Pt. Ravishankar Shukla University Raipur

CURRICULUM & SYLLABI

(Based on CBCS & LOCF)

M.A./M.Sc. Statistics

Semester System

Session: 2024-26

Approved by:	Board of Studies	Academic Council
Date:		

7/9/24

M.Sc. Statistics

The Master of Science in Statistics is a two-year, four-semester program designed to provide students with a comprehensive understanding of advanced statistical tools and techniques with their applications. Through a balanced curriculum covering diverse areas, students establish a strong foundational knowledge during the initial semesters. As the program progresses, students have the flexibility to tailor their learning by choosing specialized electives that align with their interests and career goals. Upon completion of the program, students will be well-prepared for diverse career paths, including academia, research, and technology sectors. With a solid statistical background, they will excel as analytical thinkers and contribute effectively to various fields.

Program Outcomes:

Upon successful completion of the Master of Science in Statistics program, students will be able to:

PO-1	**Knowledge:** Demonstrate a deep understanding of advanced statistical concepts, theories, and techniques in various subfields of Statistics.
PO-2	**Critical Thinking and Reasoning:** Exhibit advanced critical thinking skills by analyzing and evaluating mathematical arguments, theories, and proofs, and by making reasoned judgments about statistical concepts and their implications.
PO-3	**Problem Solving:** Formulate abstract statistical problems and derive solutions using rigorous logical reasoning. Demonstrate mastery in constructing mathematical proofs and justifications.
PO-4	**Advanced Analytical and Computational Skills:** Possess advanced skills in statistical analysis and computation, including proficiency in using statistical software, programming languages, and computational tools for numerical simulations and data analysis.
PO-5	**Effective Communication**: Communicate complex statistical ideas and results effectively to both technical and non-technical audiences, through written reports, presentations, and teaching.
PO-6	**Social/ Interdisciplinary Interaction**: Integrate statistical concepts and techniques into interdisciplinary contexts, collaborating effectively with professionals from other fields to address complex problems.
PO-7	**Self-directed and Life-long Learning**: Recognize the importance of ongoing professional development and lifelong learning in the rapidly evolving field of mathematics, and will exhibit the ability to continue learning independently or in formal educational settings.
PO-8	**Effective Citizenship**: **Leadership and Innovation:** Lead and innovate in various statistical contexts, contributing to advancements in the field and applying statistical insights to emerging challenges.
PO-9	**Ethics**: Demonstrate ethical and responsible conduct in statistical research, teaching, and collaboration, adhering to professional standards and best practices.
PO-10	**Further Education or Employment:** Engage for further academic pursuits, including Ph.D. programs in statistics or related fields. Get employment in academia, research institutions, industry, government, and other sectors.
PO-11	**Global Perspective**: Recognize the global nature of statistical research and its impact, appreciating diverse cultural perspectives in statistical practices.

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PROGRAMME SPECIFIC OUTCOMES (PSOs) : At the end of the program, the student will be able to:

PSO1	Understand the nature of abstract statistics and explore the concepts in further details.
PSO2	Apply the knowledge of statistical concepts in interdisciplinary fields and draw the inferences by finding appropriate solutions.
PSO3	Pursue research in challenging areas of statistics.
PSO4	Employ confidently the knowledge of statistical software and tools for treating the complex statistical problems and scientific investigations.
PSO5	Qualify national level tests like NET/GATE etc.

M.Sc. Statistics

PROGRAMME STRUCTURE

Semester	Course Nature	Course Code	Course Title	Course Type (T/P)	Hrs/ Week	Credits	Marks		
							CIA	ESE	Total
Semester-I	Core	SAT 110	Real Analysis and Linear Algebra	T	5	5	30	70	100
	Core	SAT 120	Statistical Methods	T	5	5	30	70	100
	Core	SAT 130	Probability and Measure	T	5	5	30	70	100
	Core	SAT 140	Applied Statistics	T	5	5	30	70	100
	Core	SAT 150	Lab Course I: Practical based on Course II	P	4	2	30	70	100
	Core	SAT 160	Lab Course II: Practical based on Courses III & IV	P	4	2	30	70	100
Semester-II	Core	SAT 210	Biostatistics	T	5	5	30	70	100
	Core	SAT 220	Statistical Computing	T	5	5	30	70	100
	Core	SAT 230	Stochastic Processes	T	5	5	30	70	100
	Core	SAT 240	Sampling Theory	T	5	5	30	70	100
	Core	SAT 250	Lab Course I: Practical based on Course II	P	4	2	30	70	100
	Core	SAT 260	Lab Course II: Practical based on Courses III & IV	P	4	2	30	70	100
	Core	SAT 270	Internship	P	*	2	30	70	100
Semester-III	Core	SAT310	Inference-I	T	5	5	30	70	100
	Core	SAT320	Design of Experiments	T	5	5	30	70	100
	Elective-1 (Select any one)	SAT331	Operations Research (I)	T	5	5	30	70	100
		SAT332	Demography						
	Elective-2 (Select any one)	SAT341	Statistical Quality Control	T	5	5	30	70	100
		SAT342	Survival Analysis						
	Core	SAT350	Lab Course I: Practical based on Course I & II	P	4	2	30	70	100
	Core	SAT360	Lab Course I: Practical based on Course III & IV	P	4	2	30	70	100
Semester-IV	Core	SAT410	Inference-II	T	5	5	30	70	100
	Core	SAT420	Multivariate Analysis	T	5	5	30	70	100
	Elective-3 (Select any one)	SAT431	Advance Operation Research	T	5	5	30	70	100
		SAT432	Econometrics						
	Elective-4 (Select any one)	SAT441	Reliability Theory	T	5	5	30	70	100
		SAT442	Actuarial Statistics						
	Core	SAT450	Lab Course I: Practical based on Course I & II	P	4	2	30	70	100
	Core	SAT460	Lab Course I: Practical based on Course III & IV	P	4	2	30	70	100
	Core	SAT 470	Project Work	P	4	2	30	70	100

Note: * Total 60 hours during summer vacation.

1. In place of Elective Course Student can choose paper(s) from MOOC Courses (Swayam Portal) subject to the following conditions:
   a. The chosen paper will be other than the papers offered in the current course structure.
   b. The paper will be PG level with a minimum of 12 weeks' duration.
   c. The list of courses on SWAYAM keeps changing, the departmental committee will finalize the list of MOOC courses for each semester.
   d. The paper(s) may be chosen from Swayam Portal on the recommendation of Head of the Department.
2. The candidates who have joined the PG Programme in School of Studies (University Teaching Department), shall undergo Generic Elective Courses (only qualifying in nature) offered by other departments/SoS in Semester II and Semester III.
3. The candidates who have joined the PG Programme in School of Studies (University Teaching Department), shall undergo Skill Enhancement Course/Value Added Course (only qualifying in nature) in Semester I and Semester II.

Generic Elective Courses: (Offered to PG students of other Departments/SoS only)

Semester	Course Code	Course Title	Course Type (T/P)	Hrs/ Week	Credits	Marks		
						CIA	ESE	Total
II	SAT 520	Statistical Methods	T	3	3	30	70	100
III	SAT 530	Applied Statistics	T	3	3	30	70	100

Skill Enhancement/Value Added Courses:(Offered to the PG students of SoS in Statistics)

Semester	Course Code	Course Title	Course Type (T/P)	Hrs/ Week	Credits	Marks		
						CIA	ESE	Total
I	SAT 610	Indian Knowledge System (IKS)	P	2	2	30	70	100
III	SAT 630	Programming in Python	P	2	2	30	70	100

M.Sc. STATISTICS Program

Specification of Course	Semester	No. of Courses	Credits
Core	I-IV	22	80
Elective	III-IV	04	20
Total		26	100
Additional Courses(Qualifying in nature, for Student admitted in School of Studies only)			
Generic Elective	II-III	02	06
Skill Enhancement (Value Added Courses)	III	01	02
Indian Knowledge System (IKS)	I	01	02

FIRST SEMESTER

Paper I: Real Analysis and Linear Algebra

Paper II: Statistical Methods

Paper III: Probability and Measure

Paper IV: Applied Statistics

Paper V: Lab Course I: Practical Based on Papers I &II

Paper VI: Lab Course II: Practical Based on Papers III & IV

Paper–I

Real Analysis and Linear Algebra

Learning Outcome: Techniques of Linear Algebra are useful in various statistics coerces are covered in this course. After learning this course, the student will be well equipped to apply these techniques inn many major Statistics courses like Linear Inference, Multivariate Analysis and Operations Research etc.

UNIT-I

Recap of elements of set theory; Introduction to real numbers, Introduction to n-dimensional Euclidian space; open and closed intervals (rectangles), compact sets, Bolzano - Weirstrass theorem, Heine - Borel theorem.

UNIT-II

Sequences and series and their convergence, Real valued function, Properties of real valued continuous function on R^n , Uniform continuity, Sequences and series of functions, Uniform convergence, Power series and radius of convergence.

UNIT-III

Fields, vector spaces, subspaces, linear dependence and independence, basis and dimension of a vector space, finite dimensional vector spaces, completion theorem, examples of vector spaces over real and complex fields, linear equations, Determinants.

UNIT-IV

Vector spaces with an inner product, Gram-Schmidt orthogonalization process, orthonormal basis and orthogonal projection of a vector. Kronecker product. Linear transformations, algebra of matrices, row and column spaces of a matrix.

UNIT-V

elementary matrices, rank and inverse of a matrix, null space and nullity, partitioned matrices, Hermit canonical form, generalized inverse, Moore-Penrose generalized inverse, Idempotent matrices, Solutions of matrix equations. Real quadratic forms, reduction and classification of quadratic forms.

REFERENCES

1. Apostol, T.M. (1985). Mathematical Analysis, Narosa, Indian Ed.
2. Courant, R. and John, F. (1965). Introduction to Calculus and Analysis, Wiley.
3. Rudin, Walter (1976). Principles of Mathematical Analysis, McGraw Hill.
4. Shanti Narayan: A course of mathematical analysis. S. Chand & Co. Ltd.
5. Graybill, F.A.(1983). Matrices with applications in statistics, 2nd Ed. Wadsworth.

6. Rao, C.R.(1973). Linear statistical inference and its applications, 2nd ed. John Wiley and Sons, Inc.
7. Searle, S.R. (1982). Matrix Algebra useful for Statistics. John Wiley and Sons. Inc.
8. Shanti Narayan: Matrices
9. Vashishtha, A. R.: Matrices

Paper –II
Statistical Methods

Learning Outcome: This course is useful for the students conversant with various techniques used inn summarization and analysis of data. The focus will be both on theoretical as well as practical aspects. This is highly useful in research methodology and case study. The course is job oriented.

UNIT-I

Diagrammatic and representation of data, Frequency distribution, measures of location, dispersion and skewness, Moments and cumulats, moment generating function.

UNIT-II

Simple correlation coefficient, Multiple and Partial Correlation. Linear and Multiple Regression, and their application, Intra class correlation, Correlation ratio.

Definition of probability, Additive and multiplicative theorems of probability, Bayes' theorem, Basic distribution function probability mass function, probability density function, joint, marginal and conditional p.m.f.. Random Variables and its mathematical expectations, conditional Expectation, Expectation of sum and multiplication of random variables.

UNIT-III

Standard Discrete Distributions- Bernoulli, Binomial, Poisson, Geometric, Hyper geometric and Multinomial distribution. Limiting form of Binomial and Poisson distributions.

UNIT-IV

Standard continuous distributions-Uniform, Exponential, Normal Beta, Gamma and Cauchy distributions. Order Statistics-their distributions and properties. Joint & Marginal distributions of Order-Statistics.

UNIT-V

Statistical hypotheses, Type I and II errors, level of significance, test of significance, concept of p-value. Tests of significance for the parameters of normal distribution (one sample and two sample problems) and the relevant confidence intervals. Chi-square test of goodness of fit and independence of attributes. Test of significance for correlation coefficient ($\rho=0$, $\rho=\rho_0$)

REFERENCES

1. Dudewicz, E.J. and Mishra, S.N.(1988) : Modern Mathematical Statistics, Wiley, Int'l Student's Edition.
2. Rohatgi, V.K. (1984) : An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.
3. Rao, C.R. (1973) : Linear Statistical Inference and its Applications, 2/e, Wiley Eastern.
4. Weather ,Burn,C.E. : A first Course in Mathematical Statistics.
5. Keany,J.F. and Keeping,E.S. : Mathematics of Statistics Pt. I and II
6. Kendall,M.G. and stuart A : Advanced Theory of Statistics.
7. Mood ,gybrill and Boes : Introduction to theory of Statistics
8. Hogs and Craig : Mathematical Statistics
9. Goon,gupta and Dasgupta : Fundamental of Mathematical statistics Vol.I

Paper –III
PROBABILITY AND MEASURE

Learning Outcome: The course will Lay the foundation to probability theory and statistical modeling of outcomes of real life random experiments through various statistical distributions.

UNIT-I

Random experiment, Axiomatic definition of probability, Classes of sets, fields, sigma-fields, minimal sigma-field, Borel sigma-field in R_k, sequence of sets, limsup and liminf of a sequence of sets. Measure, Probability measure, properties of a measure.

UNIT-II

Lebesgue and Lebesgue- Steljes measure on R_k, Measurable set, Measurable functions, Random variables, sequence of random variables, almost sure convergence, convergence in probability (and in measure).

UNIT-III

Convergence in r^{th} mean Integration of a measurable function with respect to a measure Convergence in distribution, Convergence in R Monotone convergence theorem, Fatou's lemma, Dominated convergence theorem, Borel-Cantelli Lemma, Independence,.

UNIT –IV

Weak law and strong law of large numbers for iid sequences, Definition and examples of Markov dependence, Chebychev's Inequality, Probability generating function with examples. Markov, Holder-Jenson and Liapunov inequality.

UNIT -V

Characteristic function and its properties uniqueness theorem, Levy's continuity theorem (statement only), CLT for a sequence of independent random variables under Lindeberg's condition, CLT for iid random variables. Problems based on CLT.

REFERENCES

1. Ash, Robert.(1972): Real Analysis and Probability. Academic Press.
2. Billingsley, P.(1986): Probability and Measure. Wiley.
3. Dudley, R. M. (1989): Real Analysis and Probability, Wadsworth and Brooks/Cole.
4. Kingman, J F C and Taylor, S.J. (1966). Introduction to Measure and Probability. Cambridge University Press.
5. B.R. Bhat: Probability Theory.

Paper –IV
APPLIED STATISTICS

Learning Outcome: This course is highly practical and useful in daily life for the study of hike in prices and population growth. Employers use these techniques for payment of salaries of their employees.

UNIT-I

Sources of demographic data –census, register, adhoc survey, hospital records, measurement of mortality ,crude death rate, age specific death rates, standardized death rate infant mortality rates, Complete and abridged life table-Kings method, Greville's method and method of Reed and Merrel, Construction of life table.

UNIT-II

Laws of mortality-Fitting of Makeham's law, Measurement of fertility-crude birth rate, general fertility rate, age-specific birth rate, total fertility rate, gross and net reproduction rate. The Stable and Stationary populations, Logistic curve for population growth, Population Projection.

UNIT -III

Different Component of time series, Measurement of secular trend: Fitting of mathematical curves, method of moving average, variate difference method, effect of elimination of trend ,merits and demerits of different methods of trend estimation. seasonal components, Determination of cyclical component.

UNIT -IV

Index number :meaning and construction of index number, Laspeyres, Paasche's, Edgeworth and Marshal and Fisher's ideal index numbers, tests of consistency of index number formulae, Time and Factor reversal tests, Chain base index numbers, Cost of living index numbers, Whole sale price index numbers.

UNIT-V

Periodogram analysis, Yule-Slutsky effect, Correlogram Analysis, Demand Analysis: Demand and supply curves, Price elasticity of demand and supply, determination of demand curves from market data, Engel' Law and Engle's Curve.

REFERENCES

1. O. S. Srivastava (1983) – A text book of demography ,Vikas Publishing House.
2. Parimal Mukhopadhaya (1999) – Applied Statistics, Books and Allied (P) Ltd.
3. V. K. Kapoor and S. C. Gupta: Applied Statistics, Sultan Chand and Sons.

Paper V : Lab Course I – Practical Based on Paper I & II

Paper VI : Lab Course II – Practical Based on Paper III & IV

SECOND SEMESTER

Paper – I : **Biostatistics**
Paper - II : **Statistical Computing**
Paper - III : **Stochastic Processes**
Paper - IV : **Sampling Theory**
Paper-V: **Lab Course - I: Practical based on Papers I and II**
Paper-VI: **Lab Course -II : Practical based on Papers III &IV**
Paper- VII : **Choice Based Credit System (Minor Elective from other Subject)**

Paper -I

Biostatistics

Learning Outcome: The course is useful for the study of various statistical tools and techniques in Biological data related to medical statistics. Effectively apply these tools on solving the biological problems occurring in real life.

UNIT-I

Clinical Trials, Introduction to Biostatistics, Ethics -,Measures of disease frequency and disease burden. Clinical Trials - Goals of Clinical Trials, Phases of Clinical Trials , Classification of Clinical Trials - Randomization: Fixed Allocation, Simple, Blocked, Stratified, Baseline Adaptive and Response Adaptive - Blinding: Single, Double and Triple.

UNIT-II

Multiple Regression and Logistic Regression, Multiple Regression– Assumptions, uses, Estimation and interpretation of coefficients, Testing the regression coefficients, Coefficient of determination, Testing model adequacy. Logistic regression: Introduction, Logistic regression model.

UNIT-III

relative risk – logic , Odds ratio – properties of odds ratio , the relationship between the odds ratio and relative risk , Maximum Likelihood estimates and interpretation of coefficients , Test for coefficients , Test of overall regression and goodness of fit using Maximum Likelihood technique , Deviance statistics, Wald test, LR test and score test.

UNIT-IV

Types of Cox Regression Models- graphical approach, log-log plots , Observed versus expected plots, time-dependent covariates ,Stratified Cox Procedure- hazard function, Extension of the Cox PH model - hazard ratio formula, extended Cox likelihood - An overview of Proportional odds model.

UNIT – V

Use of Level of significance, degree of freedom, p value in terms of Biostatistics. Assumptions and applications of non-parametric tests-Chi-square test, Sign test, Run test, Median test, Wilcoxon-Rank Sum test, Mann Whitney U test, Kruskal Walis Test and Kruskal Walis Test.

REFERENCES

1. Chow, S. C., and Liu, J. P. (2004). Design and Analysis of Clinical Trials: Concepts and Methodologies, Second Edition, Wiley – Interscience, John Wiley & Sons, NJ.

2. Friedman, l. M., Furberg, C. D., and DeMets, D. L. (2010), Fundamentals of Clinical Trials, Fourth edition, Springer – Verlag, NY.
3. Van Belle, G., Fisher, L. D., Heagerty, P. J., and Lumley, T. (2004). Bio-Statistics - A Methodology for the Health Science, Second Edition, Wiley, NY.
4. Daniel, W. W. and Chad L. Cross(2018). Bio-Statistics: A foundation for analysis in the Health Sciences, Eleventh Edition, John Wiley & Sons, NY.
5. Kleinbaum, D. G., and Klein, M. (2012): Logistic regression: A Self-Learning Text, Third Edition, Springer – Verlag, NY.
6. Kleinbaum, D. G., and Klein, M. (2012): Survival Analysis: A Self-Learning Text, Third Edition, Springer – Verlag, NY.

Paper – II

Statistical Computing

Learning Outcome: This is job oriented course and useful in the computation of statistical constants.

UNIT -I

Numerical Analysis: Finite differences & interpolation, Interpolation with unequal intervals, Central differences Interpolation-Gauss's, Stirling's and Bessel's Formulae.

UNIT -II

Numerical differentiation and integration, Trapezoidal rule, Simpson's one third, 3/8 rule, Weddle's rule, Euler-Maclaurin Summation Formula, Newton-Cotes Formula, Gauss formula for approximation to factorials, Difference equation of first and second order.

UNIT -III

Overview of R, R data types and objects (vector, matrix, data frame, list, array, factor, time series), reading and writing data (both from console and external files) and different types of indexes in R.

UNIT –IV

Calling external programs in R and linking to data bases. Data visualization using R (both two and three dimensions). Statistical Computing and mathematical computing based on descriptive statistics.

UNIT-V

multivariate data representation, simple hypothesis test, analysis of variance, numerical integration, root extraction, matrix computations, etc .

REFERENCES

1. W.H. Press, S.A. Teukolsky, W.T. Vellering, and B.P. Flannery (1993). Numerical Recipes in C, Second Edition. Cambridge University Press.
2. R.A. Thisted (1988). Elements of Statistical Computing. Champman and Hall.
3. Rajaraman,V.: Computer Oriented Numerical Methods.
4. Grewal, B. S.: Numerical methods.
5. Saxena, H. C.: Finite differences.
6. Sandeep Rakshit(2017): R Programming for beginners, Mc Graw Hill Publication.
7. Michael J. Crawley (2017): The R Book, Willey Publication.

8. John Chambers, Software for data analysis: Programming with R, Springer, 2008.
9. Phil Spector, Data manipulation with R, Springer, 2008.

Paper - III

Stochastic Processes

Learning Outcome: This course reveals probabilistic approach of various phenomenon like random events happening in real world.

UNIT -I

Introduction to stochastic processes (sp's).; classification of sp's according to state space and time domain. Countable state Markov chains (MC's), Chapman-Kolmogorov equations; calculation of n-step transition probability and its limit. Stationary distribution, Classification of states; transient MC;

UNIT -II

Probability generating function, Properties of probability generating function .Laplace transform & its properties, Random walk and Gambler's ruin problem; with applications, Renewal theory: Elementary renewal theorem and applications.

UNIT -III

Statement and uses of key renewal theorem; study of residual life time process. Martingle in discrete time, inequality, convergence and smoothing properties, Discrete state space continuous time MC ; Kolmogorov- Feller differential equations,

UNIT –IV

Poisson process, birth and death process ; Applications to queues and storage problems. Wiener process as a limit of random walk; first - passage time and other problems. Stationary process: weakly stationary and strongly stationary processes.

UNIT- V

Moving average and auto regressive processes. Branching process: Galton-Watson branching process, probability of ultimate extinction, distribution of population size. Statistical inference in MC and Markov processes.

REFERENCES

1. Adke, S.R. and Manjunath, S.M. (1984): An Introduction to Finite Markov Processes, Wiley
Eastern.
2. Bhat, B.R. (2000): Stochastic Models: Analysis and Applications, New Age International, India.
3. Cinlar, E. (1975): Introduction to Stochastic Processes, Prentice Hall.
4. Feller, W. (1968): Introduction to Probability and its Applications, Vol.1, Wiley Eastern.
5. Harris, T.E. (1963): The Theory of Branching Processes, Springur-Verlag.
6. Hoel, P.G., Port, S.C. and Stone, C.J. (1972): Introduction to Stochastic Processes, Houghton
Miffin & Co.
7. Jagers, P. (1974): Branching Processes with Biological Applications, Wiley.
8. Karlin, S. and Taylor, H. M. (1975): A first Course in Stochastic Processes, Vol.1, Academic Press.
9. Medhi, J. (1982): Stochastic Processes, Wiley Eastern10. Parzen, E.(1962): Stochastic Processes, Holden-Day.

Paper - IV
Sampling Theory

Learning Outcome: The course is practical and useful in competitive examinations. It gives the techniques to understand the trend of whole population on the basis of a sample.

UNIT-I

Sample Surveys : concept of population sample and properties of estimator for finite populations, need for sampling, census and sample survey, sample selection and sample size, Basic finite population sampling techniques ,simple random sampling with and without replacement.

UNIT-II

Stratified sampling, systematic sampling and related results on estimation of population mean/total. Allocation problem in stratified sampling. Optimum allocation, Neyman allocation and Proportional allocation, Estimation of gain in precision due to stratification, Post Stratification, Construction of strata, Effect of increasing number of strata. Systematic sampling. Comparison of stratified, systematic and simple random sampling.

UNIT-III

Systematic sampling under a linear model. Ratio regression estimators based on srswor and stratified methods of sampling. Bias of ratio estimate and optimum property of ratio estimate, Regression estimate with pre-assigned and with estimated regression coefficient, product method of estimation, comparison of ratio, regression and product estimate with sample mean.

UNIT-IV

Unequal probability sampling: pps wr/wor methods [including Lahiri's scheme] and related estimators of a finite population mean [Desraj estimator and Murthy's estimator]. Estimation of population proportion, Non-sampling errors, estimation of population mean in presence of non-response,

UNIT - V

Cluster sampling. One stage cluster sampling, variance and cost functions, sampling with probability proportional to cluster size, Hurwitz-Thompson estimator , two stage cluster sampling ,Allocation of sample to two stages :equal first stage unit comparison of two stage with one stage sampling.

REFERENCES

1. Cochran, W.G. : Sampling Techniques [3rd Edition, 1977). Wiley
2. Des Raj and Chandak (1998) : Sampling Theory. Narosa
3. Murthy, M.N. (1977). Sampling Theory & Methods. Statistical Publishing Society, Calcutta.
4. Sukhatme et al (1992). Sampling Theory of Surveys with Applications. lowa State University Press & IARS.
5. Singh, D. and Chaudhary, F.S. (1986). Theory and Analysis of Sample Survey Designs. New Age International Publishers.

Paper V: Lab Course I – Practical Based on Paper I and III

Paper VI: Lab Course II – Practical Based on Paper IV

Paper VII: Choice Based Credit System (Minor Elective from other Subject)

Internship (Total 60 hours during summer vacation)

THIRD SEMESTER

Paper – I	:	Inference -I
Paper – II	:	Design of Experiments
Paper – III	:	Elective –I (Select any one)
		(a) Operations Research –I
		(b)Demography
Paper– IV	:	Elective –II (Select any one)
		(a) Statistical Quality Control
		(b) Bayesian Inference
Paper-V	:	Lab Course - I
		Practical based on Papers I and II
Paper-VI	:	Lab Course – II
		Practical based on Papers III and IV
Paper- VII	:	Choice Based Credit System (Minor Elective from other Subject)

Paper - I

INFERENCE- I

Learning Outcome: The objective of the course is to provide a systematic account of drawing conclusions about a population which can be infinite in size. It gives various methods of estimating parameters of a population.

UNIT- I

Theory of Point estimation, properties of a good estimator, Unbiasedness , Consistency, efficiency and sufficiency, Cramer -Rao inequality and its extension, Bhattacharya bounds, Fisher –Neyman factorization theorem. Completeness, Rao-Blackwell theorem and Lehmann Scheffe theorem.

UNIT –II

UMVUE, Concept of Minimal sufficient statistics, Likelihood function, examples from standard discrete and continuous distributions. such as Bernoulli, Binomial, Poisson, normal, exponential gamma etc) Methods of estimation – Method of maximum likelihood estimators, properties of maximum likelihood estimators.

UNIT - III

Method of scoring, method of moments, method of minimum chi-square, method of minimum variance, B.A.N. estimators. CAN estimators, invariant estimator. Concepts of critical regions, Test functions; two kinds of errors. Size function, power function, level of significance.

UNIT -IV

M. P. and UM.P Test, Neymann Pearson Lemma, M.P. test for simple null against simple alternative hypothesis, randomized and non-randomised tests, Confidence interval and confidence coefficients, Theory of confidence set, Relationship with the theory of hypothesis testing, Confidence interval for large samples.

UNIT - V

Loss function, Risk function, Admissibility, Minimax rule, Bays rule, Structure of Bayes rule, Construction of a Minimax rule, prior and posterior distributions, important class of priors such as non-informative and conjugate priors, point and interval estimation as decision problem.

REFERENCES:

1. Kendall M.G. and Stuart A.(1972) : Advanced Theory of Statistics, Vol. 2, Charles Griffin and Co., New York.
2. Rohatgi V.K. (1988): An Introduction to Probability and Mathematical Statistics. Wiley Eastern Ltd. New.Delhi (Student Edition)
3. Lehmann, E.L.(1986): Testing Statistical hypotheses (Student Edition).
5. Rao, C. R. (1973): Linear Statistical Inference.
6. Zacks, S. (1971): Theory of Statistical Inference, John Wiley and Sons, New York.
7. Dudewicz, E.J. and Mishra, S.N. (1988). Modern Mathematical Statistics. Wiley Series in Prob. Math. Stat., John Wiley and Sons, New York (International Student Edition)
8. Ferguson, T.S. (1996). A course on Large Sample Theory. Chapman and Hall, London.

Paper – II

Design of Experiments

Learning Outcome: This course is useful for comparing various methods of tool / technique used in a particular situation of comparison. It is highly useful in Agriculture and Pharmaceutical Industries.

UNIT –I

Gauss- Markov set-up, Estimability condition, best point estimates/interval estimates of estimable linear parametric functions ,Normal equations and Least squares estimates, Gauss-Markov Theorem, Introduction to fixed, mixed and random effects linear models. Analysis of variance for one way and two way classified data with equal and unequal number of observations per cells,

UNIT -II

Introduction to design of experiments, Principle of design of experiments, completely randomized design, Randomized block design, Latin square design. Missing plot technique - general theory and applications, efficiency of a design. Analysis of covariance model.

UNIT -III

Graeco Latin Square design, Cross-over designs, Analysis of covariance: Applications to standard designs with one concomitant variable, Split plot and split block experiments, efficiency of whole plot and sub plot treatments, merits and demerits of split plot experiments.

UNIT -IV

General factorial experiments, factorial effects; best estimates and testing the significance of factorial effects ; study of 2 and 3 factorial experiments in randomized blocks ; complete and partial confounding. Fractional replication for symmetric factorials, 2^n experiment with 2^k blocks per replicate, 3^2 experiment.

UNIT - V

General block design and its information matrix. criteria for connectedness, balance and orthogonality, BIBD- Analysis with intrablock information and recovery of interlock information ; PBIBD, Youden design - intrablock analysis.
Application areas: Response surface experiments; first order designs and orthogonal designs.

REFERENCES

1. Aloke Dey (1986) :Theory of Block Designs, Wiley Eastern.
2. Angela Dean and Daniel Voss (1999) : Design and Analysis of Experiments, Springer.
3. Das, M.N. and Giri, N.(1979) : Design and Analysis of Experiments, Wiley Eastern
4. Giri, N. (1986) : Analysis of Variance, South Asian Publishers
5. John, P.W.M. (1971) : Statistical Design and Analysis of Experiments, Macmillan.
6. Joshi, D.D. (1987) : Linear Estimation and Design of Experiments, Wiley eastern.
7. Montgromery, C.D.(1976): Design and Analysis of Experiments; Wiley, New York.
8. Pearce, S.C. (1984): Design of Experiments, Wiley, New York.

Elective – I (Select any one)

Paper - III (a)
Operations Research

Learning Outcome: Operations Research deals with the application of scientific methods and techniques to decision-making problems. A decision-making problem occurs where there are two or more alternative courses of action, each of which leads to a different and sometimes unknown end result. Operations research is also used to maximize the utility of limited resources. The objective is to select the best alternative, that is, the one leading to the best result. It has applications in the management and administration of military, government, commercial, and industrial systems. It also helps in resource allocation and replacement, inventory control and scheduling of large-scale construction projects.

UNIT-I

Definition and scope of Operational research ; phases in Operations Research ; models and their solutions ; decision-making under uncertainty and risk, use of different criteria ; The structure and formation of a linear programming problem, Graphical and simplex procedure, Two phase methods, and charne's-M method with artificial variables ; duality theorem .

UNIT -II

Transportation and Assignment problems, Routing and traveling salesman problem .

UNIT -III

Inventory problems – Deterministic models of inventory , Economic Lot size formula, instantaneous production case, finite production rates situation ,cases when shortages are allowed /not allowed. Stochastic inventory models – a single period model with no set up cost.

UNIT -IV

Basic characterics of queuing systems, Steady-state solutions of M/M/1 and M/M/c models with associated distributions of queue-length and waiting time. M/G/1 queue and Pollazcek Khinchine result. Steady-state solutions of M/Ek/1 and E_k/M/1 queues, Machine interference problem. Transient solution of M/M/1 queue.

UNIT -V

Decision-making in the face of competition, two-person games, pure and mixed strategies, existence of solution and uniqueness of value in zero-sum games, finding solutions in 2x2, 2xm and mxn games. Non-zero sum games, co-operative and competitive games, equilibrium solutions and their existence in bi-matrix games. Nash equilibrium solution. ;

REFERENCES

1. Taha H.A. (1982) Operational Research : An Introduction ; Macmillan.
2. Hillier F.S. and Leiberman G.J. (1962) Introduction to Operations Research ; Holden Day.
3. Kanti Swarup, Gupta, P.K. and Singh M.M. (1985) Operations Research ; Sultan Chand& Sons.
4. Philips D.T., Ravindran A. and Solberg J. Operations Research, Principles and Practice.

5. Churchman C.W., Ackoff R.L. and Arnoff E.L.(1957) Introduction to Operations Research ; John Wiley.
6. Kleinrock L. (1975) Queueing Systems, vol. 1, Theory ; John Wiley
7. Saaty T. L. (1961) Elements of Queueing Theory with Applications ; McGraw Hill
10. Hadley G.and Whiting T.M. (1963) Analysis of Inventory Systems ; Prentice Hall
11. Starr M.K. and Miller D.W. (1962) Inventory Control-Theory and Practice ; Prentice Hall
12 . Mckinsey J.C.C. (1952) Introduction to the Theory of Games ; McGraw Hill
13. Wagner H.M. (1973) Principles of O.R. with Applications to Managerial Decisions ; Prentice Hall
14. Gross, D. and Harris, C. M. (1974): Fundamentals of Queueing Theory; John Wiley

Paper – III (b)
DEMOGRAPHY (Major Elective)

Learning Outcome: The course is useful in understanding of demographic phenomenon of a particular geographical area encountering the events like fertility, mortality, marriage, migration and social mobility. Government employees like Indian statistical service and non government organisions use techniques. It is a job oriented course.

UNIT – I

Coverage and content errors in demographic data, Chandrasekharan-Deming formula to check completeness of registration data, adjustment of age data-use of Whipple, Myer and UN indices.

UNIT – II

Population transition theory Measures of fertility; Stochastic models for reproduction, distributions of time of birth, inter-live birth intervals and of number of births (for both homogeneous and homogeneous group of women).

UNIT - III

estimation of parameters; estimation of parity progression from open birth interval data. Measures of Mortality; construction of abridged life tables, infant mortality rate and its adjustments, model life table..

UNIT – IV

Stable and quasi-stable populations, intrinsic growth rate. Models of population growth and their filling to population data.

UNIT – V

Internal migration and its measurement, migration models, concept of international migration. Methods for population projection, component method of population projection, Nuptiality and its measurements.

REFERNCES:

1. Kumar, R.(1986): Technical Demography, Wiley Eastern Lts.
2. Benjamin, B.(1969): Demographic Analysis, George, Allen and Unwin.
3. Chiang, C.L.(1968): Introduction to Stochastic Progression.
4. Cox, P.R. (1970): Demography, Cambridge University Press.
5. Keyfitz, N. (1977): Introduction to the Mathematics of Population-with Revision, Addison-Wesley, London.
6. Spiegelman, M.(1969): Introduction to Demographic Analysis, Harvard University Press.
7. Wolfenden, H.H.(1954): Population Statistics and Their Compilation, Am Actuarial Society

Elective – II (Select any one)

PAPER - IV (a)

Statistical Quality Control

Learning Outcome: The paper shows the applications of Statistics to maintain quality in Engineering or industrial set up. The theory of control charts, sampling plans and process capability indices is the basis for judging whether the process is in statistical control or not. The topics are quite helpful during industrial training/placements of M.Sc. Students.

UNIT-I

Definition of quality and its dimensions, evolution of quality control, chance and assignable causes of variation, statistical process control (SPC), statistical basis of control charts, criteria to evaluate control charts' performance, classical (Shewhart-type) control chart for variables and attributes- - R, - S, , , , charts.

UNIT-II

Control charts with memory – CUSUM chart, Moving sum/ Moving average chart, EWMA chart, Control chart for high-yield processes- -chart, -chart, exponential chart, gamma chart.

UNIT-III

Softwares for SPC, Sequential sampling plan. Tolerance limits and Specification limits. Process capability Analysis, process capability and machine capability indices Cp, C_{pk} and C_{pm},

UNIT –IV

Estimation and test of hypothesis relating to indices for normally distributed characteristics. Single, Double, Multiple sampling plans, Baysian sampling plan.

UNIT-V

Introduction to acceptance sampling. Rejection and Rectification types.consumer's risk, producer's risk. Operating characteristic curve, average sample number (ASN) curve, AQL, AOQL, ATI, LTPD.

REFERENCES

1. Montgomery, D.C. (1985) Introduction to Statistical Quality Control ; Wiley.
2. Ott, E.R. (1975) Process Quality Control ; McGraw Hill.
3. Wetherill, G.B. (1977) Sampling Inspection and Quality Control ; Halsted Press.
4. Wetherill, G.B. and Brown, D.W. (1991) Statistical Process Control, Theory and Practice ; Chapman and Hall.
5. Duncan, A. J.(1986): Quality Control and Industrial Statistics. 5th ed., Richard D. Ervin, Homewood, Illiions.
6. Ekambaram, S.K. (1963): The Statistical basis of quality control charts. Asia Publishing House, London.
7. Grant, E.L. & Leavenworth, R.S. (1988): Statistical Quality Control. 6th ed., McGraw-Hill Book Co., New York.
8. Bowker, A.H. & Goode, H.P. (1952): Sampling inspection by variables. McGraw-Hill Book Co., New York.
9. Schilling, E.G. (1982): Acceptance sampling in quality control. Marcel Dekker, Inc., New York.

Paper IV (b)
Survival Analysis

Outcome: Students will acquire

(a) statistical analysis used in survival data,
(b) knowledge about behavior of biological data,

UNIT I

Survival Analysis: Functions of survival times, survival distributions and their applications- exponential, gamma, Weibull, Rayleigh, lognormal, death density function for a distributionhaving bath-tub shaped hazard function.

UNIT II

Censoring Schemes: Type I, Type II and progressive or random censoring with biological 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: Actuarial and Kaplan-Meier methods for estimating survival function and variance of the Estimator.

UNIT III

Competing Risk Theory: Indices for measurement of probability of death under competing risks and their inter-relations. Estimation of probabilities of death using maximum likelihoodprinciple and modified minimum Chi-square methods. Theory of independent and dependent risks. Bivariate normal dependent risk model.

UNIT IV

Stochastic Epidemic Models: Simple epidemic models, general epidemic model definition and concept (without derivation). Duration of an epidemic. Statistical Genetics: Introduction, concepts-Genotype, Phenotype, Dominance, Recessiveness, Linkage and Recombination.

UNIT V

Coupling and Repulsion. Mendelian laws of Heredity, Random mating, Gametic Array .relation between genotypic array and gametic array under random mating. Distribution of genotypes under random mating. Clinical Trials:Planning and design of clinical trials, Phase I, II and III trials. Single Blinding.

SUGGESTED READING:

1. Lee, E.T. and Wang, J.W. (2003): Statistical Methods for Survival data Analysis, 3rdEdition, John Wiley and Sons.
2. Biswas, S. (2007): Applied Stochastic Processes: A Biostatistical and PopulationOriented Approach, Reprinted 2ndCentral Edition, New Central Book Agency.
3. Kleinbaum, D.G. (1996): Survival Analysis, Springer.

   Chiang, C.L. (1968): Introduction to Stochastic Processes in Bio Statistics, JohnWiley and Sons.

   Indrayan, A. (2008): Medical Biostatistics, 2nd Edition Chapman and Hall/CRC.

Paper V : Lab Course I – Practical Based on Papers I and II
Paper VI : Lab Course II – Practical Based on Papers III and IV
Paper- VII : Choice Based Credit System (Minor Elective from other Subject)

FOURTH SEMESTER

Paper – I : Inference -II
Paper – I : Multivariate Analysis

Paper - III : Elective –III (Select any one)
(a) Advance Operations Research
(b) Econometrics
Paper - IV : Elective –IV (Select any one)
(a) Reliability Theory
(b) Actuarial Statistics

Paper - V : Lab Course - I
Practical based on Papers I, II and III
Papers-VI : Lab Course-II
Project Work

Paper-I
Inference II

Learning Outcome: The objective of the course is to provide a systematic account of Neyman Pearson theory of testing and closely related theory of point estimation and confidence sets, together with their applications. The course is highly job oriented.

UNIT -I

Test of Hypothesis: Generalized form of Neyman Pearson lemma, UMP test for simple null hypothesis against one sided alternatives in one parameter exponential family .Unbiased test, uniformly most powerful unbiased test ,Type "A" and type A_1 critical regions or locally most powerful unbiased test.

UNIT-II

Composite Hypothesis and similar regions, similar regions and complete sufficient statistics, Construction of most powerful similar regions, Unbiased critical regions, optimum regions and Sufficient Statistics.

UNIT -III

Likelihood ratio test, properties of likelihood ratio test, Likelihood ratio test for the mean of normal population, LR test for equality of means and variances of two and several normal populations.

UNIT -IV

Sequential analysis: Wald's sequential probability ratio test (SPRT) with prescribed errors of two types, OC and ASN function of SPRT.

UNIT -V

Non parametric test, Rank test, Wilcoxon test, Median test, Sign test, Mann-Whitney U test, Wald-Wolfowitz run test, Kolomogorov-Smirnov test, One and two sample problem, chi square test of goodness of fit.

REFERENCES

1. Kale, B.K. (1999): A first Course on Parametric Inference, Narosa Publishing House.
2. Rohatgi V. (1988): An Introduction to Probability and Mathematical Statistics. Wiley Eastern
   Ltd. NewDelhi (Student Edition)
3. Lehmann, E.L.(1986)-(Latest): Theory of point Estimation (Student Edition).
4. Lehmann, E.L.(1986): Testing Statistical hypotheses (Student Edition).
5. Rao, C. R. (1973): Linear Statistical Inference.
6. Zacks, S. (1971): Theory of Statistical Inference, John Wiley and Sons, New York.

7. Gibbons,J.D.(1985) : Nonparametric statistical inference 2nd Ed.,Marcel dekker,Inc.
8. Dudewicz, E.J. and Mishra, S.N. (1988). Modern Mathematical Statistics. Wiley Series in Prob. Math. Stat., John Wiley and Sons, New York (International Student Edition)
9. Ferguson, T.S. (1996). A course on Large Sample Theory. Chapman and Hall, London.
10. Ferguson, T.S. (1967) : Mathematical Statistics, Academic Press.

Paper – II
Multivariate Analysis

Learning Outcome: The course deals with the statistical estimation and testing problems when the underlying structure is not univariate but multivariate in nature. Various multivariate techniques (estimation and testing) required to handle two or more correlated response variables, will be discussed under multivariate normal setting. One sample, two sample and c-sample multivariate normal mean vector testing problems will be discussed.

UNIT-I

Multivariate Normal Distribution and its properties, Reproductive property, transformation by a vector, singular /non-singular matrix, conditional distribution of a sub-set of multivariate normal variable/ Random sampling from a multivariate normal distribution.

UNIT-II

Maximum likelihood estimators of parameters. Distribution of sample mean vector. Null and non-null distribution of simple correlation coefficient. Null distribution of partial and multiple correlation coefficient. Distribution of sample regression coefficients.

UNIT – III

Distribution of Hotelling's T^2 statistic. Application in tests on mean vector for one and more multivariate normal populations and also on equality of the components of a mean vector in a multivariate normal population, Fisher-Behran statistic, Mahalanobis D^2 Statistic.

UNIT-IV

Distribution of sample generalized variance. Wishart matrix - its distribution and properties, Characteristic function of Wishart distribution, chi-square distribution as a particular case of Wishart distribution. Multivariate linear regression model-estimation of parameters, tests of linear hypotheses about regression coefficients.

UNIT-V

Classification and discrimination procedures for discrimination between two multivariate normal populations - sample discriminant function, probabilities of misclassification and their estimation, classification into more than two multivariate normal populations. Principal components, Dimension reduction, Canonical variables and canonical correlation - definition, use, estimation and computation. Introduction to Factor and Cluster Analysis.

REFERENCES

1. Cook, R.D. and Weisberg, S. (1982). Residual and Influence in Regression. Chapman and Hall.
2. Draper, N.R. and Smith, H.(1998). Applied Regression Analysis. 3rd Ed. Wiley.
3. Gunst, R.F. and Mason, R.L.(1980). Regression Analysis and its Applications – A Data Oriented Aproach. Marcel and Dekker.
4. Rao, C.R.(1973). Linear Statistical Inference and Its Applications. Wiley Eastern.
5. Weisberg, S. (1985). Applied Linear Regression. Wiley.
6. Andrson, T.W.(1983) : An Introduction to multivariate statistical analysis. 2nd Ed. Wiley. Giri, N.C.(1977) : Multivariate Statistical inference. Academic Press.
7. Kshirsagar, A.M. (1972) : Multivariate Analysis. Marcel Dekker.
8. Morrison, D.F. (1976) : Multivariate statistical methods. 2nd Ed. McGraw Hill.
9. Muirhead, R.J.(1982) : Aspects of multivariate statistical theory, J. Wiley.
10. Seber, G.A. F.(1984) : Multivariate observations. Wiley.
11. Sharma, S.(1996) : Applied multivariate techniques. Wiley.
12. Srivastava, M.S. and Khatri, C.G. (1979).: An introduction to multivariate statistics. North Holland.
13. Johnson, R. and Wychern (1992): Applied multivariate Statistical analysis, Prentice Hall, 3rd Ed.

Elective –III (Select any one)

Paper –III (a)

Advance Operations Research

Learning Outcome: The course is useful in taking optimum decision related to industry.

UNIT -I

Replacement problems: Replacement of items that fails and those that deteriorate, group and individual replacement policies

UNIT -II

Network analysis, Shortest Path Problem, Project planning and control with PERT and CPM

UNIT-III

Integer programming-Branch and Bound technique. Dynamic programming, Deterministic and Probabilistic Dynamic programming:

UNIT - IV

decision tree and Bellman's Principle of optimality, models of dynamic programming.

UNIT -V

Quadratic programming, Kuhn-Tucker conditions for quadratic programming problem, Wolf's modified simplex method, Beale's method Goal Programming simulation :Monte Carlo method.

REFERENCES

1. Taha H.A. (1982) Operational Research : An Introduction ; Macmillan.
2. Hillier F.S. and Leiberman G.J. (1962) Introduction to Operations Research ; Holden Day.
3. Kanti Swarup, Gupta, P.K. and Singh M.M. (1985) Operations Research ; Sultan Chand& Sons.
4. Philips D.T., Ravindran A. and Solberg J. Operations Research, Principles and Practice.
5. Churchman C.W., Ackoff R.L. and Arnoff E.L.(1957) Introduction to Operations Research ; John Wiley.

Paper –III (b)

ECONOMETRICS

Learning Outcome: The course is useful in study economical events using linear statistical models which is highly useful in the forecasting purpose.

UNIT – I

Nature of econometrics, the general linear model (GLM) and its extensions, ordinary least squares (OLS) estimation and prediction, generalized least squares (GLS) estimation and prediction.

UNIT – II

heteroscedastic disturbances, pure and mixed estimation, Auto correlation, its consequences and tests. Theil BLUS procedure, estimation and prediction, multicollinearity problem, its implications and tools for handling the problem, ridge regression.

UNIT – III

Linear regression and stochastic regression, Instrumental variable estimation. Errors in variables.

Autoregressive linear regression, lagged variables, distributed lag models, estimation of lags by OLS method, Koyck's geometric lag model,

UNIT – IV

Simultaneous linear equations model and its generalization, identification problem, restrictions on structural parameters, rank and order conditions. Estimation in simultaneous equations model.

UNIT – V

recursive systems, 2 SLS estimators, limited information estimators, k-class estimators. 3 SLS estimator, full information maximum likelihood method, prediction and simultaneous confidence intervals.

REFERENCES:

1 Apte, P.G.(1990): Text books of Econometrics, Tata Mcgraw Hill.
2 Cramer, J.S.(1971): Empirical Econometrics, North Holland.
3 Gujarathi, D.(1979): Basic Econometrics, McGraw Hill.
4 Intrulligator, M.D.(1980): Econometric models-Techniques and applications, Prentice Hall of India.
5 Johnston, J.(1984): Econometric methods. Third edition, McGraw Hill.
6 Klein, L.R. (1962): An introduction to Econometrics, Prentice Hall of India.
7 Koutsoyiannis, A. (1979): Theory of Econometrics, Macmillan Press.

8 Malinvaud, E. (1966): Statistical methods of Econometrics, North Holland.
9 Srivastava, V.K. and Gelies D.A.E.(1987): Seemingly unrelated regression equations models, Maicel Dekker.
10 Theil, H. (1982): Intruduction to the theory and practice of Econometrics, John Wiley.
11 Walters, A. (1970): An introduction to Econometrics, Macmillan & Co.
12 Wetherill, G.B.(1986): Regression analysis with application, Chapman Hall.

Elective –IV (Select any one)

Paper – IV (a)
RELIABILITY THEORY

Learning Outcome: This course is useful in survival analysis of equipments in the industry. It is helpful in getting the decision of surviving time to any product.

UNIT -I

Reliability concepts and measures ; reliability function ; hazard rate ; components and systems ; coherent systems ; reliability of coherent systems ; cuts and paths ; modular decomposition ; bounds on system reliability ; structural and reliability importance of components.

UNIT -II

Life distributions ; common life distributions-exponential, Weibull, gamma etc. Estimation of parameters and tests in these models. Notions of ageing ; IFR, IFRA, NBU, DMRL, and NBUE Classes and their duals ;

UNIT -III

loss of memory property of the exponential distribution ; closures or these classes under formation of coherent systems, convolutions and mixtures. Univariate shock models and life distributions arising out of them ; bivariate shock models ; common bivariate exponential distributions and their properties.

UNIT -IV

Reliability estimation based on failure times in variously censored life tests and in tests with replacement of failed items. Stress-strength reliability and its estimation. Maintainability and availability, Maintenance and replacement policies ; availability of repairable systems ;

UNIT -V

modeling of a repairable system by a non-homogeneous Poisson process. Reliability growth models; Hollander-Proschan and Deshpande tests for exponentiality; tests for HPP vs NHPP with repairable systems. Basic ideas of accelerated life testing.

REFERENCES:

1. Barlow R.E. and Prochan F.(1985) ,Statistical theory of reliability and life testing, Rinehart and Winston
2. Lawless J.F. (1982), Statistical Models and Methods of Life time data ; John Wiley .
3. Bain L.J. and Engelhardt (1991); statistical Analysis of Reliability and Life testing Models ,Marcel Dekker.
4. Nelson ,W (1982) ;Applied Life data analysis; john Wiley .
5. Zacks S.;Reliability Theory, Springer.

Paper- IV (b)

Actuarial Statistics

Outcome: Students will acquire

(a) modelling of individual and aggregate losses,

(b) fitting of distributions to claims data, deductibles and retention limits, proportional and excess-of-loss reinsurance,

(c) Risk models: models for individual claims and their sums,

(d) finding distribution of aggregate claims, compound distributions and their applications,

(e) applications of credibility theory,

(f) finding of survival function, curate future lifetime, force of mortality,

(g) handling problems on joint life and last survivor status and multiple decrement model,

UNIT -I

Introductory Statistics and Insurance Applications: Discrete, continuous and mixed probability distributions. Insurance applications, sum of random variables. Utility theory: Utility functions, expected utility criterion, types of utility function, insurance and utility theory.

UNIT -II

Principles of Premium Calculation: Properties of premium principles, examples of premiumprinciples. Individual risk models: models for individual claims, the sum of independent claims, approximations and their applications.

UNIT -III

Survival Distribution and Life Tables: Uncertainty of age at death, survival function, time- until-death for a person, curate future lifetime, force of mortality, life tables with examples

UNIT -IV

Deterministic survivorship group, life table characteristics, assumptions for fractional age, some analytical laws of mortality.

UNIT -V

Life Insurance: Models for insurance payable at the moment of death, insurance payable at the end of the year of death and their relationships. Life annuities: continuous life annuities, discrete life annuities, life annuities with periodic payments. Premiums: continuous and discrete premiums.

SUGGESTED READING:

Dickson, C. M. D. (2005): Insurance Risk And Ruin (International Series On Actuarial Science), Cambridge University Press.
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.

Paper - V : Lab Course I: Practical based on Papers I and II

Paper - VI : Lab Course II: Practical based on Papers III and IV

Paper - VII : Project Work

M.Sc. (Statistics) Semester-I

(Offered to PG students of SoS in Statistics only)

Program	Subject	Year	Semester
M.Sc.	Statistics	1	I
Course Code	Course Title		Course Type
SAT 610	**Indian Knowledge System (IKS)- Concepts and Mathematics Tradition**		IKS
Credit	Hours Per Week (L-T-P)		
	L	T	P
2	2	--	--

Maximum Marks	CIA	ESE
100	30	70

Learning Objective (LO):

The course aims to:

- Sensitize the students about context in which they are embedded, i.e., Indian culture and civilisation including its Knowledge System and Tradition.
- Provide information about great mathematicians and astronomers who given significant contribution in Indian mathematics and astronomy.
- Help students to trace, identify, practice and develop the significant Indian mathematic.

Detailed Syllabus:

Unit No.	Topics	No. of Lectures
I	Indian Knowledge System (IKS) – An Introduction: What is IKS? Why do we need IKS? Organization of IKS. Historicity of IKS Some salient aspects of IKS.	6
II	The Vedic Corpus: Introduction to Vedas. A synopsis of the four Vedas. Sub-classification of Vedas. Messages in Vedas. Introduction to Vedāṅgas. Prologue on Śikṣā and Vyākaraṇa. Basics of Nirukta and Chandas. Introduction to Kalpa and Jyotiṣa. Vedic Life: A Distinctive Features.	6
III	Wisdom through the Ages: Gateways of ancestral wisdoms. Introduction to Purāṇa. The Purāṇic repository. Issues of interest in Purāṇas. Introduction to Itihāsas. Key messages in Itihāsas. Wisdom through Nīti-śāstras. Wisdom through Subhāṣita.	6
IV	Number Systems and Units of Measurement: Number systems in India - Historical evidence. Salient aspects of Indian Mathematics. Bhūta-Saṃkhyā system. Kaṭapayādi system. Measurements for time, distance, and weight. Piṅgala and the binary system.	6
V	Indian contribution to Statistics,Prasanta Chandra mahalanobis, C. R. Rao, Devbrata Basu, Samarendra Nath Roy, P. V. Sukhatmi, Raj Chandra Bose, Kanti Lal Mardia.K. C. Sreedhaan Pillai, Pranab K. Sen, B. L.S. Prakash Rao, V. S. Huzurbazar, Jyant Kumar Ghosh, raghu raj bahadur, Anil Kumar Bhattacharya, introduction about agencies- NSO and CSO.	6

Books Recommended:

B. Mahadevan, Vinayak Rajat Bhat, R.N. Nagendra Pavana, Introduction to Indian Knowledge System: Concepts and Applications, PHI Learning Pvt. Ltd., 2022

Reference Books:

1. K. Kapur A.K. Singh (Eds); Indian Knowledge Systems, Vol. 1 & 2. D.K. Printworld Pvt. Ltd., 2005
2. शशिवाला, ओम विकास, अशोक प्रधान (संपादक), भारती विद्या सार-1, भारतीय विद्या भवन, 2018.
3. S. B. Rao, Indian Mathematics and Astronomy: Some Landmarks (Revised Third Edition), Bhartiya Vidhya Bhavan, 2012,
4. G.G.Josheph, Indian Mathematics: Engaging with the World from Ancient to Modern Times, speaking Tiger, 2016
5. B.S. Yadav, Ancient Indian Leaps into Mathematics, Birkausher Publication, 2010
6. Dharampal, Indian Science and Technology in the Eighteenth Century, Other India Press, 2000
7. Dharampal, The Beautiful Tree: Indigenous Indian Education in the Eighteenth Century, Other India Press, 2000.