Gujarat University

Choice Based Credit Semester System

Revised Syllabus for Post Graduate (M. Sc.) Statistics Course

(Effective from June 2018)

Syllabus in M. Sc. Statistics Course gets changed in detail and will be implemented from June-2018 progressively. Credits of the papers in the old (June-2010) and new syllabus remains same. Old course students will have to clear the course only in three trials(1+2). After that they have to appear for new syllabus.

Eligibility:

A Candidate who has obtained the degree of Bachelor of Science (Statistics) of this University or of the other University recognized as equivalent there to, or a candidate who has obtained Bachelor of Science(General) Degree with Statistics as one of subjects or a student who has studied statistics at second year B.Sc. of the University and obtained his B.Sc. degree in Mathematics is eligible for M.Sc. course in the Department.

Objectives of the Program:

In this knowledge era, Science is developing at an explosive rate and Statistics as key technology of modern science has become more important and relevant as a discipline applicable to several other branches of knowledge.

Looking to the present scenario, the syllabi for M. Sc. course is being revised to strive linkages between academic field and practicing world. The syllabi is framed to meet with the requirements of academic field including competitive examinations and the course recommended by UGC, industries, government sectors, research institutions, business houses having wide spectrum of applications at various places. Latest developments and discoveries in the subject are also included.

Outcomes of the Program:

After passing this program, the students will be well equipped to meet the challenges of academic as well as of industries. The students will be able to pursue careers in pharmaceutical industries, medical fields, and clinical research organizations as bio-statistician. The students can also make a career as a data analysts, which has a very hot demand to day. The students can get job as a Statistical officer/ Research officer in government statistical organizations like Bureau of Statistics as well as in NSSO. They can

also make a career in teaching fields as teachers/professors at schools, colleges and universities.

General Structure of the Syllabus:

1. The M.Sc. Course is divided into four semesters. The teaching evaluation of the various theory papers and laboratory work will be conducted under the semester system. For this purpose each academic year is divided into two semesters. In each semester there will be four theory papers, two practical papers and seminar or project work.
2. There shall be three compulsory papers and one elective paper which is to be selected from the given set of three elective papers in semester two and four.
3. Candidates will be examined in each theory paper for 100 marks and practical papers for 100 marks wherever prescribed at the end of each semester. Seminar will be undertaken during 1st and 3rd semesters and project work will be undertaken during 2nd and 4th semesters.
4. There shall be viva – voce examination at the end of each semester to be held by the University.
5. For deciding result of M.Sc. examination at each semester the ratio between the internal and external assessment will be 30:70. For the purpose of internal assessment, the concerned Department will conduct a test in each semester. The 30 internal marks of each theory paper will be covered from the internal test, involvement of the students during the lectures in the form of question-answers, participation of the students in the departmental program and activities and continuous evaluation of the students.
6. The 30 internal marks of each practical paper will be covered from the practical test exam score and seminar / project presentation.
7. The 70 marks of external exam of each practical paper are divided in broadly three categories:
   (i) 50 marks from actual practical exam.
   (ii) 20 marks from seminar/ project work which will be divided equally (10 + 10) and included with the marks (50) of the practical papers.
   (iii) 20 marks from viva-voce exam and preparation of the journal which will be divided equally (10 + 10) and included with the marks (50) of the practical papers.
8. There shall be at least one study tour during the span of two years of P.G. study, pertaining to different kind of Industries/ Dairy Companies/Agricultural Universities/Research Institutes/ Govt. and Semi Govt. Organizations, even outside Gujarat State. The study tour is highly essential for collection of varieties of live data, study various concepts of statistical data analysis, processes and technology pertaining to the use of Statistical Methodologies.

There are Six Courses in each semester as

Course No. STA 401 – STA 406 belong to the first semester

Course No. STA 407 – STA 412 belong to the second semester

Course No. STA 501 – STA 506 belong to the third semester

Course No. STA 507 – STA 512 belong to the fourth semester

Design and Structure of M. Sc. (STATISTICS) Course for Choice Based Credit Semester system to be implemented from June 2018

Sem.	Course No.	Course Name	No. of hours per week				Course credits
			Lectures	Seminar	Practical	Total	
I	STA401	Matrix Algebra	3	1	-	4	4
	STA402	Probability Theory	3	1	-	4	4
	STA403	Parametric Estimation	3	1	-	4	4
	STA404	Theory of Sampling	3	1	-	4	4
	STA405PR	Practical 1	-	-	6	6	4
	STA406PR	Practical 2	-	-	6	6	4
		Total	12	4	12	28	24

Sem.	Course No.	Course Name	No. of hours per week				Course credits
			Lectures	Seminar	Practical	Total	
II	STA407	Reliability and Life Testing	3	1	-	4	4
	STA408	Distribution Theory	3	1	-	4	4
	STA409	Mathematical Programming	3	1	-	4	4
	STA410	Elective Paper *	3	1	-	4	4
	STA411PR	Practical 3	-	-	6	6	4
	STA412PR	Practical 4	-	-	6	6	4
		Total	12	4	12	28	24

*** Elective papers are to be selected from the following list of papers for the paper STA410**.

Elective Paper-I: Computer Programming

Elective Paper-II: R -Programming

Elective Paper-III: Measure Theory

Sem.	Course No.	Course Name	No. of hours per week				Course credits
			Lectures	Seminar	Practical	Total	
III	STA501	Testing of Hypotheses	3	1	-	4	4
	STA502	Design of Experiments	3	1	-	4	4
	STA503	Multivariate Analysis	3	1	-	4	4
	STA504	Operations Research	3	1	-	4	4
	STA505PR	Practical 5	-	-	6	6	4
	STA506PR	Practical 6	-	-	6	6	4
		Total	12	4	12	28	24

Sem.	Course No.	Course Name	No. of hours per week				Course credits
			Lectures	Seminar	Practical	Total	
IV	STA507	Time Series Analysis	3	1	-	4	4
	STA508	Regression Analysis	3	1	-	4	4
	STA509	Industrial Statistics	3	1	-	4	4
	STA510	Elective Paper *	3	1	-	4	4
	STA511PR	Practical 7	-	-	6	6	4
	STA512PR	Practical 8	-	-	6	6	4
		Total	12	4	12	28	24

*** Elective papers are to be selected from the following list of papers for the paper STA510.**

Elective Paper-I: Bio-Assays and Clinical Trials

Elective Paper-II: Actuarial Statistics

Elective Paper-III: Environmental Statistics

Semester 1

Theory Paper STA401: Matrix Algebra

Objectives: The main objective of this course is to develop methods and tools to tackle multiple natural correlated variables within a common framework. Matrix algebra provides a powerful technique to manipulate large data sets, solve systems of linear equations, and record data.

Course Contents:

Matrices over a field, operation on matrices, special types of matrices, trace and norm of a matrix. Determinants: Idea of permutation, theorems on determinants, Laplace method of expansion of a determinant, Properties of determinants. Homogenous and non-homogeneous linear equation .

Rank of a matrix - definition of row rank and column rank, properties of rank, Frobenius theorem. Regular inverse of a matrix with properties, Inverse and determinant of matrices using partition method, generalized inverse of a matrix with properties, reflexive g-inverse and Moore-Penrose g- inverse.

Characteristic roots and vectors of a square matrix, Properties of characteristic roots and characteristic vectors of symmetric, skew-symmetric and orthogonal matrices. Idempotent matrices and their properties, Matrix version of Cochran's theorem.

Hermitian and quadratic forms – classification of quadratic forms, reduction to diagonal forms, simultaneous reduction of two quadratic forms, Maxima and Minima of ratio of certain quadratic forms, Differentiation of quadratic forms.

Outcomes: Upon successful completion of this course, students should be able to use the important characteristics of matrices, such as determinant, rank, eigen values, eigenvectors, Hermitian and Quadratic forms and their different factorizations, etc. Students will also be able to use characteristics of a matrix to solve a linear system of equations.

Books:

1. Shanti Narayan (1964): A text book of matrices, 5th edition, S. Chand & Co. , New Delhi.
2. Khatri C.G. (1971): Mathematics of matrices (in Gujarati), Granth Nirman Board
3. Rao C.R.(1973): Linear Statistical Inference and its applications, 2nd edition, John Wiley and Sons, Inc.
4. Rao, C.R. and Mitra, S.K. (1980): Generalized inverse of matrices and applications, Handbook of Statistics, Volume 1, Pages471-512.
5. Searle, S.R. (1982): Matrix Algebra useful for Statistics, John Wiley
6. Ramchandra Rao, A. And Bhimasankaram, P. (1992): Linear Algebra, Tata McGraw Hill.

Semester 1

Theory Paper STA402: Probability Theory

Objectives: To provide an understanding of basic concepts of probability theory like field, ring , sigma field , probability measure etc. To provide understanding of the random variable and probability inequalities, law of large numbers. To provide basic understanding related to stochastic process and Markov process.

Course Contents:

Algebra of sets–classes of sets-field, ring, sigma field, sigma ring, generated field and ring, sequences of sets, limit superior and limit inferior and limit of sequences of sets, Measure on a field and sigma field. Measure Theoretic approach to probability - Probability space, events, algebra of events, probability of occurrence of at least one, exactly and at least m events out of n events ($l < m < n$). Conditional probability, Bayes theorem and its applications, independence of events. Random variable as measurable function, distribution function of a random variable, decomposition of a distribution function, types of random variable discrete continuous and mixed. Joint distribution functions in R^2 and R^p with properties.

Expectation, Conditional Expectation, moments and characteristic function with properties. Markov's, Chebyshev's, Holder's, Minkowski's and Jensen's and Liapounov's inequality. Sequence of random variables, Independence of random variables, Convergence in probability, in quadratic mean, in law or distribution and convergence almost surely and their interrelationship. Weak compactness theorem and Borel-Cantelli lemma.

Weak law of large numbers due to Chebyshev and Kinchine. Kolmogorov's inequality and statement of Hajek-Renyi inequality. Kolmogorov's strong law of large numbers (Proof of sufficiency condition only). Central limit theorem(CLT): Statement of central limit law. CLT due to Lindeberg- Levy and Liapounov with proof. CLT due to Lindebergand Feller (Without Proof) and applications.

Definition of Markov Chain and examples, Chapman- Kolmogorov's equations and n-step transition probabilities. Simple time-dependent stochastic process- Poisson, pure birth and birth and death processes and applications.

Outcomes: By completing this course the students will be able to (i) use basic concepts of probability theory in the study of distributions (ii) solve the problem related to probability and probability inequalities (iii) apply the theory of Markov chain to the real life data and for prediction.

Books:

1. Bhatt, B.R. (1984): Modern Probability Theory – An Introductory Text book, 2nded., Wiley Eastern.
2. Sheldon, R. (2010): A First Course in Probability, 8thed., Pearson.
3. Loeve, M.(1963): Probability Theory, 3rd ed. Van Nostrand
4. Feller,W. (1972):An Intro to Probability Theory,Vol.1WileyEastern.
5. Parzen, F.(1969): Modern Probability Theory and its applications. John Wiley.
6. Martin, E.(1970): Introduction to Mathematical Probability Theory, Prentice-Hall.
7. Rohatgi,V.(1984): An Introduction to Probability Theory, Prentice–Hall.
8. Parthasarthi, K.R.(1970): Introduction to Probability &Measure. McMillian Co.
9. Cacoulles, T.(1989): Exercise in Probability, Narosa.
10. Feller, W.(1972): An Intro. to Probability Theory and its applications,Vol-I & Vol-II Wiley Eastern.
11. Medhi, J. (1982): Stochastic Processes. Wiley Eastern.
12. Ciniar, E.(1975): Introduction to Stochastic processes. Prentice-Hall.
13. Basu, A.K. (1999) : Measure Theory and Probability Theory, Prentice-Hall of India

Semester 1

Theory Paper STA 403: Parametric Estimation

Objectives: To provide an introduction to the fundamental theory of parametric estimation. Use classical and Bayesian approaches to formulate and solve problems for parametric estimation.

Course Contents:

Sufficiency: Sufficient statistics, Fisher's information, Factorization theorem, minimal sufficiency, Lehaman-Scheffe theorem, complete sufficient statistic, Sufficiency in Exponential family of distributions and Pitman family of distributions. Ancillary statistics. Basu's theorem & its applications.

Uniformly minimum variance unbiased estimators, Minimum Variance unbiased estimators , uniformly minimum variance unbiased estimators(UMVUE),Rao-Blackwell theorem, Lehmann-Scheffe theorem on UMVUE, Bhattacharya bounds, Minimum variance bound unbiased estimators.

Methods of Estimation: Method of maximum likelihood; minimum chi-square and modified minimum chi-square, Asymptotic properties of maximum likelihood estimator (MLE).
Confidence interval estimation: Pivotal method of construction of confidence interval, confidence interval based on MLE.

Bayes Estimation: Difference between classical method and Bayes method of estimation. Concept of prior and posterior distributions, squared error and weighted squared error loss functions to estimate parameters of binominal, Poisson, geometric, uniform, exponential and normal distributions.

Outcomes: Upon satisfactory completion of the course, students become able to apply the different methods of parametric estimation to solve the problems in statistical inference. Students also become able to determine the distribution and statistical properties of estimator.

Books:

1. Mukhopadhyay, N. (2000): Probability and Statistical inference, Marcel Dekker.
2. Lehmann, E.L. (1983): Theory of Point estimation, Wiley Eastern.
3. Kale, B. K. (1999): A first course on parametric inference. Narosa publishing, New Delhi.
4. Rohatgi, V.K. & A.K. Md.E. Saleh (2001): An Introduction to Probability & Statistics, 2nd ed., John Wiley.
5. Zacks, S. (1971): Theory of Statistical Inference, John Wiley.
6. Dudewicz, E. J. and Mishra, S.N. (1988): Modern Mathematical Statistics, Wiley Eastern.
7. Goon, Gupta and Dasgupta. (1970): An outline of Statistical Theory, Vol. II, World Press, Calcutta.
8. Casella, G and Berger, R.L.(2002):Statistical Inference, Brooks/ Cole Publishing Co., Pacific Grove.
9. Box, G.E.P. and G.C. (1973): Bayesian inference in Statistical Analysis. Adison Wesley.
10. Rao, C.R.(1973): Linear Statistical Inference and its Applications, John Wiley.
11. Mood, A. M. Graybill, F. and Boes, D. C. (1974): Introduction to the Theory of Statistics, McGraw Hill.
12. Ferguson, T.S. (1967): Mathematical Statistics : A Decision Theoretic Approach, Academic Press
13. Stuart, A. (2010): Kendall's Advanced Theory of Statistics, Vol.- III, 6thed.
14. Sinha, S. K. (1998): Bayesian Estimation, New Age International (P)Ltd.

Semester 1

Theory Paper STA 404: Theory of Sampling

Objectives: The objective of this course is to present the theory and techniques of sample surveys such as probability proportional to size sampling, cluster sampling, two-stage sampling, ratio and regression methods with their application in different types of problems in our society.

Course Contents:

Review of basic concepts in sampling, sample selection and determination of sample size.Varying probability Sampling: PPS sampling with replacement, estimation of population total and mean, its variance and variance estimators, efficiency with SRS - linear relationship, gain due to PPS sampling. Selection procedures - Cumulative total method, Lahiri's method.

Stratified PPS sampling and allocation of sample size. PPSWOR - Horwitz-Thompson (HT) estimator, its variance and variance estimators due to HT and YGS (Yates, Grundy and Sen). Des Raj's estimator.

Cluster sampling: Equal cluster sampling, efficiency with SRS, cluster sampling for proportions, varying clusters under SRS and PPS sampling. Two-stage sampling: Estimator of population mean and total under sampling with SRSWR, SRSWOR, PPSWR.

Ratio estimator- its need, bias, MSE and variance, Ratio method of estimation under basic sampling schemes-SRS, Systematic, PPSWR and stratified sampling, almost unbiased ratio estimator, unbiased ratio type estimators. Difference and regression estimator, regression method of estimation of bias and variance under SRS and stratifies SRS.

Outcomes: Upon completion of this course, the students will be able to apply various sampling techniques involved in this course for project planning and data analysis on various social and economic activities of society.

Books:

1. Murthy M.N. (1967): Sampling theory and Methods. Statistical Pub. Soc., Calcutta.
2. Des, Raj (1976): Sampling Theory, Tata McGraw Hill.
3. Sukthatme, S.V.(1984): Sampling theory of surveys with applications. Indian Soc. of Agricultural Statistics, New Delhi.
4. Rish, D. (1984): Survey Sampling, John Wiley.
5. Hanseen, M.H., Hurwitz, W.N. and Madow, W.G. (1953): Sample survey - Methods and theory and applications, Vol I & II, John Wiley.
6. Cochran, W.G. (1984): Sampling Techniques, 3rd ed. Wiley Eastern.
7. Mukhopadhyay, P. (1998): Theory & Methods of Survey Sampling, Prentice - Hall of India.

PRACTICAL PAPER

STA 405PR

Based on relevant topics of the theory papers STA401 & STA402

STA 406PR

Based on relevant topics of the theory paper STA403 & STA404

SEMINAR

Semester 2

Theory Paper STA 407: Reliability & Life Testing

Objectives: To provide the basic concepts of life testing experiments and censoring schemes. To provide knowledge about the different structure of system. To provide knowledge about the reliability of a component and systems.

Course Contents:

Basics of Reliability: Reliability,Hazard function, mean time between failure(mtbf), mean time to failure(mttf). Relation between them. Non parametric method of estimation of reliability, hazard function and probability density function. Exponential life time model and its properties.

Censoring Schemes: Type I and Type II censoring with and without replacement. MLE of reliability and reliabilityparameters for exponential, Rayleigh and Weibull distributions in case of Type I and Type II censoring and their properties.

Inferential problems under censoring: UMVUE of mtbf, hazard rate, reliability under type-I and type-II censoring for exponential life time model. Determination of sample size with minimum cost under type-II censoring with and without replacement of failure units. Estimation of hazard rate of Weibull life time model due to (i) Sinha and Fu, (i) Fisher and (iii) Hotelling.

System reliability: Reliability of Series and Parallel, Reliability of mixed configuration: Series- Parallel and Parallel-Series systems. Reliability of k –out-of-n system. Structure functions of such systems to obtain their reliability. Mtbf and mttf of systems.

Outcomes: Upon satisfactory completion of the course, students become able to (i) conduct life testing experiments under different types of censoring schemes (ii) to analyze the data obtained from life testing experiments (iii) to determine reliability of different configurations like series-parallel, parallel-series, k-out of –n system etc.

Books:

1. Cox, D.R. and Oakes, D. (1984): Analysis of Survival Data, Chapman and Hall, New York.
2. Gross A.J. and Clark, V.A. (1975): Survival Distributions: Reliability Applications in the Biomedical Sciences, John Wiley and Sons.
3. Johnson, E. and Johnson N.L. (1980): Survival models and Data Analysis, John Wiley and Sons.
4. Miller, R.G. (1981) Survival Analysis, Wiley.
5. Barlow, R.E. and Proschan, F. (1975): Statistical Theory of Reliability & Life testing. Holt Rinehart & WinstonInc.
6. Zacks, S. (1991): Introduction to Reliability Analysis, Springer-Verlag.
7. Mann, N.R. Scehafer, R.E. & Singpurwalla N.D. (1974): Methods for Statistical Analysis of Reliability & Life Data, , John Wiley & Sons, N.Y.
8. Srinath, L. S. (2002): Reliability Engineering, 3-ed., EWP Ltd.

9. Sinha, S. K. (1986): Reliability and Life Testing, Wiley Eastern.
10. Lawless, J. F.(1982): Statistical Models and Methods for Life Time Data, John Wily &Sons.
11. Govil, A. K. (1983): Reliability Engineering, Tata McGraw –Hill.

Semester 2

Theory Paper STA408: Distribution Theory

Objectives: The main objective of this course is detail study of contagious distributions, Non-central distributions, distribution of order Statistics, Approximate moments and Confidence Interval, Rank order Statistics and distribution free test.

Course Contents:

Contagious distributions : Poisson –Poisson (Neyman type A), Poisson -Binomial (Neyman type B) and Poisson -Negative binomial distributions with properties & applications.

Non-central sampling distributions, non-central chi-square, t and F distributions with properties & applications. Relation between non-central chi-square, F and t distribution.

Order Statistics: Distributions (joint and marginal) of order statistics from continuous distributions and their properties, Distribution of sample range and sample median, Moments of order Statistics, Approximate moments, Confidence Interval for a sample quantile, joint normality of two sample quantiles.

Rank order Statistics, Correlation between variate values and ranks. Examples of rank statistics such as signed statistic, Wilcoxon signed rank statistic, Wilcoxon two sample statistic etc.

Outcomes: Upon successful completion of this course, students should be able to fit various contagious distributions and Non-central distributions. Students can also identify the applications of order statistics and rank order as well as can decide when and where to apply non-parametric test.

Books:

1. Johnson, N.L. and Kotz, S. (1977): Distributions in Statistics, John Wiley.
2. Jaiswal, M. C. (1973): Statistical Distributions (in Gujarati), University Granth Nirman Board.
3. Rohatagi, V. K. (1984): An Introduction to Probability theory and mathematical Statistics, John Wiley.
4. David, H. A. (1981): Order Statistics, 2nd edition, John Wiley.
5. Gibbons, J.D. and Chakraborti, S. (1992): Non-parametric Statistical Inference, 3rd edition, Marcel Dekker, Inc. New York, Basel, Hong Kong.

Semester 2

Theory Paper STA 409: Mathematical Programming

Objectives: This course aims to create to successfully applying mathematical programming techniques such as revised simplex method, integer programming, fractional programming, goal programming, etc. to all kinds of decision-making problems.

Course Contents:

Revised simplex method. Duality in linear programming – Duality theorem – complementary slackness theorem – Dual simplex method.

Sensitivity analysis in linear programming, parametric linear programming. Game strategy – Two- person –zero sum game problem – conversation of zero-sum game problem into linear programming problem and vice – versa.

Integer programming: Gomory's cutting plane method, Branch and Bound method, zero-one linear programming . Fractional programming. Elements of dynamic programming with simple illustrative examples.

Goal programming: Difference between linear programming and Goal programming approach, Goal programming model formulation, Graphical solution method of goal programming. Modified simplex method of goal programming, alternative simplex method for Goal programming.

Outcomes: Upon completion of this course, the students will be able to identify, formulate and solve problems using fundamental principles of mathematical programming in selected domains. Students will be able to successfully carryout small and medium-range projects considering both the technical and financial perspective.

Books:

1. Hadley, G.S. (1969): Linear Programming, Addison –Wesley Co.
2. Hadley, G.S. (1964): Non- Linear dynamic programming, Addison –Wesley Co.
3. Gass, S.I. (1975): Linear Programming, 4thed, McGraw Hill.
4. Taha, H.A. (1989): O.R.- An Introduction, Mc Millan &Co.
5. Frederick, S. and Lieberman, G., Hiller, J. (1990): Introduction to O.R.5th ed. , Holden- Day.
6. Sharma, J.K. (1988): Operations Research, Tata McGraw Hill.
7. Sharma, S.K. (1989): Operations Research, KedarNath Ram Nath & Co.
8. Kantiswarup, K., Gupta, P.K., Mohan, M. (1985): O.R., Sultan Chand & Sons.
9. Rao, S.S. (1978): Optimization Theory &Applications.
10. Hu, T.C. (1969): Integer Programming and Network Flows.

Semester 2

Theory Paper STA 410 (Elective Paper-I): Computer Programming

Objectives: To get familiar with basic concepts of computer programming like structure of functions, loops, input-output statements etc. To gain ability to develop computer programme. To be familiarized with C^{++} programming.

Course Contents:

Introduction to Computers: Hardware, Software And firmware, Data Representation, Computer peripherals, problem solving Techniques and programming languages, Computer Applications

Introductory Concepts: Algorithm, Programming Logic. Structure of C++ program, Preprocessors, Header files, Data Types: int, Char, float, bool, enumeration. Operations, I/O Statements Control Statements: if, switch, for-loop, do-while, break and continue statements. Arrays: One dimensional and multi-dimensional, array declaration, array initialization, processing with arrays etc. Strings as character array, manipulation of strings

Functions: Introduction, defining function, return statement, types of functions, recursive functions, function overloading, call by value and call by reference, using arrays as function arguments, function having default arguments. File Handling, Pointers: pointer declaration, pointer arithmetic, pointers and functions, pointers and arrays. Scope and lifetime of variables: local, global, static, automatic, external, register. Writing some useful computer programs for Statistical Computing.

Introduction to C#, overview of C# Literals, Variables and Data types, Operators and Expressions, Decision Making and Branching, Decision making and Lopping, Arrays, Strings , Structures and Enumerations, Statistical computing using C#.

Outcomes: Students will be able to (i) prepare programs for problems associated with industrial or statistical methodology (ii) prepare computer programme in C^{++} language.

Books:

1. Decker, R. and Hirshfield, S. (1998): The Object Concept: An Introduction to Computer Programming using C++, PWS Publishing.
2. Lippmann, S.B. and Lajoie, J. (1998): C++, Third Ed. Addition Wesley.
3. Savitch,W.J.(2001): Solving with C++ , The object of Programming Third Ed., Addison Wesley.
4. Rajaraman, V. (1981): Computer Oriented numerical methods, Prentice-Hall, New Delhi.
5. Sastry, S.S. (1987): Introductory methods of numerical analysis, Prentice-Hall.
6. Lafore, R. (2002): Object Oriented Programming with C++ , Sam's Publishing.
7. Hubbard, J. (2000): Programming with C++.
8. Balagurusamy, (2010) : Programming in C# E, Tata McGraw-Hill.
9. Stephens, R: C# 24 -Hour Trainer, 2nd ed., Wiley.

Semester 2

Theory Paper STA 410 (Elective Paper-II): R-Programming

Objectives: To get familiar with basic tools used in R. To get ability to analyse the data using R-package. To get ability to prepare new program in R.

Course Contents:

Introduction to R: Basic data structure, Vectors, matrix, list and data frame, sub setting, input and output.

Functions in R: Describe simple R functions, describe the parts of a function using correct terminology: body, format, arguments, return value.

Control flow and Vectorization: If -statement, For-Loop statement, Convert a For-Loop to While Loop, meaning of vectorization, use of vectorization instead of For-Loop to perform simple mathematical operations.

Programing of statistical problems and data analysis using –R.

Outcomes: As R is free and open-source, students will be able to (i) apply R-package for effective data analysis (ii) create any form of statistics and data manipulation (iii) use R-programming in almost every field like finance, marketing, sports, medical, clinical etc. (iv) create and edit visualizations with R.

Books:

1. Peng, R. D. (2016): R Programming for Data Science, 5th ed. https://leanpub.com/rprogramming
2. John, V. (2004): Using R for Introductory Statistics, Chapman &Hall/CRC.
3. Wickham, H. (2014): Advanced R. Chapman and Hall/CRC.http://catalog.lib.msu.edu/record=b10629576~S39a
4. Dalgaard, P. (2002): Introductory Statistics with R, Springer.
5. Dennis, B. (2013): The R Student Companion, Taylor & Francis Group.
6. Matloff, N. (2011): The Art of R Programming: A Tour of Statistical Software Design, William.
7. Lander, J. P. (2014): R for Everyone: Advanced Analytics and Graphics, Addison-Wesley.

Semester 2

Theory Paper STA 410 (Elective Paper-III): Measure Theory

Objectives: The main objective of this course is to study Algebra of sets, measure as an extension of probability, Outer measure, construction of outer measure from measure, Measurable function, Integral of measurable unction, Lebesgue measure and Lebesgue-Stieltjes measure .

Course Contents:

Continuity property of a measure and continuity theorem on measure. Outer measure, construction of outer measure from measure, Caratheodory theorem on outer measure. Outer measurability of sets, class of measurable sets, Extension theorem (without proof).

Measurable function, algebra of measurable functions, composite measurable function, simple measurable functions. Sequence of measurable functions and measurability of their limit operations.

Concepts of almost everywhere, almost uniform convergence, convergence in measure. Statementof Egorov theorem (without proof). Integral of measurable function with respect to a measure space and properties, indefinite integral, monotone convergencetheorem.

Construction of Lebesgue measure on the real line, complete measure, Lebesgue-Stieltjes measure through distribution function, statement of correspondence theorem (without proof).

Outcomes: Upon successful completion of this course, students should know the difference between probability and measure, field and generated field, Sequences of points and sets, Measure and Outer measure, measurable functions and Sequence of measurable functions Lebesgue measure and Lebesgue-Stieltjes measure.

Books:

1. Halmos, P.R. (1980): Measure Theory, Van Nostrand.
2. Loeve, M. (1963): Probability Theory, Van Nostrand.
3. Kingman, J.F.C. and Taylor, S.J. (1996): Introduction to Measure and Probability, Cambridge University.
4. Basu, A.K. (1999): Measure Theory and Probability. Prentice Hall of India.

PRACTICAL PAPER

STA 411PR

Based on relevant topics of the theory papers STA407 & STA408

STA 412PR

Based on relevant topics of the theory papers STA409 & STA410

PROJECT WORK

Semester 3

Theory Paper STA 501: Testing of Hypotheses

Objectives: To provide sufficient knowledge about (i) the formulation of different types of hypotheses (ii) the different types of tests like MP, UMP, UMPU etc. (iii) the determination of best test.

Course Contents:

Non-randomized and randomized test function. Neyman- Pearson fundamental lemma for randomized test. Size -□and level -□tests. Monotone likelihood ratio property. Uniformly most powerful(UMP) tests, Theorem on UMP tests, Unbiased tests, UMP unbiased tests. Tests for exponential family and Pitman family.

Test with Neyman structure. tests in the presence of nuisance parameter for exponential family and Pitman family. Uniformly most accurate and uniformly most accurate unbiased confidence intervals. Likelihood ratio test(LRT) for simple and composite null hypotheses. Asymptotic distribution of LRT statistic.

SequentialProbability Ratio Test(SPRT) for simple null against simple alternative hypotheses.Bounds of SPRT. OC and ASN functions. Wald's fundamental identity and its use to obtain OC and ASN functions. Applications of SPRT.

Non parametric tests: Kolmogorov-Smirnov test and its comparison with chi-square test of goodness of fit. The Sigel-Tukey test. The Kruskal-Wallies one-way ANOVA test. Friedman's two-way analysis of variance test

Outcomes: Upon satisfactory completion of the course students become able to (i) determine the appropriate hypotheses , tests related to such hypotheses (ii) derive many interesting conclusions from the outcome of the tests (iii) develop the problem of testing of hypothesis for a real data sets from any field.

Books:

1. Lehmann, E.L. (1986): Testing of statistical hypotheses second edition, John Wiley.
2. Mukhopadhyay, N.(2000): Probability and Statistical inference, Marcel Dekker.
3. Rohatgi, V.K. & A.K. Md.E. Saleh (2001): An Introduction to Probability & Statistics, John Wiley 2nd Edition
4. Dudewicz, E. J. and Mishra, S.N. (1988): Modern Mathematical Statistics, John Wiley &Sons.
5. Mukhopadhyay, P.(2006): Mathematical Statistics, 3-ed., Books Allied(P) Ltd.
6. Gibbons, J.D. (1985): Non parametric methods in Statistics second edition, MarcelDekker.
7. Wald, A. (1947): Sequential analysis, Wiley Eastern.
8. Kale, B.K. (1999): A first course on Parametric Inference, Narosa Publishing, New Delhi.
9. Rao, C.R. (1973): Linear Statistical Inference and its application, second edition, Wiley Eastern.

10. Kendall, M.G. and Staurt, A. (1968): The advanced theory of statistics, Vol.II, Charles Griffin and co. London.
11. Puri, M.L. and Sen, P.K. (1971): Introduction to the theory of non-parametric statistics, John Wiley.
12. Radles, D.A.S. and Wolfe (1957): Non parametric methods in statistics John Wiley.
13. Govindarajulu (1957): Sequential statistics procedures, American Science press, Columbus, Ohio.

Semester 3

Theory Paper STA 502: Design of Experiments

Objectives: To provide an understanding of theory of linear estimation to analyze one-way and two-way designs. To provide theory and applications of randomised block designs, latin square designs , balanced incomplete block designs, partially balanced incomplete block designs, factorial designs etc.

Course Contents:

Application of theory of linear estimation to analysis of one -way and two-way designs. Concepts of balancedness, orthogonality and connectedness. Randomized Block and Latin Square designs.

Balanced Incomplete Block Designs (BIBD), symmetrical BIBD, affine resolvable BIBD with properties and analysis. Idea of inter-block recovery of information for BIBD. Youden Square Design.

Partially Balanced Incomplete Block Design (PBIBD) - properties and analysis with intra-block recovery only.Factorial designs - general theory of factorial designs, total and partial confounding, fractional replications with special reference to 2^m& 3^m designs.

Galois field - finite geometries, construction of (i) orthogonal latin squares (ii) Balanced Incomplete Block Designs (iii) Partially Balanced Incomplete Block Designs (iv) totally and partially confounded symmetrical factorial designs.

Outcomes: By completing this course the students will be able to (i) analyze one-way and two-way designs (ii) construct different types of block designs (iii) use block designs in different fields.

Books:

1. Das, M.N. and Giri, N. (1979): Design and analysis of experiments, Wiley Eastern.
2. Chakraborti, M.C. (1962): Mathematics of Design of Experiments.
3. Dey, Aloke (1986): Theory of Block Designs.
4. Raghavrao, D. (1971): Construction and Combinatorial Problems in Designs of Experiments.
5. Kempthorne, O. (1952): The Design and Analysis of Experiments.
6. Federer, W.T. (1955): Experimental Designs.

7. Ogawa, J. (1974): Statistical Theory of the Analysis of Experimental Designs.
8. John, P.W.M. (1971): Statistical Design and Analysis of Experiments.
9. Joshi, D.D. (1987) : Linear Estimation and Design of Experiments.
10. Shah, S.M. and Jaiswal, M.C. (1985): Prayogik Yojanao, (in Gujarati), University GranthNirmanBoard.

Semester 3

Theory Paper STA503: Multivariate Analysis

Objectives: The main objective of this course is to find patterns and relationships between several variables simultaneously. Multivariate Analysis lets us to predict the effect of a change in one variable will have on other variables. Multivariate analysis is a decisive advantage over all other forms of analysis.

Course Contents:

Multivariate normal distribution - definition and properties including marginal and conditional distributions, random samples from multivariate normal distribution, sample mean vector and sample dispersionmatrix.

Multiple and Partial correlation, Canonical correlations and variables - definition & computations. Tests based on total, partial and multiple correlations and Fisher's Z transformation.

Wishart Distribution: Definition and important properties, Derivation of Wishart distribution, Joint distribution of mean vector and co-variance matrix, Results associated with Wishart distribution. Sample generalized variance and its asymptotic distribution.

Tests on mean vectors - Hotelling's T^2 for one & two sample cases. D^2 statistics and their null and non-null distributions. Classification and discriminant between two multivariate normal populations. Probability of misclassification and their estimation. Principle components, dimension reduction, sample principle components.

Outcomes: Upon successful completion of this course, students should know about the multivariate generalized distributions like multivariate normal distribution and Wishart distribution. Students will also be able to apply and identify different multivariate techniques for analyzing the data.

Books:

1. Anderson, T.W. (1983): An Introduction to Multivariate Statistical Analysis; JohnWiley.
2. Johnson and Wichern (1992): Applied Multivariate Statistical Analysis.
3. Khirsagar, A.M. (1972): Multivariate Analysis; Marcel Dekker.
4. Muirhead, R.J. (1982): Abstracts of Multivariate Statistical theory; John Wiley.
5. Seber, G.A.F. (1984): Multivariate Observations : John Wiley.

6. Srivastava and Khatri (1979): An Introduction to Multivariate Statistics : North Holland.
7. Johnson and Wichern (1972): Continuous Multivariate Distribution, John Wiley.
8. Rao C.R. (1973) : Linear Statistical Inference and its applications, Second Edition,Wiley.
9. Mardia, K.V., Kent J.T. and Bibby I.M. (1979): Multivariate Analysis.
10. Srivastava M.S. and Carter E.M. (1983): An Introduction to applied multivariate statistics, North Holland.
11. Morrison D.F. (1979): Multivariate statistical method, second edition, McGraw-Hill.

Semester 3

Theory Paper STA 504: Operations Research

Objectives: This course aims to create to successfully applying operations research techniques to inventory problems, replacement and maintenance problems, network problems, non-linear programming problems and simulation etc. faced in many different areas of research by military, government and industry.

Course Contents:

Inventory Control: Costs associated with inventory, classification of inventory systems. Probabilistic inventory models: instantaneous demand, uniform demand no setup cost models, probabilistic order–level system with constant lead time.

Replacement & Maintenance Problems: Types of Failure, replacement of items whose efficiency deteriorate with time, replacement of items that fail completely. Individual replacement policy, Group replacement policy, Staffing problem, Equipment Renewal problem.

Network Analysis and PERT-CPM: Basic ideas of a network, labelling method, matrix solution method, maximum-flow minimum-cut theorem, multisource and multi-sink problem. Critical path method, PERT network, estimation of times in PERT, Project Time-Cost Trade –off, resource allocation and project appraisal problems with crashing.

Non-linear programming: Lagrange's method- Kuhn-Tucker theory – Graphical and analytical solutions. Quadratic programming – Beal's and Wolfe's algorithm. Separable programming. Simulation: Steps of Simulation Process, Stochastic Simulation and Random numbers. General techniques for simulating continuous random variable, inverse transformation and rejection methods. Simulation of (i)Inventory Problems, (ii)Queuing Problems (iii)Maintenance Problems (iv) PERT problems. Applications of Simulation.

Outcomes: Upon completion of this course, the students will be able to apply above operations research techniques in solving industrial problems and understand the impact in a global and societal context. One cans successfully carryout large-range projects.

Books:

1. KantiSwarup, Gupta, P.K. and Man Mohan (2009): Operations Research, Sultan Chand Sons, New Delhi.
2. Hiller, J. Frederick, S. and Liberman, G. (1995): Introduction to Operations Research (6^{th} Edition) McGraw-Hill Int. Ed.
3. Taha, H.A. (1997): Operations Research (6^{th} Edition) Prentice-Hall India Ltd.
4. Ravindra, A. Philips, D.T., Solberge, J.J. (1987): Operations Research (2^{nd} Edition) John - Wiley.
5. Sharma, J. K. (1988): Mathematical models in Operations Research (Tata McGraw-Hill Co.).
6. Prabhu N. U.(1965): Queues & Inventories. John Wiley & Sons.Inc., New York, London.
7. Naddor, E. (1984): Inventory Control, John Wiley.

PRACTICAL PAPER

STA 505PR

Based on relevant topics of the theory papers STA501 & STA502.

STA 506PR

Based on relevant topics of the theory paper STA503 & STA504.

SEMINAR

Semester 4

Theory Paper STA 507: Time Series Analysis and Applications

Objectives: The main objective of this course is to study time series analysis in depth in addition with Box Jenkins methodology, stationary time series, periodogram analysis and correlogram analysis.

Course Contents:

Time Series Analysis : Determination of trend by variate difference method. Determination of cyclic components. Periodogram analysis.

Auto covariance and auto correlation functions and their properties. Interpretation of software outputs of ACF and PACF functions, Correlogramanalysis.

Stationary time series, Random Walk Model, Unit root Stochastic process, Different test for Stationary, Dickey-Fuller test (DF-test), Phillips-Perron test (PP-test).

Box-Jenkin's models, Introduction to AR, MA, ARIMA models, Detailed study of AR(1) MA (1) and ARMA (1,1) Models. Estimation of ARIMA models and Forecasting. VectorAuto-regression (VAR), Estimation and forecasting with VAR.

Outcomes: Upon successful completion of this course, students should know how to develop mathematical models that provide plausible descriptions for sample data. Students should also comfortable for applying ARIMA as well as VAR model to any time series data in the field of business & economics, agriculture, medical, psychology etc.

Books:

1. Box, G.E.P. and Jenkins, G.M.(1976): Time Series Analysis-Forecasting and control, Holden- day, SanFranciscor.
2. Anderson, T.W. (1971): The Statistical Analysis of Time Series, Wiley, N.Y.
3. Montgomery, D.C. and Johnson L.A.(1977): Forecasting and Time Series Analysis, McGraw Hill.
4. Kendall, S. M and Ord, J.K. (1990): Time Series, 3rd ed., Edward Arnold., Great Britain.
5. Brockwell, P.J. and Davis R.A. Time Series (1991): Theory and methods, Springer-Verlag.
6. Fuller, W.A. (1976): Introduction to Statistical Time Series, John Wiley, N.Y.
7. Granger, C.W.J and Newbold (1984): Forecasting Econometric Time series, Third Edition, Academic Press.
8. Priestly , M.B. (1981): Spectral Analysis & time Series, Griffin, London.
9. Bloomfield, P. (1976): Fourier Analysis of Time Series- An introduction, Wiley.
10. Granger C.W.J and Hatanka, M.(1964): Spectral Analysis of Time Series, Academic Press.
11. Nelson, C.R. (1973): Applied Time Series for Managerial Forecasting Holden-Day.
12. Findley, D.F. (1981): Applied time Series Analysis II Academic Press.
13. Gujarati, Damodar N. (2003): Basic Econometrics, 4th edition, Tata McGraw-Hill
14. Parimal Mukhopadhyay (1999): Applied Statistics, Books and Allied Pvt. Ltd. Calcutta.

Semester 4

Theory Paper STA 508: Regression Analysis

Objectives: To provide an understanding for the students on regression analysis and multiple regression. To provide deep knowledge of different criterion like hetroscadesticity, multicollinearity etc. arrises in general linear model. To provide knowledge to construct an appropriate linear model.

Course Contents:

Multiple Regression Model: Estimation of regression coefficients. Regression analysis of variance. Fitted valuesof residuals. Residual plots as test of departure from assumptions such as fitness of model, normality. Selection of explanatory variables, Mallow C_p statistic. Test

for regression coefficients.

General least square model: Estimation of parameters. Heteroscedasticity and its effect in estimation. Tests for heteroscedasticity. Multi-collinearity, Remedial measures to tackle the problem of multi- collinearity.

Auto-correlation for disturbance terms. consequences of auto-correlation. Durbin-Watson test for first order auto-correlation. Remedial measures to tackle the problem of auto-correlation. Dummy Variables: Salient features of dummy variable method, applications of dummy variables in linear model.

Logistic regression: logit transformation, ML estimation, Wald test, Score test. System of Simultaneous linear equations: Concept of structural and reduced forms. Problem of identification. Rank and order conditions. Methods of estimating parameters: Indirect least square method and two stage least square method.

Outcomes: By completing this course the students will learn to perform the following: (i) how to identify dependent and explanatory variables and develop an appropriate linear model (ii) understand both the meaning and applicability of a dummy variable (iii) be able to perform a multiple regression using computer software.

Books:

1. Draper N. R. and Smith, H. (1998): Applied Regression Analysis, 3-ed.,Wiley.
2. Weisberg, S. (2005): Applied Linear Regression, 3-ed.,Wiley.
3. Montgomery, D. C., Peck, E. A. and Vining, G. G. (2003): Introduction to Linear Regression Analysis, 5-ed,Wiley.
4. Neter, J., Wasserman, W. and Kunter, M. H. (1983): Applied Linear Regression Models, Richard, D. I., Marcel Dekker, Inc.
5. Gujarati, D. N. (2003): Basic Econometrics, 4-ed., McGraw-Hill.
6. Theil H. (1971): Principles of econometrics, John Wiley.
7. Klien L.R.(1962): An Introduction to econometrics. Prentice- Hall of India.
8. Allen R.G.D. (2005): Mathematical Analysis of econometrics, Macmillan.
9. Johnston J. (1984): Econometric methods - 3rd edition. McGraw Hill.
10. Kendall M.G. and Stuart A. (1968): Advanced theory of Statistics - Vol. 3, Charles Griffin & Co. London.
11. Searle S.R. (1971): Linear Statistical models, John Wiley and Sons.
12. Allen, R.G.D. (1973): Mathematical Economics, Macmillan.

Semester 4

Theory Paper STA 509: Industrial Statistics

Objectives: This course aims to create to successfully applying statistical techniques such as Shewhart control chart, cumulative-sum control chart, process capability analysis, design of experiments, chain sampling etc. to many different areas of research for industry.

Course Contents:

Management of quality control: SQC as an aid for management quality planning, quality costs, idea of total quality control approach, concept of Six-Sigma. Cumulative sum control charts (CSCC): Basic principles, derivation of ARL, application of CSCC for mean, standard deviation, fraction defective and number of defects per unit.

Tabular CSCC for mean, variability, standardized tabular CSCC. V-mask scheme. EWMA control chart. Moving average control chart. Comparison of these charts with Shewhart charts.

Process capability analysis: Determining the process capability using $\bar{X}$, R charts. Process capability ratio (PCR). The role of normality in determining defective parts per million. One sided specification, non-normal distributions. Chain sampling plans, continuous sampling plans, Skip-lot sampling plans.

Use of design of experiments in process development and improvement: 2^k -factorial design with $k \geq 1$. 2^{k-p} fractional factorial design. Taguchi's contribution to quality engineering: Elements and principle of quality engineering. Steps in robust design; signal to noise ratio.

Outcomes: Upon completion of this course, the students will be able to apply various statistical methods included in this course to improve the quality of the products used by our society and process improvement in industry.

Books:

1. Montgomery, D.C. (1985): Introduction to Statistical Quality Control, Wiley.
2. Montgomery, D.C. (1985): Design and Analysis of Experiments; Wiley.
3. Rayon, T.P. (1989): Statistical Methods for quality improvement. John Wiley and sons.
4. Ott, E.R. (1975): Process Quality Control ; McGraw Hill.
5. Wetherill, G.B. (1977): Sampling Inspection and Quality Control, Springer.
6. Phadke, M.S. (1989): Quality Engineering through Robust Design; Prentice Hall.
7. Wetherill, G.B. and Brown, D.W. (1991): Statistical Process Control, Theory and Practice; Chapman and Hall

Semester 4

Theory Paper STA 510 (Elective Paper-I): **Bio Assays and Clinical Trials**

Objectives: To introduce students the statistical challenges of clinical comparison of two or more treatments in human subjects. To provide knowledge of clinical trials of parallel or cross-over design, protocol, deciding the sample size, binding and survival analysis.

Course Contents:

Types of biological assays : Direct assays; Ratio estimators, Asymptotic distributions; Fieller's theorem, Regression approaches to estimating dose-response relationships : Logit and Probit approaches. Quantal responses, Methods of estimation of parameters, Estimations of extreme Quantiles, Dose allocation schemes.

Clinical trials : the need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of Phase I-IV trials, multi-center trials. Data management : data definitions, data collection systems for good clinical practice, protocol definition.

Design of clinical trials : parallel vs. cross-over designs, cross-sectional vs. longitude designs, review of factorial designs, objectives and endpoints of clinical trials, design of Phase I trials, design of single-stage and multi-stage Phase II trials, design and monitoring of Phase III trials with sequential stopping, design of bioequivalence trials.

Reporting and analysis : analysis of categorical outcomes from Phase I - III trials, analysis of survival data from clinical trials. Interim analysis method, motivating intent- to-treat analysis, Determining sample size. Surrogate endpoints : selection and design of trials with surrogate endpoints, analysis of surrogate endpoint data.

Outcomes: By completing this course the students will be able to (i) develop general working knowledge of the principles and practice of Bio-assays and clinical trials (ii) apply the concepts of sample size determination to conduct clinical trials (iii) aware of importance of specifying primary outcomes and planned analysis in the protocol (iv) aware of the uses and limitations of the AB|BA cross-over design.

Books:

1. Prem Narayan, Bhatia & Malhotra (1979): Handbook of Statistical Genetics, IASRI, New Delhi.
2. Jain, J.R. (1982): Statistical techniques in quantitative genetics, Tata Mcgraw Hill.
3. Govindarajulu, Z. and Kargar, S. (2000): Statistical Techniques in Bioassay.
4. Finney, D.J (1971): Statistical Method In Bioassay, Griffin.
5. Finney, D.J (1971): Probit Analysis (3rd Edition), Griffin.
6. Weatherile, G.B. (1966): Sequential Methods in Statistics, Griffin.
7. Piantadosi, S. (1977): Clinical: A Methodologic Perspective. Wiley and Sons.

8. Jennison, C. and Turnbull, B.W (1999): Group Sequential Methods with Applications to Clinical Trials, CRC Press.
9. Flesis, J.L (1989): The Design and Analysis of Clinical Experiments. Wileyand Sons.
10. Marubeni, E. and Valsechhi, M.G (1994): Analyzing Survival Data From Clinical Trials and Observational Studies. Wiley and Sons.
11. Friendman,L.M., Furbery, C.D. and Demets, D.L.(1998): " Fundamental of clinical Trials " Springer Publication,3rd ed., Springer.
12. Duolaowang, A. B. (2006): Clinical Trials A Practical Guide to Design, Analysis, and Reporting, Published by Remedica, USA

Semester 4

Theory Paper STA 510 (Elective Paper-II): Actuarial Statistics

Objectives: To provide knowledge to assess the properties of a data set and to model real life data for insurance and finance applications. To provide knowledge to use actuarial statistics techniques and its application in assessing probability models and data.

Course Contents:

Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curate future lifetime, force of mortality.Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate table. Multiple life functions, joint life and last survivor status, insurance and annuity benefit through multiple life functions evaluation for special mortalitylaws.

Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations. Distribution of aggregate claims, compound Poisson distribution and its applications. Distribution of aggregate claims, compound Poisson distribution and its applications. Principles of compound interest : Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding.

Life insurance :Insurance payable at the moment's of the death and at the end of the year of death- level benefit insurance, endowment insurance, differed insurance and varying benefit insurance, recursions, commutation functions. Life annuities : Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities- immediate and apportion able annuities-due.Net Premiums : Continuous and discrete premiums, true monthly payment premiums, apportion able premiums, commutation functions, accumulation type benefits. Payment premiums, apportion able premiums, commutation functions, accumulation type benefits.

Net Premium reserves :Continuous and discrete net premium reserve, reserves on a semi continuous basis, reserves based on true monthly premiums, reserves on and apportion able or discounted continuous basis, reserves at fractional durations, allocations of loss to policy years, recursive formulas and differential equations for reserves, commutation functions.Some practical considerations : Premiums that include expenses-general expenses types of expenses, per policy expenses. Claims amount distributions, approximating the individual model, stop-loss insurance.

Outcomes: By the end of this course students become able to (i) explain the concept of survival models (ii) describe estimation procedures for life time distributions (iii) describe the binomial model of mortality, derive estimator for the probability of death and compare this model with the multiple state models (iii) understand and discuss the ethical dimensions and implications of the modelling introduced in the course.

Books:

1. Bowers,N.L., Gerber, H.U., Hickman, J.C., Hickman, D.A. and Nesbitt, C.J.(1986): Actuarial Mathematics', Society of Actuaries, Itasca, Illinois, U. S.A. 2-ed.
2. Spurgeon E.T. (1972): Life Contingencies, Cambridge University Press.
3. Neill, A. (1977): Life Contingencies, Heinemann.

Semester 4

Theory Paper STA 510 (Elective Paper-III): Environmental Statistics

Objectives: To provide need for studying statistics. Become aware of a wide range of applications of statistics in environmental management. Understand the concept of probability and statistics. Differentiate between descriptive and inferential statistics.

Course Contents:

Basic elements & tools of statistical analysis: Data structure, Basic concepts, Variables measurements types of experiments, Measures of central tendency & deviation. Probability & Distribution, Distribution frequencies & cross-tabulation, Distribution & distribution fitting, Normal t, χ^2, F, Poisson, Binomial & Geometric.

Statistical Models for Pollution: Statistical Models for Pollution air, Water, Soil and waste. Lotka – Voterra Model, Leslie's Matrix Model, Point source Stream Pollution Model, Box model Gaussian plume model.

Statistical Methods: Hypothesis testing, Significance & correlation, Liner models & regressions, Pearson and other correlation coefficients.

Multiple regression, Difference among means, F-test 1 way ANOVA, 2 way ANOVA.

Outcomes: After completing this course students will be able to (i) develop an intuitive statistical sense (ii) analyse model and quantify uncertainty (iii) extract information and draw scientific inference from large amount of data collected to solve environmental problems.

Books:

1. Wayne R.,Ott (1995): Environmental Statistics & Data Analysis, CRC Press.
2. Manly (2001): Statistics for environmental Science and management Chapman and Hall, CRC.
3. Walpole R. and R. Myers (1993): Statistics for Engineers and Scientists 5^{th} ed. Macmillan, N.Y.
4. Zar Jerrold, H. (1998): Bio statistical Analysis Prentice HallN.J

PRACTICAL PAPER

STA 511PR

Based on relevant topics of the theory papers STA507 & STA508.

STA 512PR

Based on relevant topics of the theory paper STA509 & STA510.

PROJECT WORK