. (12L)

Unit III : Game theory : Introduction and assumptions, two person zero sum game, pure and mixed strategies existence of solution and uniqueness of value in zero sum game, Dominance property, Finding solution of 2X2 2xm and mxn games non –zero sum game equivalence between game theory and L.P.P (12L)

Unit IV: Replacement models: Introduction, Types of failures, Bulk and age replacement, Replacement of equipment fails suddenly, replacement for the equipment deteriorates with time and the value of money a)changes with time, b) does not change with time, Dynamic approach for maintenance problem, **G**roup replacement policy, Replacement of items with long life. (12L)

Unit V: Networks : Definition, Concept of network, drawing of network, determination of flow's , critical path method and PERT, max flow min cut theorem, Advantages and limitation of networks. Sequencing problem introduction, Assumption processing of n jobs through two machine processing of n jobs through three machines with identical machine sequence for all jobs processing of two jobs m machines. (12L)

Text books :

1) A. Ravindran, D.T. Phillips, J.J. Solberg. (2001) Operations Research Principles and practices, 2nd ed. John wiley and sons.
2) Taha H.A.(2006): Operations Research, An introduction, 8 Ed Prentice Hall.
1) Sharma J.K (2003) Operations Research theory and application, Macmillan business books.

References :

1) Kanti Swarup , Manmohan and P.K. Gupta (2010): Operations Research, S. Chand Publication
2) Gross D. and Harris C.M. Fundamentals of queuing theory.
3) Wagner H. M. (1975) Principles of Operations Research, 2nd ed. Prentice Hall.

STA-516: STATISTICAL SIMULATIONS

SEM: IV **Marks: 100**
Credits: 04

Unit-I: Statistic simulations: generating random variables, simulating normal, gamma and beta random variables. Comparison of algorithms to generate random variables. Generating random variables from failure rates. (12L)

Unit-II: Simulating multivariate distributions, MCMC methods and Gibbs sampler, simulating random fields, simulating stochastic process. (12L)

Unit- III: Variance reduction technique: importance sampling for integration, control variates and antithetic variables. Simulating a non-homogeneous Poisson process (12L)

Unit IV: Optimization using Monte Carlo methods, simulated annealing for optimization. Solving differential equations by Monte Carlo methods. (12L)

Unit- V: Jackknife and Bootstrap. Bootstrap methods: re-sampling paradigms, bias and standard errors, Bootstrapping for estimation of sampling distribution. Confidence intervals, variance stabilizing transformation, bootstrapping in regression and sampling from finite populations. (12L)

Reference Books:

Fishman, G.S. (1996) Mante Carlo: Concepts, Algorithms and Applications. (Springer).
Rubinstein, R.Y. (1981); Simulation and the Monte Carlo Method. (Wiley).
Ripley, B.D. (1987) Stochastic Simulations (Wiley).

Ross, S. M. (2002) Simulation (Third Edition) (Academic).
Efron,B. and Tibshirani. R.J. (1993); An introduction to the Bootstrap.
Davison, A.C. and Hinkley,D.V. (1997) Bootstrap methods and their applications (Chapman and Hall).
Sho.J and Tu,D (1995); The Jackknife and the Bootstrap. Springer Verlag.

STA 517 : DATA MINING

COURSE OUTCOME

After completing this course students will be able to:

CO1: Prepare data for mining using pre-processing techniques.

CO2: Learn unsupervised learning techniques for both univariate and multivariate data.

CO3: Learn supervised learning techniques for medium to high dimensional spaces.

CO4: Apply categorization algorithms to real-world challenges across multiple fields.

SEM-IV **Marks : 100**
Credits :04

Unit I : General Overview of Data Mining and its Components Introduction and Data Mining Process. Data Preparation and Exploration, Visualization Techniques. Association rules frequent items support and confidence of a frequent itemset. Relationships between association rules and frequent itemsets feature selection, Apriori algorithm. (12L)

Unit II : Regression and classification trees (CART), Assessment and model selection: Bias variance trade off, training error rate, AIC, BIC, CIC, DIC (information criterion), cross validation Ada boosting, Random forest. (12 L)

Unit III : Density based Clustering, outlier detection, sequence mining, KNN method ,Bayes classifier (12L)

Unit IV : Support vector machine, kernel machines, Artificial neural network , multilayer Perceptron network (12L)

Unit V : Text collection and transformation, text mining and modeling, text classification, clustering and summarization. Application using R/ python **(12L)**

Text Books

1) Berson A. and smith S.J. (1997) Data warehousing, Data mining and OLAP (McGraw- Hill)

2) Breiman L, Friedman J.H. Olshen R.A. And stone C.J. (1984) classification and regression trees. (wadsworth and brooks /cole)
3) Han J and Kamber M (2000) Data mining concepts and techniques (Morgan Kaufmann)
4) Daniel T.Larose, (2006). Data Mining Methods and Models. Wile-Interscience

Reference Books :

1) Mitchell T.M. (1997) Machine learning (McGraw- Hill)
2) Ripley B.D. (1996) Pattern Recognition and neural Networks (Cambridge University Press)

STA 518: Seminar/ Project Dissertation part-III

SEM-IV **Marks : 100**
Credits :04

I. Detailed review of literature
II. Statistical Analysis of Data using statistical software
III. Seminar

STA 520: PRACTICAL-VII

Course Outcome

After completing this course students will be able to

CO1: Preprocess data using R Programming and Python.

CO2: Use different classifiers like SVM, ANN, CART, Random Forest, Naïve Bayes etc. on real-world data using R Programming and Python.

CO3: Evaluate the performance of data mining models using metrics such as accuracy, specificity, sensitivity F1-score, ROC curves, and confusion matrices.

CO4: Apply text-mining techniques that will help to deal with textual data using R Programming and Python.

(Data Mining and Actuarial Statistics)

SEM: IV **Max Marks :50**
Credits :02

1	Data Preprocessing
2	CART and Association Rule
3	Random Forest
4	Ada Boost and XG boost
5	Support Vector Machine
6	Naïve Bayes and KNN
7	Density base clustering (DBSCAN)
8	Artificial Neural Network
9	Text Mining
10	Measurement of Reliability (Series and Parallel)

STA -521: PRACTICAL-VIII

SEM: IV **Max Marks: 50**

Credits: 02

(Reliability, Clinical Trails and Operation Research-II)

Note.: Practicals based on other elective courses will be allotted accordingly if they opt.

1	Dynamic programming problem, Simulation
2	Queuing theory
3	Game theory
4	Replacement problem
5	Network problem – PERT/CPM
6	Computation of Premiums
7	Benefit payable at end of year of death
8	Discrete life Annuities
9	Construction of Life Tables
10	Mortality laws