DEPARTMENT OF STATISTICS
COTTON UNIVERSITY

POST GRADUATE SYLLABUS

(LOCF FORMAT)

Introduction

Statistics as a subject is an important branch of knowledge and is devoted to various techniques of collection, presentation, analysis and interpretation of data. It is a science of learning from data. The subject provides tools for making decisions when conditions of uncertainty prevail. Hence Statistical tools and techniques are used in almost all fields whichare indispensable for people working in fields like agriculture, business, management, economics, finance, insurance, education, biotechnology and medical science, etc. For the last two decades, large amount of data have been handled with the help of computers and more sophisticated statistical techniques can be used in an effective manner to draw valid conclusions. Knowledge of different aspects of Statistics has become crucial in the present scenario. There is a continuous demand for statisticians in fields of education, industry, software and research. The syllabi of post graduate course in Statistics are framed in such a way that the students at the end of the course, can be thorough in statistical techniques for pursuing higher studies and simultaneously can apply statistical tools judiciously to a variety of data sets to arrive at some valid conclusions.

Learning Outcomes Based Framework

MSc in Statistics programme consists of 84 credits spread over four semesters. Each credit has one hour of classroom teaching per week. This programme emphasizesboth 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.

MSc in Statistics programme is of two years duration, with semester pattern.

- During the first semester, students will be given the knowledge of mathematical analysis, measure theory, probability and probability distributions as well as theory and techniques involved in sampling from a population. Students will also learn how to solve practical problems related to the mentioned topics using software (such as Excel) and programming language (such as R).
- During the second semester, students will be given the knowledge of linear

algebra, mathematical analysis, multivariate analysis, theory of estimation, testing of hypothesis and design of experiment. Students will also learn how to solve practical problems related to the mentioned topics using software (such as Excel) and programming language (such as R).

- During the third semester, students will be given the knowledge of regression analysis, non-parametric analysis, decision theory, time series analysis. A student will also be able to select his/her/they special paper and an elective paper from a pool of options.
- During the fourth semester, students will be given the knowledge of stochastic process. A student will also be able to select his/her/they second special paper and an elective paper from a pool of options. They will also have to prepare and present a dissertation, under the supervision of a faculty, on some area of human interest.

Graduate Attributes in Statistics

- **Disciplinary Knowledge**: The proposed curriculum is expected to provide the students a sound knowledge of Statistics covering various aspects. As a result, they will not only appear appropriate for pursuing higher studies in the subject but also develop skill to apply the statistical knowhow to a variety of real life problems.
- **Critical Thinking**: The proposed course is designed to enrich the students with ability to examine the various statistical issues in a more logical and methodical manner. It is expected that the students will strengthen themselves both computationally and analytically.
- **Problem Solving**: The students will be able to critically examine various hypotheses and research queries, and will be able to identify and consult relevantresources to find their rational answers.
- **Analytical Reasoning**: The students are expected to develop capability to identify logical flaws and loopholes in the arguments of practicing Statisticians, analyze and synthesize data from a variety of sources and accordingly draw conclusions.

- **Research Related Skills:** The students should be able to develop original thinking for formulating new problems and providing their solutions. As a result they will be able to develop research related skills for their own subject as well asfor those who are practicing Statistics.
- **Communication Skills and Team Work:** The students are expected to developeffective and confident Communication skill after completion of the course. Theywill have an ability to work in a team as well as in isolation.
- **Moral and Ethical Awareness**: After completion of the course, the students areexpected to develop ethical and social responsibility as well. As a result, the students will be able to identify ethical issues, avoid unethical behavior such as fabrication, falsification or misrepresentation and misinterpretation of data.
- **Scientific Reasoning:** The students will be able to analyze, interpret and draw appropriate conclusions from both quantitative and qualitative data and critically evaluate ideas, evidence and experiences with an unbiased and consistent approach.
- **Reflective thinking:** The students should be sensitive to real experiences with respect to self, society and nation.
- **Information/Digital literacy:** The proposed course is expected to develop digital literacy among the students for using ICT in different learning situations. The students should be able to equip themselves with in depth programming and simultaneously use appropriate Statistical software for advanced Statistical computing with high level graphical interface.
- **Self-directed Learning:** The students are expected to be familiar with data collection, compilation, analysis and interpretation and writing of project reportsindependently.
- **Multicultural Competence:** The students are expected to be aware of values andbeliefs of different cultures and have a global perspective by examining various forms of primary and secondary data resources.
- **Leadership Readiness/Qualities:** The students will be capable of mapping out the tasks of a team or an organization, formulating an inspiring vision,

building ateam for achieving the desired objectives, motivating and inspiring team membersaccordingly, and using management skills to guide people in the right direction smoothly and efficiently.

- **Lifelong Learning:** The proposed course is designed to develop independent, coherent and decisive thoughts among the students that will ultimately develop competency in their lives. Simultaneously, they will develop entrepreneurship andentrepreneurship aptitude. This latter aspect will help them achieve risk-taking and innovative ability, an essential requirement of any large organization.

Programme Learning Outcomes in MSc in Statistics

The student graduating with the Degree M.Sc. in Statistics should be able to

1. Demonstrate the ability to use skills in Statistics and its related areas of technology for formulating and tackling Statistical related problems and identifying and applyingappropriate principles and methodologies to solve a wide range of problems associated with Statistics.
2. Acquire
   (i) a fundamental/systematic or coherent understanding of the academic field of Statistics, its different learning areas and applications in Medical Statistics, Actuarial Statistics, Agricultural Statistics, Financial Statistics, Population Statistics, Financial Econometrics, Clinical Trials and Epidemiology, Queuing Theory, Stochastic Processes, etc.,
   (ii) procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Statistics, including professionals engaged in research and development, teaching and government/public service;
   (iii) Skills in areas related to one's specialization area within the disciplinary/subject area of Statistics and current and emerging developments in the field of Statistics.

3. Recognize the importance of statistical modeling simulation and computing, and the roleof approximation and mathematical approaches to analyze the real world problems.
4. Plan and execute Statistical related experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages, and report accurately the findings of the experiment/investigations while relating theconclusions/findings to relevant theories of Statistics.
5. Demonstrate relevant generic skills and global competencies such as

   (i) problem-solving skills that are required to solve different types of Statistics- related problems with well-defined solutions, and tackle open-ended problems that belong to the disciplinary-area boundaries;

   (ii) investigative skills, including skills of independent investigation of Statistics- related issues and problems;

   (iii) communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise mannerto different groups/audiences of technical or popular nature;

   (iv) analytical skills involving paying attention to detail and ability to construct logical arguments using correct technical language related to Statistics and ability totranslate them with popular language when needed;

   (v) ICT skills;

   (vi) Personal skills such as the ability to work both independently and in a group.

6. Demonstrate professional behavior such as

   (i) being objective, unbiased and truthful in all aspects of work and avoiding unethical, irrational behavior such as fabricating, falsifying or misrepresenting dataor committing plagiarism;

   (ii) The ability to identify the potential ethical issues in work-related situations;

   (iii) Appreciation of intellectual property, environmental and sustainability issues; and

   (iv) Promoting safe learning and working environment.

TABLES OF COURSE LEARNING OUTCOMES

		Table 1 : MSc (Statistics) Courses Program Outcome					
Paper Code		Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6
	STA 701 C			✓			
	STA 702 C			✓			
	STA 703 C	✓					
	STA 704 C	✓			✓		
	STA 705 L	✓			✓	✓	✓
	STA 801 C			✓			
	STA 802 C	✓					
	STA 803 C	✓					
	STA 804 C	✓			✓		
	STA 805 L	✓			✓	✓	✓
	STA 901 C	✓			✓		
	STA 902 C	✓			✓		
	STA 903 C	✓			✓		
STA 904	SPL (A)	✓	✓				
	SPL (B)	✓	✓				
	SPL (C)	✓	✓				
	STA 905 OE I	✓		✓		✓	
	STA 1001 C	✓		✓			
STA 1002	SPL (A)	✓	✓				
	SPL (B)	✓	✓				
	SPL (C)	✓	✓				
	STA 1003 OE 2	✓					
	STA-DPW	✓			✓	✓	✓
SEC	STA 004 SEC			✓	✓	✓	

Outline of Courses and Credits

The M.Sc. programmes will consist of four semesters with the minimum credits required for the complete programme being 84.

Each course in a programme will be from one of the following categories:

1. **Core Course (Core):** A course that should compulsorily be studied by a candidate as a core requirement is termed a Core Course. Each core course is of **4** credits.

2. **Lab Course (LAB):** A Lab (Laboratory) course is a compulsory course in the first two semesters of the M.Sc. programme where the major part of the study involves laboratory work. Each Lab course is of **4** credits.

3. **Elective Course:** A course that can be chosen from a pool of courses and which may extend the discipline/subject of study or which provides exposure to some other discipline/subject or which enhances the student's proficiency or skill is termed an Elective course.

   (i) **Special Paper (SPL):** A course within the parent department that will lead to specialized knowledge and expertise. Each **SPL** course is of **5** credits.

   (ii) **Open Elective (OPE):** An elective course offered under the main discipline/subject of study is an Open Elective and may be offered to students of other disciplines. A student from a given discipline will be eligible to take one open elective in the third semester and one in the fourth semester. Each **OPE** course is of **4** credits.

   (iii) **Skill Enhancement Course (SEC)**: These courses may be chosen from a pool of courses designed to provide skill-based knowledge and should ideally contain both theory and lab/hands-on/training/fieldwork. The primary purpose is to provide students with life skills in hands-on mode to increase their employability. Each **SEC** course is of **2** credits.

4. **Practical/Tutorials** A practical or tutorial component (or both) is to be provided with every core and special paper/open elective paper.

5. **Dissertation/Project Work (DPW):** A course designed for students to acquire special/advanced knowledge that they study on their own with advisory support by a teacher/faculty member is a dissertation/project work. A **DPW** course is of **6** credits.

A student in the M.Sc. programme will take the following minimum number of courses in different categories of courses:

Table 1: Credit distribution for M.Sc. course.

Category	Number of courses	Credits for each course	Total Credits
Core	12	4	48
LAB	2	4	8
SEC	2	2	4
SPL	2	5	10
OPE	2	4	8
DPW	1	6	6
		Total	84

The distribution of credits and courses in each of the four semesters for the M.Sc. programme will be according to the following scheme:

Table 2: Semester Course and Credit distribution: M.Sc.

Semester	Core	LAB	SEC	SPL	OPE	DPW	Credit
I	C1(4) C2(4) C3(4) C4(4)	LAB1(4)	SEC1(2)				22
II	C5(4) C6(4) C7(4) C8(4)	LAB2(4)	SEC2(2)				22
III	C9(4) C10(4) C11(4)			SPL1(5)	OPE1(4)		21
IV	C12(4)			SPL2(5)	OPE2(4)	DPW(6)	19
Credit	48	8	4	10	8	6	84

Course overview

SEMESTER I

Paper Code	Paper Name	Credits
STA 701 C	Mathematical Analysis	4+0+0= 4
STA 702 C	Measure Theory and Probability	4+0+0= 4
STA 703 C	Distribution Theory	4+0+0= 4
STA 704 C	Survey Sampling	4+0+0= 4
STA 705 L	Practical I	0+0+4= 4
	SEC*	0+0+2=2
	Total Credits:	22

*Refer to Skill Enhancement Course list.

SEMESTER II

Paper Code	Paper Name	Credits
STA 801C	Linear Algebra	4+0+0=4
STA 802C	Multivariate Analysis	4+0+0= 4
STA 803C	Statistical Inference-I	4+0+0= 4
STA 804C	Design of Experiments	4+0+0= 4
STA 805 L	Practical II	0+0+4= 4
	SEC*	0+0+2=2
	Total Credits:	22

*Refer to Skill Enhancement Course list.

SEMESTER III

Paper Code	Paper Name	Credits
STA 901C	Linear Model and Regression Analysis	3+0+1= 4
STA 902C	Statistical Inference II	3+0+1= 4
STA 903C	Time series Analysis	3+0+1= 4
STA 904 SPL*	A. Demography B. Actuarial Studies C. Advanced Statistical Computing and Data Mining	4+1+0= 5 4+1+0= 5 4+0+1= 5
STA 905 OE-1	Demography and Data Mining	4+0+0= 4
	Total Credits:	21

*Any one elective is to be selected from the list.

SEMESTER IV

Paper Code	Paper Name	Credits
STA 1001C	Stochastic Processes	4+0+0= 4
SAT 1002SPL*	A. Bio Statistics B. Econometrics C. Operations Research	4+0+1= 5 4+0+1= 5 4+1+0= 5
STA 1003 OPE	Linear Programming Problem and Reliability	4+0+0= 4
STA- DPW	Dissertation / Project Work	0+0+6=6
	Total Credits:	19

*Any one elective is to be selected from the list.

SEMESTER I

STA 701C
Mathematical Analysis
Credit (4+0+0)

Course Learning Objectives:

- To study basics of one variable calculus and multivariable variables calculus.
- To study properties of analytic functions, complex integration and series expansions of complex valued functions.

Course Learning Outcomes:

At the end of the course, the students will be able to

- Understand the convergence of sequence of real numbers and sequence of functions.
- Realize the speciality of uniform convergence.
- Find multiple integrals on different domains.
- Understand the concept of analytic functions.
- Find complex integration over curves and contours.
- Relate analytic functions and their integration over closed contour.
- Understand definite integrals, Taylor's and Laurent's series.

CONTENTS:

Unit I: (Lectures: 16)
Review of sequence of real numbers; sequence and series of real valued functions, Cauchy's criterion and Weierstrass's M- test, uniform convergence and its relation to continuity, Uniform convergence and its relation to continuity, differentiability and integration, Convergence of Improper Integrals.

Unit II: (Lectures: 14)
Concept of Multiple integrals, Double integral over rectangle, Double integral over region, simple examples involving change of variables in multiple integrals, Dirichlet integral and Liouville's extension.

Unit III: **(Lectures: 14)**
Properties of complex numbers. Region in complex plane. Analytic function. Contour integration: Cauchy's theorem, Cauchy integral formula. Liouville's theorem. Fundamental theorem of Algebra.

Unit IV: (Lectures: 16)
Power series and radius of convergence. Taylor's and Laurent's series. Singular points and their types. Residue at singular point and residue at infinity. Cauchy residue theorem. Evaluation of real integrals involving sine and cosine using residue.

SUGGESTED READING:

1. Apostol, T.M. (1985): Mathematical Analysis, Narosa, Indian Ed.
2. Bak, J. and Newman, D. J. (2010): Complex Analysis,3rd Edition, Springer.
3. Bartle, R.G. and Sherbert, D.R. (2011): Introduction to Real Analysis, 4th Edition, Wiley, New York.
4. Conway, J.B. (1978): Functions of one complex variable, Springer-Verlag.
5. Mardsen, J. E., Tromba, A.J. Weinstein, A(2005): Basic Multivariable Calculus, Springer Verlag, New Delhi
6. Mathews, J. Howell, R.W. (2011): Complex Analysis for Mathematics and Engineering, Jones and Bartlett, New Delhi.
7. Rudin, W. (1985): Principles of Mathematical Analysis, McGraw Hill.
8. Tyagi, B.S. (2017): Functions of a Complex Variable, Kedar Nath Ram Nath, Meerut

STA 702 C
Measure Theory and Probability
Credit 4(4+0+0)

Course Learning Objectives:

Measure Theoretic Probability serves as building block that will enable students to learn advanced concepts in Probability Theory and will help them to deal with function spaces. The learning objectives include developing a clear understanding of the fundamental concepts

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- σ -fields, limsup and liminf of a sequence of sets.
- Probability measure, properties of a measure, Lebesgue-Stieltjes measure.
- Outer measure, class of outer measurable sets in a Sigma field.
- Monotone convergence theorem
- Fatou's lemma
- Dominated convergence theorem
- Moment inequalities
- Characteristic functions, uniqueness/inversion/Levy continuity theorems
- Helly's theorem, Helly-Bray Theorem
- Modes of convergence and their interrelations
- Borel –Cantelli lemma
- Chebyshev's and Khinchine's WLLN
- Strong law of large numbers and Kolmogorov's theorem.
- Central limit theorem, Lindeberg-Levy, Liapunov and Lindeberg-Feller forms of CLT.
- Basic concept of Martingals.

CONTENTS:

Unit I: (Lectures: 14)
Concepts of classes of sets, fields, σ -fields, minimal σ -field, Borel σ – field, sequence of sets, limsup and liminf of a sequence of sets. Measure, Probability measure, properties of a measure, Lebesgue-Stieltjes measure, Idea of product space and product measure. Outer measure, outer measurability, class of outer measurable sets in a Sigma field.

Unit II: (Lectures: 16)
Construction of outer measure function, Lebesgue measure, Lebesgue Measurable sets, extension of measure on a field, complete measure space.

Measurable transformation and function, random variable, simple and Elementary function, induced measure and distribution function, properties of measurable functions, measurable function as the limit of simple function. Integration of a measurable function with respect to a measure, Monotone convergence theorem, Fatou's lemma, Dominated convergence theorem.

Unit III: (Lectures: 16)
Moment inequalities:Markov's, Cramer's, Holder's and Kolmogorov's, Jenson, Liapounov, and Minkowsky's inequalities. Characteristic functions, uniqueness/inversion/Levy continuity theorems, Helly's theorem, Helly-Bray Theorem.
Sequence of random variables and modes of convergence (convergence in probability, almost surely, mean squareand and in distribution) and their interrelations. Statement of Slutsky's theorem. Borel –Cantelli lemma and Borel 0-1 law.

Unit IV: (Lectures: 14)
Laws of large numbers, Chebyshev's and Khinchine's WLLN, necessary and sufficient condition for the WLLN, three series criterion, strong law of large numbers and Kolmogorov's theorem. Central limit theorem, Lindeberg-Levy, Liapunov and Lindeberg-Feller forms of CLT. Basic concept of Martingals (Definition and simple problems).

SUGGESTED READING:

1. Ash, R. B. and Doléans-Dade, C.A. (1999): Probability and Measure Theory, Second Edition, Academic Press, New York.
2. Basu,A.K. (2004): Measure Theory and Probability , Prentice Hall of India.
3. Bhat, B.R. (1999): Modern Probability Theory, 3rd Edition, New Age International Publishers.
4. Billingsley, P. (2012): Probability and Measure, Anniversery Edition, John Wiley & Sons.
5. Capinski, M. and Zastawniah (2001): Probability through Problems, Springer.
6. Chae, S.B. (1995): Lebesgue Integration, 2nd Edition, Springer Verlag, New York
7. David, S (1996): Elementary Probability, Oxford Press
8. Edward P.J, Ford J.S. and Lin (1974): Probability for Statistical Decision- Making, Prentice Hall.
9. Feller, W. (1968): An Introduction to Probability Theory and its Applications, Vol. 1, 3rd Edition, John Wiley & Sons.
10. Goon A.M., Gupta M.K. Dasgupta B. (1999): Fundamental of Statistics, Vol. II, World Press, Calcutta.
11. Mood A.M, Graybill F.A and Bose D.C (1974): Introduction to the Theory of Statistics, McGraw Hill.
12. Hoel P.G (1971): Introduction to Mathematical Statistics, Asia Publishing House.

STA 703 C
Distribution Theory
Credit (4+0+0)

Course Learning Objectives:

The learning objectives include:

- Idea about various advanced probability distributions, their corresponding truncated, weighted, mixture and modified forms.
- To understand the concept of non - central distributions and their applications in statistical inference.
- Knowledge about order statistics.

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Various theoretical probability distributions along with their properties and applications.
- Transforming of random variables.
- Definitions, applications and properties of extreme valued distributions, symmetric distributions, truncated distributions, mixture distributions, weighted distributions and modified distributions.
- Generalized power series distributions, Exponential family of distributions.
- Non – central chi-square, t and F distributions and their applications.
- Order statistics and its applications.

CONTENTS:

Unit I: (Lectures: 18)
Functions of random variables and their distributions using Jacobian of transformation and other tools.
Probability distributions: Logarithmic, positive and negative multinomial, distributions of extremes: Grumble, Freichet, Weibull and their properties. Symmetric distributions, generalized power series distributions, Exponential family of distributions.

Unit II: (Lectures: 22)
Censoring, Truncation and weighted distributions. Truncated Binomial, Poisson, Logarithmic, Normal and Cauchy distributions.
Mixture distributions: Definition, finite mixtures, Zero modified and inflated distributions with examples, Mixed Poisson distributions and its properties and examples of Poisson mixtures, Mixtures of Binomial distributions with examples.

Unit III: (Lectures: 12)
Sampling distributions: Non-central chi-square, t, and F distributions, their properties and the related distributions.

Unit IV: (Lectures: 08)
Order statistics - their distributions and properties; Joint and marginal distributions of order statistics (discrete and continuous).

SUGGESTED READING:

1. Arnold, B.C., Balakrishnan, N., and Nagaraja, H.N. (1992): A First Course in Order Statistics, John Wiley & Sons.
2. David, H.A., and Nagaraja, H.N. (2003): Order Statistics, Third Edition, John Wiley and Sons.
3. Dudewicz, E.J.and Mishra, S.N.(1988): Modern Mathematical Statistics, Wiley, Int'l Students' Edition.
4. Johnson, N.L., Kemp, and Kotz, S. (2005): Univariate Discrete Distributions, Wiley, 3rd Edition.
5. Mukhopadhyay, P. (2015): Mathematical Statistics. New Central Book Agency
6. Rao, C.R. (1973): Linear Statistical Inference and Its Applications, 2/e, Wiley Eastern
7. Rohatgi, V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.

STA 704C
Survey Sampling
Credit 4(4+0+0)

Course Learning Objectives:

This course familiarizes the students with concepts and statistical methods employed in Survey Sampling. It enables them with tools and techniques necessary for applying sampling techniques in daily life and research activities.

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Distinctive features of sampling schemes and its related estimation problems.
- Various approaches (design based and model-based) to estimate admissible parameters; with and without replacement sampling scheme, sampling with varying probability of selection.
- Methods of stratified sampling, controlled sampling and double sampling procedure with unequal probability of selection.
- Systematic sampling and its applications to structured populations.
- Cluster and two stage sampling with varying sizes of clusters/first stage units.
- Randomized response techniques for sensitive characteristics.

CONTENTS:

Unit I: (Lectures: 10)
Basic ideas and distinctive features of sampling. Probability sampling designs, sampling schemes. Review of important results in simple and stratified random sampling, Fixed (Design-based) and Super population (Model-based) approaches. Non-sampling errors with special reference to non-response. Sample size determination.

Unit II: (Lectures: 18)
Sampling with varying probabilities (Unequal probability sampling) with and without replacement methods including Lahiri's scheme: pps, πps and non- πps sampling procedures. Related estimators of a finite population mean: Horvitz-Thompson, Yates and Grundy estimator, Hansen-Hurwitz and Des Raj estimators for general sample size, Murthy's estimators.

Unit III: (Lectures: 14)
Stratified random sampling: Two-way stratification, Construction of strata, Number of strata, Method of collapsed strata, Post stratification.
Double sampling with special reference to the selection with unequal probabilities in at least one of the phases. Two phase sampling for stratification.

Unit IV: (Lectures: 18)
Systematic sampling and its applications to structured populations: population with linear trend, periodic population, auto correlated population and stratified population. Cluster sampling with varying sizes of clusters. Two stage sampling with varying sizes of first stage units. Concept of randomized response technique for sensitive characteristics.

SUGGESTED READING:

1. Cassel, C.M., Sarndal, C-E and Wretman, J.H. (1977): Foundations of Inference in Survey Sampling, Wiley Inter-Science, New York.
2. Chaudhari, A. and Stenger, H. (2005): Survey Sampling Theory and methods, 2nd Edn., Chapman and Hall.
3. Chaudhari, A. and Vos, J.W.E. (1988): Unified Theory and Strategies of Survey Sampling, North –Holland, Amsterdam.
4. Cochran, W.G. (1977): Sampling Techniques, John Wiley & Sons, New York .
5. Hedayat, A.S., and Sinha, B.K. (1991): Design and Inference in Finite Population Sampling, Wiley, New York.
6. Levy, P.S. and Lemeshow, S. (2008): Sampling of Populations-Methods and Applications, Wiley.
7. Mukhopadhyay, P. (2009): Theory and Methods of Survey Sampling, 2nd edition, Prentice Hall of India, New Delhi.
8. Murthy, M.N. (1967): Sampling Theory and Methods, Statistical Publishing Society, Calcutta
9. Raj, D. and Chandhok, P. (1998): Sample Survey Theory. Narosa Publishing House.
10. Sarndal, C.E., Swensson, B. and Wretman, J.H. (1992): Model Assisted Survey Sampling, Springer-Verlag, New York.
11. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984): Sampling Theory of Surveys with Applications, Iowa State University Press, Iowa, USA.
12. Thompson, S. K. (2002): Sampling, John Wiley and Sons, New York.

STA- 705 L
Credit 4(0+0+4)

Course Learning Objectives:
This course trains the students in solving real life practical problems using statistical software.

Course Learning Outcomes:

After completion of the course students will be able to solve practical problems pertaining to sample survey and probability distributions using software like R and Excel.

CONTENTS:

Lab based on STA-703C and STA-704C

SEMESTER II

STA 801C
Linear Algebra
Credit 4(4+0+0)

Course Learning Objectives:

To study vector spaces, linear transformation, matrix representation of a linear operator and basic matrix theory.

Course Learning Outcomes:

At the end of the course the students will able to

- Understand the basics of finite dimensional vector spaces.
- Relate matrices with linear transformations.
- Understand concept of angle between vectors.
- Find eigenvalues and eigenvectors.
- Use different factorization techniques for matrices.
- Apply the techniques of matrix theory to other branch of mathematics and practical problems.

CONTENTS:

Unit I: **(Lectures: 12)**
Fields, linear spaces, subspaces, linear dependence and independence, basis and dimension of a linear space. Theory of linear equations. Introduction to n dimensional Euclidian Space. Inner product. Linear space with inner product. Orthogonalization of vectors. Orthonormal basis of a linear space.

Unit II: **(Lectures: 15)**
Linear Transformations, Kernel and Image of a linear transformation, Rank and Nullity, Matrix representation of a linear operator, Change of Basis, Similarity, Inner product spaces with examples, Cauchy-Schwarz inequality with applications, Orthogonality, Orthonormal sets and Bases, Gram Schmidt Orthogonalization Process.

Unit III: **(Lectures: 15)**
Eigen values and eigen vectors, Spectral decomposition of a symmetrical matrix (Full rank and non-full rank cases), Example of spectral decomposition, Spectral decomposition of asymmetric matrix, Cayley Hamilton theorem, Algebraic and geometric multiplicity of characteristic roots, Diagonalization of matrices, Factorization of a matrix, Eigen values and eigen vectors for solution of Differential equations.

Unit IV: (Lectures: 18)
Generalized inverse of a matrix, Different classes of generalized inverse, Properties of g-inverse, Reflexive g-inverse, left weak and right weak g-inverse, Moore- Penrose (MP) g-inverse and its properties, Real quadratic form, Linear transformation of quadratic forms, Index and signature, Reduction of quadratic form into sum of squares, Gram matrix with example,

Jordan canonical form. Lagrange's method of transformation of a positive definite quadratic form, Cochran's theorem.

SUGGESTED READING:

1. Biswas, S. (1997): A Text Book of Matrix Algebra, 2nd Edition, New Age International Publishers.
2. Golub, G.H. and Van Loan, C.F. (1989): Matrix Computations, 2nd edition, John Hopkins University Press, Baltimore-London.
3. Graybill, F.A. (1983): Matrices with applications in Statistics, 2nd Ed. Wadsworth.
4. Hadley, G. (2002): Linear Algebra. Narosa Publishing House (Reprint).
5. Rao, C.R. (1973): Linear Statistical Inferences and its Applications, 2nd edition, John Wiley and Sons.
6. Robinson, D.J.S. (1991): A Course in Linear Algebra with Applications, World Scientific, Singapore.
7. Searle, S.R. (1982): Matrix Algebra useful for Statistics. John Wiley and Sons. Inc.
8. Strang, G. (1980): Linear Algebra and its Application, 2nd edition, Academic Press, London, New York.

STA 802C
Multivariate Analysis
Credit 4(4+0+0)

Course Learning Objectives:

The learning objectives include:

- Study of theoretical concepts of Multivariate Normal Distributions along with their properties.
- Analyse Multivariate data.

Course Learning Outcomes:

On completion of the course, students should have achieved the following:

- The understanding of basic concepts associated with Multivariate Normal Distributions and their properties.
- Techniques for analysing multivariate data like MANOVA.
- Analysing Multivariate data using data reduction techniques like Principal Component Analysis, Canonical Correlation Analysis Idea of Factor Analysis.
- Classification method namely Discriminant Analysis.

CONTENTS:

Unit I: **(Lectures: 12)**
Multivariate normal distribution, Transformation of variables, Random sampling from a multivariate normal distribution, Maximum likelihood estimators of parameters, Distribution of sample mean vector, Inference concerning the mean vector when the covariance matrix is known, Multivariate Central Limit Theorem.

Unit II: **(Lectures: 12)**
Wishart matrix: its distribution and properties. Distribution of sample generalized variance. Hotelling's T^2 statistic: its distribution and properties. Applications in tests on mean vector for one and more multivariate normal populations and also on symmetry of organs. Mahalanobis' D^2.

Unit III: **(Lectures: 14)**
Likelihood ratio test criteria for testing independence of sets of variables, equality of covariance matrices, identity of several multivariate normal populations.
Distribution of the matrix of sample regression coefficients and the matrix of residual sum of squares and cross products, Rao's U-statistic, its distribution and applications, Multivariate analysis of variance (MANOVA) of one way classified data.
.

Unit IV: **(Lectures:22)**
Classification and discrimination procedures for discrimination between two multivariate normal populations - sample discriminant function, tests associated with discriminant

functions, probabilities of misclassification and their estimation, Classification into more than two multivariate normal populations.
Dimension reduction, Principal component, Canonical variables and Canonical correlation – definition, use, estimation and computation; Idea of Factor Analysis.

SUGGESTED READING:

1. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3rd Edition, John Wiley.
2. Chakravarti, I.M, Lahe, R.G & Roy, A Hand Book of Methods of Applied Statistics,Vol 1, John Wiley.
3. Giri, N. C. (1977): Multivariate Statistical inference, Academic Press.
4. Hardle, W. K. and Simar, L. (2015): Applied Multivariate Statistical Analysis, 4th Edition, Springer. Pearson Education India.
5. Johnson, R. A. and Wichern, D. W. (2015): Applied Multivariate Statistical Analysis, 6th Edition, Prectice Hall
6. Kshirsagar, A. M. (1996): Multivariate Analysis, 2nd Edition, Marcel Dekker.
7. Lawley, D. N. and Maxwell, A. E. (1971): Factor Analysis as a Statistical Method, Second Edition, London Butterworths.
8. Muirhead, R. J. (1982): Aspects of Multivariate Statistical Theory, Wiley.
9. Rao, C. R. (1972): Linear Statistical inference and its Application, John Wiley
10. Srivastava, M. S. and Khatri, C. G. (1979): An introduction to Multivariate Statistics, North-Holland.

STA 803C
Statistical Inference-I
Credit 4(4+0+0)

Course Objectives:

The learning objectives include:

- The knowledge of theory of estimation.
- Drawing inference about the unknown population parameters based on random samples.
- The knowledge about various tests for statistical hypotheses.
- Construction of critical regions.

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Different methods of finding point estimators for unknown population parameters, their advantages and disadvantages using the method of maximum likelihood estimation, method of moments and method of minimum chi-square.
- The theory and the characteristics of point Estimators.
- Different properties of minimum variance unbiased (MVU) estimators and finding the lower bounds for unbiased estimators.
- Interval estimation and confidence levels.
- The use of Neyman-Pearson Fundamental Lemma and its Generalised form for finding different tests like MP and UMP tests.
- The different Principles of statistical tests including Consistency, monotonicity and invariance principle.
- Construction of UMPU tests, Type A and Type A1 critical regions, Optimum Regions, and Similar Regions.

CONTENTS:

Unit I: **(Lectures: 20)**
Theory of point Estimation: Sufficiency- Factorization theorem and Invariance property. UMVUE related theorems including Necessary and sufficient condition of UMVUE. Rao-Blackwell theorem and Lehmann- Scheffe theorem.
Bounds for variance of Estimators: Frechet-Cramer- Rao lower bound, Frechet- Cramer- Rao lower bound for multi parameter case, Bhattacharyya bound and Chapman- Robins-Kiefer lower bound.

Method of estimation: Method of Maximum likelihood (with properties and related theorems), Method of moments, Minimum chi square and Method of minimum distance.
Introduction to BAN and CAN estimators and related theorems

Unit II: (Lectures: 12)
Interval estimation, confidence level, construction of shortest expected length confidence interval, uniformly most accurate one-sided confidence Interval and its relation to UMP tests for one-sided null against one-sided alternative hypotheses.

Unit III: (Lectures: 18)
Basic concepts of randomised and non-randomised tests; Neyman-Pearson Fundamental Lemma and Generalisation, MP and UMP tests, Consistency, monotonicity and invariance principle of tests and their construction.
UMPU- tests, Type A and Type A1 critical regions, Optimum Region and Sufficient statistic, Similar Regions.

Unit IV: (Lectures: 10)
Likelihood Ratio Tests, Asymptotic distribution of Likelihood ratio. Randomised test: Test function, Neyman-Pearson theorem, Monotone Likelihood Ratio.

SUGGESTED READING:

1. Bartoszynski, R. and Bugaj, M.N. (2007): Probability and Statistical Inference, John Wiley & Sons.
2. Ferguson, T.S. (1967): Mathematical Statistics, Academic Press. 3. Kale, B.K. (1999). A First Course on Parametric Inference, Narosa Publishing House.
3. George Cassella & Roger L. Berger (1994): Statistical Inference. Wadsworth & Brooks, California.
4. Goon, A. M., Gupta, M. K., and Dasgupta (1987): An Outline of Statistical Theory. Vol.-II, World Press.
5. Kale B. K. (1999): A First Course on Parametric Inference
6. Kendal, M. G. & Stuart, A (1960): The Advanced Theory of Statistics. Vol 2. Charles Griffin, London.
7. Lehman E.L (2011): Theory of Point Estimation, 2nd Edition, Springer
8. **Lehmann**, E L., **Romano**, J. P. (2008): Testing Statistical Hypotheses. 3rd Edition, Springer.
9. Parimal Mukhopadhyay (1996): Mathematical Statistics. New Central Book Agency, Kolkata.
10. Rao, C. R. (1973): Linear Statistical Inference and Its Application, 2/e Wiley Eastern
11. Rohatgi V.K. (2015): An Introduction to Probability and Statistics, 3rd Edition, Wiley Eastern Limited. New Delhi, (Student Edition)
12. Saxena H & Surendran P (1994): Statistical Inference, S Chand & Company Pvt. Limited
13. Zacks, S. (1971): Theory of Statistical Inference, John Wiley & Sons.

STA 804C
Design of Experiments
Credit 4(4+0+0)

Course Learning Objectives:

This course provides the students the ability to understand the design and conduct experiments, as well as to analyze and interpret data

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- The fundamental concepts of design of experiments.
- Introduction to planning valid and economical experiments within given resources.
- Idea of Orthogonal Latin Square Design, Graceo Latin Square Design, Circular design.
- Factorial experiments, Design for Bio-assays, Response Surface designs- its properties and analysis..
- Incomplete block designs (IBD)-its properties and analysis.
- Balanced Incomplete Block design (BIBD), Partially Balanced Incomplete Block Design (PBIBD) with two associated classes.
- Lattice designs, Youden square designs.
- Galois fields, Finite Projective Geometry, Finite Euclidean Geometry.
- Construction of Mutually Orthogonal Latin Squares(MOLS) and construction of BIBD using Galois fields and MOLS

CONTENTS:

Unit I: (Lectures: 10)
Review of basic designs. Variance Component Analysis: Introduction, analysis in a two way classification.
Idea of Orthogonal Latin Square Design, Graceo Latin Square Design, Circular design.

Unit II: **(Lectures: 16)**
Review of factorial experiments, Fractional replication of factorial experiment, Asymmetrical factorial experiments: Introduction, analysis, different types of asymmetrical factorial experiments.
Designs for Bio-assays (without analysis). Response Surface designs: Introduction, 1^{st} and 2^{nd} order designs with analysis.
.

Unit III: **(Lectures: 18)**
Incomplete block designs (IBD): Introduction and properties- Concepts of Connectedness, Orthogonality and Balance. Intra block analysis of IBD.
Balanced Incomplete Block Design (BIBD). Partially Balanced Incomplete Block Design (PBIBD) with 2 associated classes. Lattice designs. Youden square design.

Unit IV: **(Lectures: 16)**

Galois fields, Finite Projective Geometry and Finite Euclidean Geometry. Construction of Mutually Orthogonal Latin Squares (MOLS). Construction of BIBD by using Galois fields and MOLS.

SUGGESTED READING:

1. Bhuyan K.C (2017): Design of experiments and Sampling Methods, 1st Edition, New Central Book Agency (P) Ltd, New Delhi.
2. Bose R.C (1984): Introduction to combinatorial Theory, Wiley Series of Probability and Statistics
3. Chakrabarti, M.C. (1962): Mathematics of Design and Analysis of Experiments, Asia Publishing House, Bombay.
4. Das M.N and Giri N.C (1986): Designs and Analysis of experiments, Wiley Eastern Limited, New Delhi.
5. Dean, A. and Voss, D. (1999): Design and Analysis of Experiments, Springer. First Indian Reprint 2006.
6. Dey, A. (1986): Theory of Block Designs, John Wiley & Sons.
7. Hinkelmann, K. and Kempthorne, O. (2005): Design and Analysis of Experiments, Vol. Advanced Experimental Design, John Wiley & Sons.
8. John, P.W.M. (1971): Statistical Design and Analysis of Experiments, Macmillan Co., New York.
9. Kshirsagar, A.M. (1983): A Course in Linear Models, Marcel Dekker, Inc., N.Y.
10. Montgomery D.C (2017): Design and Analysis of experiments, 9th Edition, Wiley Eastern Limited, New Delhi.
11. Mukhopadhyay P (2005): Applied Statistics, 2nd Edition, Books and Allied (P) Ltd, Kolkata.
12. Raghavarao, D. (1970): Construction and Combinatorial Problems in Design of Experiments, John Wiley & Sons.
13. Raghavarao, D. and Padgett, L. V. (2005): Block Designs: Analysis, Combinatory, and Applications, World Scientific.

STA 805 L
Credit 4(0+0+4)

Course Learning Objectives:

This course trains the students in solving real life practical problems using statistical software.

Course Learning Outcomes:

After completion of the course students will be able to solve practical problems pertaining to statistical inference, multivariate analysis and design of experiments using software like R , SPSS and Excel.

CONTENTS:

Lab based on STA - 802C , STA - 803C and STA - 804C

SEMESTER – III

STA 901C
Linear Model and Regression Analysis
Credit 4(3+0+1)

Course Learning Objectives:

- To understand the concept of linear model under Gauss Markov set up.
- To understand the concept of variable selection in model building.
- To understand the concept of logistic regression and related properties.

Course Learning Outcomes:

After completion of the course, students will be able to

- Get an idea of Linear, Polynomial and Multiple Linear regression,
- Learn about regression diagnostics, multicollinearity, residual plots and estimation
- Carry out tests for regression coefficients.
- Study concept of coefficient of determination.
- Get an idea of how to select variables for building a regression model.
- Compute stepwise regression, Mellows CP statistic, AIC & BIC.
- Fit logistic regression model for dichotomous data with single and multiple explanatory variables.
- Perform ML estimation, large sample tests about parameters, Goodness-of-Fit tests, analysis of deviance, and Lack-of-Fit tests in Logistic regression.

CONTENTS:

Unit I: (Lectures: 10)
Linear Model: Gauss-Markov setup, Error and estimation space, Normal equations and least square estimator, solution of the Normal equations using g-Inverse, variance and covariance of least square estimates, estimation of error variance, least square estimates with restriction on parameters.
Tests of hypotheses for one and more than one linear parametric functions.

Unit II: (Lectures: 12)
Multiple regression model: Estimation of model parameters, Hypothesis Testing in multiple linear regression, Regression with and without intercept terms, standardized regression coefficients and interpretations, use of R^2 & adjusted R^2.

Residual Analysis: Definition, residual plots, normal probability plots, methods of scaling residuals-standardized and studentized residuals, Lack of fit test in regression model.

Unit III: (Lectures: 12)
Variable selection and model building: Model building problem, Model misspecification criteria for evaluating sub set regressions.

Computational techniques for variable selection (without derivation), Stepwise regression, Mellows C_P statistic, AIC & BIC - purpose & use.

Unit IV: **(Lectures: 14)**

Regression on Dummy Variables: Dummy as explanatory variable, Chow test vs Dummy Variable approach.

Generalized linear models: Linear Probability Model, Logistic regression model for dichotomous data with single and multiple explanatory variables, ML estimation, large sample tests about parameters, Goodness-of-Fit tests (Concept of deviance), analysis of deviance, and Lack-of-Fit tests in Logistic regression.

SUGGESTED READING:

1. Dobson, A.J. and Barnett, A.G. (2008): Introduction to Generalized Linear Models, Third Edition, Chapman and Hall/CRC. London.
2. Goon, A.M. and Gupta, M.K. and Dasgupta, B.(1991): An Outline of Statistical Theory, World Press Private Limited.
1. Greene W.H (2000): Econometric Analysis, 4th Edition, Prentice Hall.
2. Gujarati, D., Porter D.C and Gunasekar S. (2016): Basic Econometrics, 13th Edition, McGraw Hill Companies.
3. Johnston, J. (1985): Econometric Methods, 3rd Edition, McGraw Hill International.
4. Kmenta J (1986): Elements of Econometrics, 2nd Edition, Macmillan, New York.
5. Koutsoyiannis, A. (2004): Theory of Econometrics, 2nd Edition, Palgrave Macmillan Limited.
6. McCulloch, C.E. and Searle, S.R. (2001): Generalized, Linear and Mixed Models, John Wiley & Sons, Inc. New York
7. Myers, R.H., Montgomery, D.C and Vining, G.G. (2002): Generalized Linear Models with Applications in Engineering and the Sciences, John Wiley & Sons.
8. Madnani G.M.K (2008): Introduction to Econometrics, Principles and Applications, Oxford & IBH Publishing Co. Pvt Ltd, Delhi□□
9. Maddala, G.S. and Lahiri, K. (2009): Introduction to Econometrics, 4th Edition, Wiley & Sons.
10. Rao, C.R. (1991): Linear Statistical Inference and Its Applications, Wiley Eastern Limited.
11. Theil H (1971): Principles of Econometrics, John Wiley & Sons Inc, New York

STA 902C
Statistical Inference II
Credit 4(3+0+1)

Course Learning Objectives:
The learning objectives include:

- The knowledge of non-parametric statistical inference.
- The knowledge of the Elements of Decision Theory and Bayesian Inference.
- The knowledge of Sequential analysis.

Course Learning Outcomes:
After completing this course, students should have developed a clear understanding of:

- Development and applications of various non-parametric statistical tests.
- The basic concepts of the elements of decision theory with decision rules, loss functions, point estimation, interval estimation, and testing of hypotheses as decision problems.
- The development of Bayesian inference- prior and posterior distributions and their construction.
- Concept of Bayesian point and interval estimation and testing of Hypothesis.
- The Bayesian Computation using Analytic approach, E-M algorithm, MCMC, Gibbs sampling.
- The derivation of Wald's Sequential Probability Ratio Test (SPRT) and its properties, the construction of OC and ASN function of SPRT.

CONTENTS:

Unit I: **(Lectures: 14)**
Tests Based on Runs: Idea, Different lemmas, Expectation and Variance of Runs, Tests based on the length of longest run.
Tests of goodness of fit: The Chi-Square test, The Empirical distribution function, related theorems and corollaries; The Kolmogorov-Smirnov (KS) one sample test, related theorems and applications.
One sample and paired sample techniques: The Ordinary Sign test and The Wilcoxon Signed-rank test.
The General two-sample problem: The Wald-Wolfowitz Run test, The KS two-sample test, Man-Whitney U test.

Unit II: (Lectures: 10)
Elements of Decision Theory: Introduction, Basic Concepts, Bayes and Minimax Decision rules. Different types of loss function, Estimation of Parameters: Bayes estimate and Minimax estimate with examples, Point estimation, Interval estimation and Testing of Hypothesis as Decision Problems.

Unit III: (Lectures: 14)
Subjective and Frequentist Probability, Advantages, Bayes theorem, Subjective prior distribution of a parameter, Computation of posterior distribution, Natural Conjugate family of priors for a model, Hyper parameters of a prior form conjugate family, Conjugate families for (i) exponential family models, (ii) models admitting sufficient statistics of fixed dimension,

Non informative, improper and invariant priors, Jeffrey's invariant prior, Bayesian point estimation- as a prediction problem from posterior distribution, Bayes estimators for (i) absolute error loss, (ii) squared error loss, and (iii) 0-1 loss.
Bayesian interval estimation: Credible intervals, High posterior density regions; Bayesian testing of Hypothesis: Specification of the appropriate form of the prior distribution for a Bayesian testing of hypothesis problem; Bayesian Computation: Analytic approach, E-M algorithm, MCMC, Gibbs sampling.

Unit IV: (Lectures: 10)
Sequential Analysis: Wald's Sequential Probability Ratio Test (SPRT), Properties of SPRT, Efficiency of SPRT, The Fundamental Identity of Sequential Analysis, OC Function, ASN.

SUGGESTED READING:

1. Aitchison, J. and Dunsmore, I.R. (1975) : Statistical Prediction Analysis, Cambridge University Press.
2. Bansal A.K (2007) : Bayesian Parametric Inference, Alpha Science International Limited.
3. Box, G.E.P. and Tiao, G.C. (1973): Bayesian Inference in Statistical Analysis, Addison & Wesley.
4. DeGroot, M.H. (1970): Optimal Statistical Decisions, McGraw Hill
5. Gibbons J.D (1985): Non Parametric Statistical Inference 2nd Ed. Marcel Dekker Inc.
6. Goon, A. M., Gupta, M. K., and Dasgupta (1987): An Outline of Statistical Theory. Vol.-II, World Press.
7. Kale B. K. (1999): A First Course on Parametric Inference
8. Lee, P. M. (1997): Bayesian Statistics: An Introduction, Arnold Press
9. Leonard, T. and Hsu, J.S.J. (1999): Bayesian Methods, Cambridge University Press
10. Mukhopadhay P (1996): Mathematical Statistics New central Book Agency (Kolkata)
11. Rao, C. R. (1973): Linear Statistical Inference and Its Application, 2/e Wiley Eastern
12. Robert, C.P. (2001): The Bayesian Choice: A Decision Theoretic Motivation, Second Edition, Springer Verlag, New York.
13. Rohatgi V. (2015): An Introduction to Probability and Statistics, 3rd Edition, Wiley Eastern Limited. New Delhi, (Student Edition)
14. Seigel sidney : Non Parametric Statistics for Behavioural Science Mc. Graw Hill.

STA 903 C
Time series Analysis
Credit 4(3+0+1)

Course Learning Objectives:

The objective of this course is to study intermediate and advanced topics in time series namely, Moving Averages (MA), Autoregressive (AR), ARMA, ARIMA Models, ARCH, GARCH, Spatio Temporal Analysis, Co-integrataion Longitudinal and Panel Data analysis.

Course Learning Outcomes:
After successful completion of this course, student will be able to:

- Acquire knowledge of various advanced time series models, estimation methods and related theories.
- Eliminate Seasonal and Cyclical components of Time Series and conduct Periodogram and Correlogram analysis.
- Understand and apply statistical techniques pertaining to Auto-corrleation, Autor-regressive process, Moving Average, ARMA and ARIMA models, Box-Jenkins methodologies, Spectral analysis.
- Conduct exponential and moving average smoothing, Holt winters smoothing, Forecasting based on smoothing.
- Understand and apply statistical techniques pertaining to ARCH, GARCH, Spatio Temporal Analysis, Cointegration, Longitudinal and Panel Data Analysis.

CONTENTS:

Unit 1: **(Lectures: 8)**
Introduction to Time Series, Decomposition of Time Series, Measurement of Trend, Variate Difference method, Elimination of Seasonal and Cyclical components of Time Series, Periodogram and Correlogram analysis.

Unit II: **(Lectures: 14)**
Discrete parametric stochastic processes, Introduction to Stationary processes, Auto-covariance, Auto-correlation and Auto-regressive process, Properties of Auto-covariance function, Concept of Weak Stationarity, Autoregressive (AR), Moving Average (MA), Linear processes.

Unit III: (Lectures: 14)
ARMA and AR integrated MA (ARIMA) models, Box-Jenkins methodologies, ARIMA (p, d, q), Spectral Analysis: Spectral densities of AR and MA.
Exponential and Moving Average Smoothing, Holt winters smoothing, Forecasting based on smoothing.

Unit IV: **(Lectures: 12)**
ARCH, GARCH, Spatio Temporal Analysis, Cointegration, Longitudinal and Panel Data Analysis.

SUGGESTED READING:

1. Anderson, T.W. (1971): Statistical Analysis of Time Series, Wiley, NY
2. Box, G.E.P and Jenkins, G.M.(1976): Time series Analysis-Forecasting and Control, Holden-day, San Francisco.
3. Brokckwell, P.J. and Davis, R.A.(1996): Introduction to Time Series and Forecasting, Springer, New York.
4. Enders, W.,(2008): Applied Econometric Time Series, 2nd Edition, Wiley
5. Medhi, J. (2009): Stochastic Processes, 3rd Ed., New Age International Publishers, New Delhi, India.

SPECIAL PAPERS (Any one)

STA 904 SPL A
Demography
Credit 5(4+1+0)

Course Learning Objectives:

The learning objectives include:

- To understand the mathematical procedure that measure population growth.
- Concept about one sex model and quasi stable population.
- Knowledge about Migration and Nuptuality.
- Introduce the concept of fertility models.
- Introduce the concept of multiple decrement life table, multistate life table and model life table.

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Stable and stationary population for studying the structure of population.
- Estimating mathematical procedures that measure population change and its underlying factors and help in visualizing the future prospects of population growth.
- Concepts and mathematical modelling for estimating migration and nuptuality.
- Different fertility models such as Dandekar's modified Poisson and Binomial model etc. and their properties.
- Mathematical theory behind multistate life table and multiple decrement life table.
- Different types of model life tables, their properties and application.

CONTENTS:

Unit I: (Lectures: 12)
Theory of stable population: one sex model, concept of stationary, stable and Quasi stable model.

Unit II: (Lectures: 12)
Migration: Basic concept and estimation – direct and indirect methods. Models for migration.
Population projection- component and matrix method.
Evaluation and adjustment of age data: concept and type of age errors, digit preference-Whipple index, Myer's index, blended method, method of smoothing.

Unit III: (Lectures: 12)
Methods of estimating basic demographic measures from incomplete data.
Nuptiality: different measures, nuptiality tables, computation of nuptiality from census data.

Unit IV: (Lectures: 12)
Estimation of fertility rates by indirect methods, stochastic models for reproduction distribution of time to first birth, inter live birth intervals and number of births, estimation of parameters. Shep's model.

Unit V: (Lectures: 12)
Multistate Demography. Multistate life tables. Multiple decrement life tables. Model life table: United Nations Model life table, Coley-Demeny Model life table, Model life table for developing countries. Life table from the perspective of Markov chain distribution.

SUGGESTED READING:

1. Bhende A.A , Kanitkar T. (2010): Principles of Population Studies, Himalaya Publishing House.
2. Biswas S, Sriwastav G.L. (2011): Stochastic Processes in Demography and Application, New Central Book Agency (P) Ltd.
3. Chiang C.L. (1968): Introduction to Stochastic Process in Biostatistics, John Wiley.
4. Cox P.R. (1970): Demography, Cambridge University Press
5. Keyfitz N. (1977): Applied Mathematical Statistics, Spring Verlag.
6. Namboodiri and Suchindran (1986): Life Table and its applications, Academic Press.
7. Ramkumar R. (2006): Technical Demography, New Age International (P) Limited, Publisher.
8. Shryock H.S, Seiga , J.S and Associates (1997): Method and Materials Of Demography, Academic Press Inc., London.
9. Spiegelman M. (1969): Introduction to Demographic Analysis, Harvard University Press.

STA 904 SPL B
Actuarial Studies
Credits: 5(4+1+0)

Course Learning Objectives:

This course familiarizes the students with concepts and statistical methods used in Actuarial Science. It enables them with tools and techniques necessary for applying actuarial methods in phenomena for financial research and insurance.

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Working mechanism of insurance companies and its role in nation building.
- Utility theory, utility functions- its determination and applications.
- Premium calculation, based on premium principles.
- Models for individual and aggregate claims for short and extended period.
- Survival models and life tables.
- Life insurance models, life annuities and reinsurance.
- Real illustrations for the concepts mentioned above through practical assignments.

CONTENTS:

Unit I: (Lectures: 12)

Introduction to insurance systems: Overview of insurance business, Role of statistics in Insurance, Insurance business in India.

Economics of Insurance: Introductory statistics, Some discrete, continuous, mixed and multivariate probability distributions. Utility theory, Insurance and utility, Utility functions-determination and applications.

Unit II: (Lectures: 18)

Risk theory: Individual risk models for a short term-models for individual claim random variables, convolution of random variables, approximations for the distributions of the sum.

Collective risk models for a single period-distribution of aggregate claims, selection of basic distributions, claim amount distribution, properties of certain compound distributions, approximations to the distributions of aggregate claims.

Collective risk models for an extended period-Discrete and continuous time models, ruin probabilities and the claim amount distribution, First surplus below initial level, Maximal aggregate loss.

Unit III: (Lectures: 18)

Survival models and life tables: Survival function, Force of mortality and related concepts, Life tables and related characteristics, Fractional ages and some analytical laws of mortality, Select and ultimate life tables.

Multiple decrement tables: Distribution of two random variables in regard to a single life time, Random survivorship group, Associate single decrement tables, Central rates of multiple decrement-with constant force and uniform distribution assumption only, Construction of a multiple decrement table, Stationary Population.

Unit IV: (Lectures: 16)

Life insurance: Insurances payable at the moment of death, Level benefit insurance, Endowment insurance, Deferred insurance, Varying benefit insurance, Insurances payable at the end of the year of death.

Annuities and Premiums: Annuities certain, Continuous life annuities, Discrete Life annuities, Life annuities with periodic payments, Loss at issue random variable, fully continuous and fully discrete premiums (concepts only).

Reinsurance: Proportional and non-proportional reinsurance, Reinsurance arrangements, Excess of loss for the insurer and reinsurer, Impact of inflation.

SUGGESTED READING:

1. Bowers, N. L., Gerber, H. U., Hickman, J. C., Jones, D. A. And Nesbitt, C. J. (1997): Actuarial Mathematics, Society of Actuaries, Itasca, Illinois, U.S.A.
2. Dickson, C. M. D. (2005): Insurance Risk and Ruin (International Series On Actuarial Science), Cambridge University Press.
3. Charpentier,A. (2015) Computational Actuarial Science with R, Taylor & Francis Group, LLC, CRC Press.
4. Promislow, S. David.(2015): Fundamentals of Actuarial Mathematics, John Wiley & Sons, Ltd.

STA 904 SPL C
Advanced Statistical Computing and Data Mining
Credit 5(4+0+1)

Course Learning Objectives:

The main objective of this paper is to introduce some advanced statistical computing techniques to extract information, visualization and knowledge about various
industries.

Course Learning Outcomes:

The main objective of this paper is to introduce some advanced statistical computing techniques to extract information, visualization and knowledge about various
industries.

CONTENTS:

Unit I: (Lectures: 14)
Random number generation: Review; simulating multivariate distributions; simulating stochastic processes. Stochastic differential equations: introduction, Numerical solutions. Monte Carlo Integration; Variance reduction methods.

Unit II: (Lectures: 14)
Markov Chain Monte Carlo methods: The Metropolis–Hastings Algorithm; Gibbs sampling. EM algorithm. Smoothing with kernels: density estimation, choice of kernels.

Unit III: (Lectures: 16)
Review of classification methods from multivariate analysis; classification and Decision trees. Clustering methods from both statistical and data mining viewpoints; Vector Quantization. Unsupervised learning; supervised learning.

Unit IV: (Lectures: 16)
Artificial neural networks: Introduction, multilayer perceptron network, self-organizing feature map and radial basis function network. Structural risk minimization, Introduction to support vector machine. Overview of current applications.

SUGGESTED READING:

1. Bishop, C.M. (1995): Neural Networks for pattern Recognition, Oxford University Press.
2. Duda, R.O., Hart, P.E. and Strok, D.G. (2000): Pattern Classification, 2nd Edition, Wiley, USA.
3. Hastie, T., Tibshirani, R., Friedman, J. (2008) :The Elements of Statistical Learning: Data Mining,Inference,and Prediction, 2ndEdn., Springer.
4. Han, J. and Kamber, M. (2000): Data Mining: Concepts and Techniques, Morgan Kaufmann.
5. Haykin, S. (1998) : Neural Networks: A Comprehensive Foundation, 2nd Edition, Prentice Hall.

6. Hand, D., Mannila, H., and Smyth, P. (2001): Principles of Data Mining, MIT Press.
7. McLachlan, G.J. and Krishnan, T. (1997): The EM Algorithms and Extensions, Wiley.
8. Nakhaeizadeh, G. and Taylor G.C., (1997): Machine Learning and Statistics, John Wiley & Sons.
9. Pooch, Udo W. and Wall, James A. (1993): Discrete Event Simulation (A practical approach), CRC Press.
10. Rubinstein, R.Y. (1981). Simulation and the Monte Carlo Method, John Wiley & Sons.
11. Robert, C.P. & Casella, G. (2004) Monte Carlo Statistical Methods, 2nd Edn., Springer.

STA 905 OE-I
Demography and Data Mining
Credit 4(4+0+0)

Course Learning Objectives:

The learning objectives of this course include:

- Introducing students to Indian Census and demographic surveys such as SRS and NFHS.
- To learn how to construct life tables.
- To learn measures of fertility, mortality and population growth from cohort data.
- Introducing students to basic concepts of data mining and the role of statistics in data mining.
- To learn random sample generation.

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Different stages of demographic transition.
- Working mechanism of Indian Census, SRS and NFHS.
- To check the completeness of registration data using Chandrasekaran-Deming formula.
- Concept of Life Tables, their applications.
- Concept of Abridged life tables and their construction by Reed and Merrell method, Greville's method and King's Method.
- Basic measures of Fertility, Mortality and Population Growth.
- Basic of Data mining and role of statistics in data mining.
- Different data mining types.
- Tools used for data visualization in data mining.
- Generating random sample using Inverse transformation and acceptance-rejection methods.

CONTENTS:

Unit I: (Lectures: 16)
Demographic transition theory. Idea of Census, SRS, NFHS (with special reference to India and Assam). Coverage and content errors in demography data, use of balancing equations and Chandra-Sekharan Deming Formula. Infant mortality rate, adjusted infant mortality rate. Population growth rates- arithmetic, geometric and exponential.

Unit II: (Lectures: 14)
Life tables and its applications. Methods of construction of abridge life table (Greville and Chiang method), Gompertz, Makeham curve. Fertility measures from cohort data.

Unit III: (Lectures: 16)
Introduction to Data Mining and Knowledge Discovery in Databases, Global models and local patterns in databases, Measurement and its types, distance measures, data transformation and data quality, Data visualization- single variable, between two variables, more than two variables.

Unit IV: (Lectures: 14)
Simulation: Introduction, Definition, Advantages, Disadvantages and Applications of Simulation, Steps in a Simulation procedure, Monte Carlo method.
Generation of random numbers using congruence method, Generation of random variables using Inverse transform method and Acceptance-rejection method.

SUGGESTED READING:

1. Chiang C.L. (1968): Introduction to Stochastic Process in Biostatistics, John Wiley.
2. Goon A.M., Gupta M.K. and Dasgupta B. (2005): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
3. Gupta S.C and Kapoor V.K (2007): Fundamentals of Applied Statistics, 11th Edition, Sultan Chand & Sons.
4. Hand D, Mannila H. and Smyth P. (2001): Principles of Data Mining, Prentice-Hall of India pvt. Ltd.
5. Maimon O and Rokach L. (2010): Data Mining and Knowledge Discovery Handbook, Second Edition, Springer.
6. Namboodiri and Suchindran (1986): Life Table and its applications, Academic Press.
7. Pai J, Han J and Kamber M. (2011): Data Mining: Concepts and Techniques, (Third edition), Elsevier.
8. Ramkumar R. (2006): Technical Demography, New Age International (P) Limited, Publisher.

SEMESTER IV

STA 1001 C
Stochastic Processes
Credit 4(4+0+0)

Course Learning Objectives:

The learning objectives include:

- To define, design, model and analyse random processes.
- To identify the real life applications of stochastic processes.
- To understand Branching process and renewal theory.

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- The fundamental concepts of stochastic processes.
- Tools needed to analyse stochastic processes.
- Markov processes, Markov chains and its applications.
- Poisson process and its variations.
- Branching Process and related theorems
- Renewal theory with its applications.

CONTENTS:

Unit I: (Lectures: 14)

Review of Basic Probability Concepts. Introduction to Stochastic Processes. Stationary and Evolutionary Processes.
Markov Chains: Transition Probability Matrices, Chapman- Kolmogorov equations, Generalization of independent Bernoulli trials, Sequence of chain dependent trials, Some Examples and Classification of States and Chains. Stability of Markov System, Graph theoretic approach, Markov chain with denumerable number of states.
Random walk and Gambler's Ruin problem.

Unit II: (Lectures: 16)

Poisson Processes: Postulates and Properties of Poisson Process, Time dependent Poisson Process, Weighted Poisson Process, Arrival, Inter arrival and Conditional Arrival Distributions. Pure Birth process, Yule Process, Polya Process, Pure Death Process, Birth and Death Process, Chiang's Illness Death Process.

Unit III: (Lectures: 14)

Branching Process: Introduction, Properties of Generating Functions of Branching Processes. Probability of Extinction, Distribution of Total Number of Progeny, Discrete Time Branching Process and Results, Continuous Time Branching Process and applications.

Idea of Brownian Motion: Limit of Random Walk, its Defining Characteristics.

Unit IV: (Lectures: 16)

Renewal Processes: Preliminaries, Distribution of the Forward and Backward Recurrence Time, Queueing Paradox, Asymptotic Renewal Theorem, Elementary Renewal Theorem (without proof).
Martingales: Definitions and Some Examples, Martingales from Markov Chain, Stopping Times, Optional Stopping Theorem, Wald's Martingale.

SUGGESTED READING:

1. Bhat, B.R. (2000). Stochastic Models- Analysis and Applications, New Age International Publishers.
2. Biswas, S. (2012). Applied stochastic Processes, New Age International Publishers.
3. Feller, William (1968). An Introduction to Probability Theory and its Applications, Vol. 1(Third Ed.), John Wiley.
4. Hoel, P.G., Port, S.C. and Stone C.J. (1972). Introduction to Stochastic Processes, Houghton Miffin & Co.
5. Karlin, S. and Taylor, H.M. (1975). A first course in Stochastic Processes, Second Ed.Academic Press.
6. Medhi, J. (1994). Stochastic Processes, 2nd Edition, Wiley Eastern Ltd.
7. Parzen, Emanuel (1962). Stochastic Processes, Holden-Day Inc.
8. Prabhu, N.U. (2007). Stochastic Processes: Basic Theory and its Applications, World Scientific.
9. Ross, Sheldon M. (1983). Stochastic Processes, John Wiley and Sons, Inc.
10. Takacs, Lajos (1967). Combinatorial Methods in the Theory of Stochastic Processes, John Wiley and Sons, Inc.
11. Williams, D. (1991). Probability with Martingales, Cambridge University Press.

SPECIAL PAPERS (Any one)

STA 1002 SPL A
Bio Statistics
Credit 5(4+0+1)

Course Learning Objectives:

The learning objectives include:

- To analyse censored data and its application in public health.
- Estimate death probabilities by using the theory of competing risks in a cause-specific mortality study.
- Need of conducting clinical trials for introducing new drug.
- To compute probability of gametes in different generations under random mating.

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- The fundamental concepts of survival functions and their interrelationship.
- Survival distributions and their applications.
- Handling of censored data and estimating mean survival time.
- Actuarial and Kaplan-Meier methods (Non-parametric methods).
- Competing Risk Theory. Dependent and independent risk.
- Simple Stochastic epidemic model.
- Basic concept of genetics.
- Need of Clinical drug trials.

CONTENTS:

Unit I: (Lectures: 16)

Introduction to survival data, time and event. Functions of survival time, survival distributions and their applications viz. Exponential, Gamma, Weibull, Rayleigh, Lognormal, death density function for a distribution having bath-tub shape hazard function. Censored data: different types of censoring viz. right (type I, type II and type III), left and interval censoring with real life examples. Estimation of mean survival time and variance of the estimator for type I and type II censored data with numerical examples. Non-parametric methods for estimating survival function and variance of the estimator and confidence intervals viz. Actuarial and Kaplan–Meier methods. Methods for comparing two survival distributions: parametric methods viz. Likelihood Ratio test, Cox's F-test and non parametric methods viz. Log Rank test, Wilcoxon test. Semi parametric model for survival data: Cox Proportional hazard model.

Unit II: (Lectures: 12)

Analysis of Epidemiologic and Clinical Data: Studying association between a disease and a characteristic: (a) Types of studies in Epidemiology and Clinical Research (i) Prospective study (ii) Retrospective study (iii) Cross-sectional data, (b) Dichotomous Response and Dichotomous Risk Factor: 2X2 Tables (c) Expressing relationship between a risk factor and a disease (d) Inference for relative risk and odds ratio for 2X2 table, Sensitivity, specificity and predictivities.

Unit III: (Lectures: 14)

Competing risk theory: Indices for measure-ment of probability of death under competing risks and their inter-relations. Estimation of probabilities of death under competing risks by maximum likelihood and modified minimum Chi-square methods. Theory of independent and dependent risks. Bivariate normal dependent risk model. Conditional death density functions. Idea of DNA sequence.

Unit IV: (Lectures: 10)

Stochastic epidemic models: Simple and general epidemic models (by use of random variable technique). Basic biological concepts in genetics, Mendels law, Hardy- Weinberg equilibirium, random mating, distribution of allele frequency (dominant/co-dominant cases), Approach to equilibirium for X-linked genes, natural selection, mutation, genetic drift, equilibirium when both natural selection and mutation are operative, detection and estimation of linkage in heredity.

Unit V: **(Lectures: 8)**

Planning and design of clinical trials, Phase I, II, and III trials. Consideration in planning a clinical trial, designs for comparative trials. Sample size determination in fixed sample designs.

SUGGESTED READING:

1. Biswas, S. (1995): Applied Stochastic Processes. A Biostatistical and Population Oriented Approach, Wiley Eastern Ltd.
2. Collett, D. (2003): Modelling Survival Data in Medical Research, Chapman & Hall/CRC.
3. Cox, D.R. and Oakes, D. (1984): Analysis of Survival Data, Chapman and Hall.
4. Elandt Johnson R.C. (1971): Probability Models and Statistical Methods in Genetics, John Wiley & Sons.
5. Ewens, W. J. (1979): Mathematics of Population Genetics, Springer Verlag.
6. Ewens, W. J. and Grant, G.R. (2001): Statistical methods in Bio informatics: An Introduction, Springer.
7. Friedman, L.M., Furburg, C. and DeMets, D.L. (1998): Fundamentals of Clinical Trials, Springer Verlag.
8. Gross, A. J. And Clark V.A. (1975): Survival Distribution; Reliability Applications in Biomedical Sciences, John Wiley & Sons.
9. Indrayan, A. (2008): Medical Biostatistics, Second Edition, Chapman & Hall/CRC.
10. Lee, Elisa, T. (1992): Statistical Methods for Survival Data Analysis, John Wiley & Sons.
11. Li, C.C. (1976): First Course of Population Genetics, Boxwood Press.

STA 1002 SPL B
Econometrics
Credit 5(4+0+1)

Course Learning Objectives:
This course aims at making economic research in a mathematically simple way in applied econometric research.

Course Learning Outcomes:
After completion of the course, students should have developed a clear understanding of:

- Simple linear regression model.
- Multiple linear regression model in matrix notation.
- Violations of various assumptions under regression analysis viz. multicollinearity, heteroscedasticity and autocorrelation.
- Lagged variables and distributed lag models.
- Models of simultaneous relationships between various economic factors.

CONTENTS:

Unit I: (Lectures: 16)
Nature of econometrics. The Classical Linear Normal Regression Model (Matrix Approach): Estimation, test and their properties.
Heteroscedasticity, Autocorrelation and Multicollinearity: implications and consequences, tests and solutions.

Unit II: (Lectures: 08)
Generalized least squares(GLS) estimation: Heteroscadatic and autocorrelated structure. Zelner's SURE method.

Unit III: (Lectures: 12)
Distributed lag models, Polynomial lag models, Almon's lag model, Determination of degree of polynomial and lag length. Adaptive expectation model, Partial adjustment model, Compound Geometric lag model. Methods of estimation. Vector Auto Regression (VAR), The Granger Causality Test.

Unit IV: (Lectures: 12)
Simultaneous-equation models: Identification problems. Restrictions on structural parameters – Rank and Order Condition for identification. Restrictions on variances and covariance.

Unit V: (Lectures: 12)
Simultaneous-equation methods: Estimation - Recursive systems, Two Stage Least Squares(2SLS) estimators, Limited Information(Least Variance Ratio) estimators, k-class estimators.

SUGGESTED READING:

1. Greene W.H (2000): Econometric Analysis, 4th Edition, Prentice Hall.
2. Gujarati, D., Porter D.C and Gunasekar S. (2016): Basic Econometrics, 13th Edition, McGraw Hill Companies.
3. Johnston, J. (1985): Econometric Methods, 3rd Edition, McGraw Hill International.
4. Kmenta J (1986): Elements of Econometrics, 2nd Edition, Macmillan, New York.
5. Koutsoyiannis, A. (2004): Theory of Econometrics, 2nd Edition, Palgrave Macmillan Limited.
6. Madnani G.M.K (2008): Introduction to Econometrics, Principles and Applications, Oxford & IBH Publishing Co. Pvt Ltd, Delhi□□
7. Maddala, G.S. and Lahiri, K. (2009): Introduction to Econometrics, 4th Edition, Wiley & Sons.
8. Theil H (1971): Principles of Econometrics, John Wiley & Sons Inc, New York

STA 1002 SPL C
Operations Research
Credit 5(4+1+0)

Course Learning Objectives:

The main course objective of this paper is to introduce quantitative and model based techniques for model formulation and effective decision–making.

Course Learning Outcomes:

After successful completion of this course, student will be able to:

- Apply statistical methods pertaining to queuing models and develop operational research models from the verbal description of the real system.
- Understand the characteristics of different types of decision-making environments and decision making approaches.
- Understand the mathematical tools that are needed to solve optimization problems.
- Analyze the queueing and inventory situations.
- Understand discrete event simulation and decision analysis with inclusion of modelling based on random events involving uncertainties.
- Conceptualise optimum event management through Network scheduling.
- Implement the theory of Game in real life situation and solution of game having mixed strategy.
- Understand the equivalence of game theory with linear programming problems.
- Understand the importance of resource allocation in case of inventory management.
- Optimal inventory policy for EOQ model and its variations.
- Solving quantity discounts model with price breaks.

CONTENTS:

Unit I: (Lectures: 15)
Queuing Theory:
General concept: Basic Characteristics of a Queue, Notations, Transient and Steady state, Little's formula (without proof).
Steady state distribution and waiting time distribution of M/M/1 and M/M/c models; Steady state distribution of M/M/1/k, M/M/c/c and M/M/c//m (m>c). (Models are to be discussed with numerical examples)

Unit II: (Lectures: 15)
Inventory Management:
Inventory control – definition, Variables in Inventory problems, Characteristics of Inventory system, Classification of Inventory models, Deterministic Inventory models – Concept of Economic Ordering Quantity (EOQ), Static demand models, EOQ model without shortage – The Economic Lot Size with uniform demand, The Economic Lot Size with different rates of demand in different cycles, The Economic Lot Size with finite rate of replenishment; EOQ model without shortage – The EOQ with constant rate of demand and constant scheduling time,

The EOQ with constant rate of demand and variable scheduling time, The Production Lot Size model with shortages.

Unit III: (Lectures: 16)

Resource Analysis and Time Estimate in Network Scheduling:

Different time estimates related to any project under CPM and PERT, Probability distribution associated with PERT, Probability of achieving completion date of project, Resource allocation – Resource Smoothing and Resource Leveling.

Unit IV: (Lectures: 14)

Game Theory:

Introduction to Game theory: Two person Zero sum game; The Minimax-Maximin Principle; saddle points; Game without saddle point; Pure and Mixed strategies; Solution procedure of 2x2 game; Graphical solution procedure; Equivalence of Rectangular game and linear programming.

SUGGESTED READING:

1. Goel, B., Mittal, S.K. (23001): Operations Research Pragati Prakshan.
2. Hadley, G: (2002) : Linear Programming, Narosa Publications.
3. Hillier, F. S. and Lieberman, G.J. (2001): Introduction to Operation Research, 7th Edition, Irwin.
4. Kanti Swarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chand and Sons.
5. Sharma, S. D. (2002): Introduction to Operation Research, thirteenth Edition, Kedar Nath and Ram Nath & Co.
6. Taha, H. A. (2006): Operation Research: An Introduction, Eighth Edition, Prentice Hall.
7. Winston, W.L. and Goldberg, J.B. (2004): Operations Research: Applications and Algorithms, Thomson Brooks/Cole.

STA 1003 OE-II
Linear Programming Problem and Reliability
Credit 4(4+0+0)

Course Learning Objectives:

After completion of the course, we expect that the student will be able to

- Formulate fairly complex optimization problems and will be able to solve it.
- Apply statistical techniques pertaining to assignment problems, reliability theory and some common life distributions.

Course Learning Outcomes:

At the end of the course the students will able to

- Understand solution properties of general linear programming problem, the simplex algorithm, the artificial variable technique and the two – phase algorithm of solving LPP.
- Use of duality to solve a LPP.
- Realize sensitivity analysis.
- Solve transportation and assignment problems.
- Understand the concept of reliability theory, structure function, coherent systems, bath tub model and related concepts.
- Apply statistical methods in life distributions and estimate parameters by the method of MLE and Bayesian methods, Stress-strength model.
- Understand system reliability under Markovian setup –Series and Parallel.

CONTENTS:

Unit I: (Lectures: 16)

LPP: The general linear programming problem, Properties of the solutions to a linear programming problem.

Generation of extreme points development for an optimum feasible solution, the simplex algorithm, the artificial variable technique, the two – phase algorithm.

Unit II: (Lectures: 16)

Duality in linear programming, the symmetric and asymmetric duals, Dual simplex method.

Sensitivity analysis: Changes in cost coefficient and elements of requirement factors.

Application of linear programming: the assignment problem (solution of balanced and unbalanced problem), the transportation problem (optimum solution of balanced and unbalanced problem).

Unit III: (Lectures: 14)

Reliability Theory: Concept and Measures, Notion of Ageing, Hazard rate, IFR and DFR distributions and related Theorem, Structure Function, Coherent Systems, Component and Systems, Reliability of Coherent Systems, bath tub model.

Unit IV: (Lectures: 18)

Life distributions (Exponential, Gamma, Weibull), Estimation of parameters by the method of MLE and Bayesian methods, Stress- Strength Model. System Reliability under Markovian setup – Series and Parallel.

SUGGESTED READING:

1. Bain, L. J and Engelhardt, M. (1991). Statistical Analysis of Reliability and Life Testing Models, Marcel Dekker.
2. Barlow, R. E. And Proschan, F (1985): Statistical Theory of Reliability and Life Testing, Holt, Rinehart and Winston.
3. Biswas, S. (1996): Statistics of Quality Control, Sampling Inspection and Reliability, New Age International Publishers.
4. Goel, B., Mittal, S.K. (23001): Operations Research Pragati Prakshan.
5. Hadley, G: (2002) : Linear Programming, Narosa Publications.
6. Hillier, F. S. and Lieberman, G.J. (2001): Introduction to Operation Research, 7th Edition, Irwin.
7. Kanti Swarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chand and Sons.
8. Taha, H. A. (2006): Operation Research: An Introduction, Eighth Edition, Prentice Hall.
9. Sharma, S. D. (2002): Introduction to Operation Research, thirteenth Edition, Kedar Nath and Ram Nath & Co.
10. Winston, W.L. and Goldberg, J.B. (2004). Operations Research: Applications and Algorithms, Thomson Brooks/Cole.

STA- DPW
DISSERTATION / PROJECT WORK
Credit 6(0+0+6)

Course Learning Objectives:

The aim of the course is to initiate students to write and present a statistical report, under the supervision of a faculty, on some area of human interest. The project work will provide hands on training to the students to deal with data emanating from some real life situation and should be chosen so that there is enough scope to apply and demonstrate the statistical techniques learned in the theory course.

Course Learning Outcomes:

The project work will provide hands on training to the students to deal with data and relate it to some theoretical concepts.

CONTENTS:

The project work itself is a practical problem and it relates to some theoretical concepts which have been covered in previous semesters of the Post-graduate course. Students are required to prepare, present and submit a detailed project report/ dissertation on the work done. The dissertation shall clearly state the problem(s) addressed, the methodology adopted, the assumptions and hypotheses formulated, review of literature consulted, statistical analyses performed and inferences drawn. Assessment shall be based on dissertation, presentation and viva-voce. There shall be an external examiner and internal examiner (preferably the supervisor) for the evaluation of the project work.