KARNATAK UNIVERSITY,

DHARWAD

Regulations and Syllabus

Department of Studies in

STATISTICS

(I to IV Semester)

CHOICE BASED CREDIT SYSTEM

With effect from 2013 – 14

PREAMBLE

The Post Graduate Department of Statistics is one of the earliest Department established in Karnatak University, Dharwad. It was established in the year 1951. To begin with, this Department was started with a modest faculty and over the last seven decades, the Department has grown into a major center of Teaching and Research in Statistics. The Department had special assistance Programs for Thoerotical Research in Statistics viz., COSIST Phase I & II, DRS Phase I, II & III sanctioned by UGC and FIST Programme by DST.

The Computer Laboratory and well established Statistical Library bear ample testimony to the growing strength of the Department. The department supports various academic activities of the University. At present the Department offers the following Courses:

1. **M.A/ M. Sc. in Statistics (Two years: Four Semesters)**
2. **M.Phil. in Statistics (Minimum One Year)**
3. **Ph. D in Statistics (Minimum Three Years)**

The Department offers two Open Elective Courses for Post Graduate Students across faculty.

- **i) Statistical Methods (for IInd Semester)**
- **ii) Applied Statistics (for IIIrd Semester)**

c) Specialization Papers:

Semester-II

STCT: 2.3: Demography

STCT: 2.4: Actuarial Statistics

Semester-III

STCT: 3.4: Operations Research

STCT: 3.5: Econometrics

PG86: M.A/M. Sc. in Statistics

PROGRAMME OUTCOMES

Post graduates of Statistics programme will:

1. Have broad knowledge of theoretical statistics and its applications in various study disciplines.
2. Have in depth knowledge about different branches of statistics offered by the department.
3. Acquire computational skills.
4. Develop the abilities to analyse the data of econometric, biological, social science, actuarial, demographic, epidemic, financial etc.
5. Be able to conduct field surveys.
6. Have professional outlook and attitude as academicians, data analysts, researchers.

Course Codes for M.A/M.Sc. in Statistics

I –SEMESTER	II –SEMESTER	III –SEMESTER	IV –SEMESTER
PG86T101	PG86T201	PG86T301	PG86T401
PG86T102	PG86T202	PG86T302	PG86T402
PG86T103	PG86T203A	PG86T303	PG86T403
PG86T104	PG86T203B	PG86T304A	PG86T404
PG86P101	PG86T203C	PG86T304B	PG86P401
PG86P102	PG86P201	PG86T304C	PG86P402
PG86P103	PG86P202	PG86P301	PG86P403
PG86P104	PG86P203A	PG86P302	
	PG86P203B	PG86P303	
		PG86P303A	
		PG86P303B	

COURSE STRUCTURE AND SCHEME OF EXAMINATION FOR SEMESTER I, II, III ANDIV

SEMESTER – I THEORY

Sl. No.	Paper Code No. and Title		Credits	No. of Hrs/ Theory/	Duration of Exam in Hrs Theory/ Practical	Internal Assessment Marks Theory/ Practical	Marks at the Exams	Total Marks
1	PG86T101	Liner Algebra	4	4	3	25	75	100
2	PG86T102	Probability Theory	4	4	3	25	75	100
3	PG86T103	Theory of Sampling	4	4	3	25	75	100
4	PG86T104	Programming in C and Simulation	4	4	3	25	75	100
PRACTICALS								
1	PG86P101	(Based on PG86T101)	2	4	4	10	40	50
2	PG86P102	(Based on PG86T102)	2	4	4	10	40	50
3	PG86P103	(Based on PG86T103)	2	4	4	10	40	50
4	PG86P104	(Based on PG86T104)	2	4	4	10	40	50

SEMESTER – II

Sl. No.	Paper Code No. and Title		Credits	No. of Hrs/ Theory/	Duration of Exam in Hrs Theory/ Practical	Internal Assessment Marks Theory/ Practical	Marks at the Exams	Total Marks
1	PG86T201	Probability Distributions	4	4	3	25	75	100
2	PG86T202	Theory of Point Estimation	4	4	3	25	75	100
Any one of the Specialization								
3	PG86T203A	Demography	4	4	3	25	75	100
4	PG86T203B	Actuarial Statistics	4	4	3	25	75	100
5	PG86T203C	Statistical Methods	4	4	3	25	75	100
PRACTICALS								
1	PG86P201	(Based PG86T201)	2	4	4	10	40	50
2	PG86P202	(Based PG86T202)	2	4	4	10	40	50
Any one (Corresponding to Specialization Theory Paper)								
3	PG86P203A	(Based PG86T203A)	2	4	4	10	40	50
4	PG86P203B	(Based PG86T203B)	2	4	4	10	40	50

SEMESTER – III

Sl. No.	Paper Code No. and Title		Credits	No. of Hrs/ Theory/	Duration of Exam in Hrs Theory/ Practical	Internal Assessment Marks Theory/ Practical	Marks at the Exams	Total Marks
1	PG86T301	Elementary Stochastic Processes	4	4	3	25	75	100
2	PG86T302	Testing Hypotheses	4	4	3	25	75	100
3	PG86T303	Statistical Oriented R- Programming	2	2	2	10	10	50
Any one of the Specialization								
4	PG86T304A	Operations Research	4	4	3	25	75	100
5	PG86T304B	Econometrics	4	4	3	25	75	100
6	PG86T304C	Applied Statistics	4	4	3	25	75	100
PRACTICALS								
1	PG86P301	(Based on PG86T301	2	4	4	10	40	50
2	PG86P302	(Based on PG86T302)	2	4	4	10	40	50
3	PG86P303	(Based on PG86T303)						
Any one (Corresponding to Specialization Theory Paper)								
3	PG86P303A	(Based on PG86T304A)	2	4	4	10	40	50
4	PG86P303B	(Based on PG86T304B)	2	4	4	10	40	50

SEMESTER – IV

Sl. No.	Paper Code No. and Title		Credits	No. of Hrs/ Theory/	Duration of Exam in Hrs Theory/ Practical	Internal Assessment Marks Theory/ Practical	Marks at the Exams	Total Marks
1	PG86T401	Multivariate Analysis	4	4	3	25	75	100
2	PG86T402	Linear Models	4	4	3	25	75	100
3	PG86T403	SQC & Reliability Theory	4	4	3	25	75	100
4	PG86T404	Project	6	8	Presentation 50 Marks	25	75	150
5	PG86P401	(Based on PG86T401)	2	4	4	10	40	50
6	PG86P402	(Based on PG86T402)	2	4	4	10	40	50
7	PG86P403	(Based on PG86T403)	2	4	4	10	40	50

SYLLABUS

M.A / M.Sc PROGRAMME IN STATISTICS UNDER SEMESTER WISE CHOICE BASED CREDIT SYSTEM (CBCS) FROM THE ACADEMIC YEAR 2013-2014

SEMESTER- I

PG86T101: LINEAR ALGEBRA

PG86T101: Linear Algebra-Course Outcomes

After completion of the course, the candidate will:

1. have a thorough knowledge in various aspects of linear algebra
2. have in depth knowledge in basics of vector algebra
3. have ability to use important tools such as determinants, rank, inverse and generalized inverse in statistics.
4. Acquire the knowledge of linear transformations, orthogonal bases and projections
5. Study the importance and methodologies of calculating eigen values and eigen vectors
6. have ability to understand and solve emerging research problems using the tools studied in linear algebra

UNIT – 1:

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.

10T + 12P

UNIT – 2:

Vector spaces with an inner product, Gram- Schmidt orthogonalisation process, orthonormal basis and orthogonal projection of a vector, linear transformations.

10T + 8P

UNIT – 3:

Algebra of matrices, row and column spaces of a matrix, elementary matrices, determinants, rank and inverse of a matrix, null space and nullity, partitioned matrices, Kronecker product.

Hermite canonical form, generalized inverse, Moore - Penrose inverse, idempotent matrices, solution of matrix equations.

10T + 12P

UNIT – 4:

Characteristics roots and Vectors, Cayley - Hamilton theorem, minimal polynomial, similar matrices algebraic and geometric multiplicity of characteristics roots, spectral decomposition of a real symmetric matrix, simultaneous reduction of a pair of real symmetric matrices, Hermitian matrices, singular values and singular decomposition, Jordan decomposition.

10T + 8P

UNIT – 5:

Real quadratic forms, reduction and classification of quadratic forms, index and signature, triangular reduction of a positive definite matrix. extrema of quadratic forms, vector and matrix differentiation.

8T + 8P

(50 Lectures)

REFERNCES:

1. Biswas, S (1984) Topics in Algebra of matrices
2. Graybill, F. A (1983) Matrices with applications in statistics, 2nd edition, Wadsworth.
3. Hadley, G (1987) Linear Algebra , Narosa
4. Rao, A. R and Bhimasankaram P (1992) Linear Algebra, Tata McGraw Hill .
5. Rao, C.R (1973) Linear statisrical Inference and its applications, 2nd ed. Wiley.
6. Rao, C.R and Mitra, S.K (1971) Generalised inverse of matrices and its applications, Wiley
7. Searle, S. R. (1982) Matrix Algebra Useful in Statistics, Wiley.
8. Raghava Rao (1972) Matrix Theory, Oxford and IBH Publishing Company.

Practical : PG86P101: Linear Algebra-Course Outcomes

Gains understanding of the tools of linear equations, generalized inverse, eigen values and eigen vectors, various quadratic forms, diagonalization of a real symmetric and also simultaneous diagonalization of real matrices using statistical softwares.

PG86T102: PROBABILITY THEORY

PG86T102 : Probability Theory-Course Outcomes

On completion of this course students will:

- Understand the concepts of random variables, sigma-fields generated by random variables, probability distributions and independence of random variables related to measurable functions.
- have knowledge about measurable functions, Lebsgue measure, Lebsgue – Stieltjes measure.
- Analyze modes of convergence, knowledge about convergence in probability, convergence in distribution function and almost sure convergence.

- Understand weak and strong laws of large numbers, prove Borel-Cantelli lemmas and central limit theorem.

UNIT – 1:

Classes of sets, fields, sigma field, minimal sigma field, Borel sigma field in R^k, sequence of sets, limit infimum and limit supremum of a sequence of sets.

8T + 8P

UNIT – 2:

Measure, probability measure, properties of measure, Cartheodary extension theorem (Statement only), monotone class theorem (statement only), Lebesgue and Lebegue Stieltje's measures on R^k.

8T + 12P

UNIT – 3:

Measurable functions, random variables, sequence of random variables;, convergence in probability (and in measure) almost sure convergence, convergence in moments, convergence in distribution. Monotone convergence theorem, Fatou's Lemma, dominated convergence theorem.

12T + 12P

UNIT – 4:

Characteristic functions, uniqueness theorem, Levy continuity theorem (statement only). Independence, weak law of large numbers, Borel – Cantelli lemma, strong law of large numbers for a sequence of random variables,

14T + 8P

UNIT – 5:

Central limit theorem for a sequence of independent random variables under Lindberg's condition and for a sequence of i i d random variables.

8T + 8P

(50 Lectures)

REFERENCES:

1. Bhat, B.R. (1981), Modern Probability Theory, Wiley Eastern
2. Billingsley, S (1979), Probability and Measure, Wiley
3. Chow, Y.S. and Teicher, H (1979) Probability theory, Narosa
4. Dudley R.M. (1989) Real Analysis and Probability, Wadsworth & Brooks/Cole.
5. Kingman, J.F.C. and Taylore S.J. (1966), Introduction to measure and probability, Cambridge University Press.
6. A.K. Basu (1999), Measure Theory and Probability, PHI

Practical : PG86P102 Probability Theory-Course Outcomes

Based on theory knowledge students are able to solve practical problems independently.

PG86T103: THEORY OF SAMPLING

PG86T103 : Theory of Sampling-Course Outcomes

After studying this course, the candidate will be:

- Able to take up a project to collect primary data.
- Able to prepare questionnaires, plan the scheme of the survey, train investigators, tabulate and dissiminate data.
- Able to identify the nature of population sampling methodology to be adopted and recognize right tool for analysis.
- Able to handle various kinds of non sampling errors to collect non erroneous data.
- Able to carry out sampling surveys on sensitive issues.

UNIT – 1:

Concept of Random Sampling, Sampling Design, Sampling Scheme and Sampling Strategy. Review of SRSWR, SRSWOR, Stratified and Systematic Sampling Procedures.

12T & 12P

UNIT – 2:

Sampling with varying probabilities: Procedures of selecting sample, PPSWR, PPSWOR, Desraj's Ordered Estimates, Murty's unordered Estimates. I P P S: Horvitz – Thompson Estimator and it's properties, Midzuno – Sen scheme of sampling, Rao – Hartly – Cochran procedure.

13T + 12P

UNIT – 3:

Ratio and Regression Estimators with their properties. Cluster sampling, Sub sampling with units of equal and unequal sizes. Double sampling procedures used in Ratio, Regression estimators and in stratification and PPS sampling.

13T + 16P

UNIT – 4:

Non Sampling Errors: Errors in Surveys, Model for measurement of observational error.
Nonresponse error: Hansen – Hurwitz, Deming's, Politz - Simons Techniques.
RRT: Warner's Model.

12T & 8P

(50 Lectures)

REFERENCE:

1. Cochran W.G. (1984) Sampling Techniques. Wiley Eastern, New Delhi.
2. Desraj (1976) Sampling Theory. Tata Mc. Graw Hill.
3. Mukhyopadhyay. P (1998) Theory and Methods of Survey Sampling. Prentice Hall of India Pvt. Ltd.
4. Murthy M.N. (1977) Sampling Theory and Methods. Statistical Publishing Society, Calcutta.
5. Singh and Chaudhary F.S. (1986) Theory and Analysis of Sample Survey Designs. Wiley Eastern New Delhi.
6. Sukhatme P.V. Sukhatme B.V. Sukhatme S. and Ashok C (1984) Sampling Theory of Surveys with Applications. Indian Society of Agricultural Statistics, New Delhi.

Practical : PG86P103 : Theory of Sampling-Course Outcomes

The candidate will acquire knowledge on selecting random samples under sampling scheme like SRS and PPS. Calculating various estimators and their precisions.

PG86T104: PROGRAMMING IN C AND SIMULATION

PG86T104 : Programming in C and Simulation-Course Outcomes

After studying this course, the candidate will:

- be able to be develop logic of problem solving.
- Develop C-Programs for problems of different branches of statistics.
- Acquire knowledge of higher/advanced features C-Programming.
- Artificially simulate various environments.

UNIT – 1:

Programming in C: Structure of C Programme, Variables, Data types, Operations and Expressions. Input – Output functions and Format specification.

10T &12P

UNIT – 2:

Control statements: do, do-while and for loops. if, if-else and switch statements. Arrays, Functions, Pointers, Structures, Unions, File handling, C – Processors, C – Standard, Library and Header files.

25T & 20P

UNIT – 3:

Simulation: Generation of Binomial, Beta, Geometric Exponential, Poisson, Normal Random Variables. Statistical Applications- using C-Programming Language.

15T & 16P

(50 Lectures)

REFERENCE:

1. Kerighan and Ritchie (1997). The C-Programming Language. PHI
2. E-Balaguruswamy (1990) Programming in C McGraw- Hill.
3. J. Jayasri (1992) The C-Language Trainer with C-Graphic and C++ Sage India Ltd.

Practical : PG86P104 : C-Programming Practical-Course Outcomes

Demonstrates understanding of logic, syntax and working of C-programs on various aspects of statistical Analysis and simulation of statistical Models.

Semester – II

PG86T201: PROBABILITY DISTRIBUTIONS

PG86T201 : Probability Distributions- Course Outcomes

On completion of this course students will be able to:

- Understand the most common discrete and continuous probability distributions and their real life applications.
- Compute marginal and conditional distributions from joint distributions.
- Get familiar with transformation of univariate and multivariate densities. Understanding of distribution helps to understand the nature of data and to perform appropriate analysis.
- Acquire the application knowledge of compound, Truncated, mixture and non-central probability.

UNIT – 1:

Standard discrete distributions: Bernoulli, Binomial, Poisson, Geometric, Hypergeometric, Negative binomial, Logarithmic series, Rectangular and Multinomial distributions.

12T & 12P

UNIT – 2:

Standard continuous distributions: Normal, Lognormal, Cauchy, Uniform, Exponential, Logistic, Weibull, Double exponential, Gamma, Bivariate normal, Bivariate exponential distributions.

12T & 12P

UNIT – 3:

Conditional, Compound, Truncated and Mixture of distributions. Functions of random variables and their distributions.

6T & 8P

UNIT – 4:

Sampling Distributions: Central and Non-central chi-square, t and F distributions and their properties. Distribution of quadratic forms under normality.

12T & 8P

UNIT – 5:

Order Statistics: Distributions of order statistics and their properties with applications. Joint and Marginal distributions of order statistics. Distributions of range and median.

8T & 8P

(50 Lectures)

REFERENCE:

1. Dudewicz E.J and Mishra S.N. (1988) Modern Mathematical Statistics. Wiley
2. Johnson and Kotz (1972) Distributions in Statistics, Vol I, II and III, Houghton and Miffin
3. Rohatgi, V.K. (1984) An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern
4. Rao, C.R. (1973) Linear Statistical Inference and its applications, 2nd Edn. Wiley Eastern.

Practical: PG86P201 Probability Distributions-Course Outcomes

Course Outcomes : Based on theory knowledge students are able to do practical problems independently.

PG86T202: THEORY OF POINT ESTIMATION

PG86T202 : Theory of Point Estimation-Course Outcomes

On completion of this course, the candidate will:

- Learn various aspects of estimation including characteristics of an estimator.
- Have knowledge on various families of distributions and their advantages in obtaining estimators.
- Learn different methods of estimation and their advantages.
- Develop a logic to analyse the situation and apply appropriate statistics tools.

UNIT – 1:

Likelihood Function, Group Families, Exponential class of densities and it's properties, Fisher Information, Sufficiency, Neyman – Fisher factorization Theorem, Minimal sufficient statistics and their construction, Completeness, bounded completeness and relation with minimal sufficiency, ancillary statistics, Basu's Theorem and it's Applications.

20T & 20P

UNIT – 2:

Unbiased Estimators, Characterization of UMVUE, Rao – Blackwell and Lehmann – Scheffe Theorem and their uses. 8T & 8P

UNIT – 3:

Cramer- Rao inequality for single parameter case, Chapman - Robbins bounds and Bhattacharya bounds.

7T & 8P

UNIT – 4:

Methods of Estimation: Method of moments, method of minimum chi-square, method of maximum likelihood and it's properties, Method of scoring and it's applications. Asymptotic effiency of MLE, CAN and BAN estimators.

15T & 12P

(50 Lectures)

REFERENCES:

1. Kale B.K (1999) A first course on parametric inference. Narosa.
2. Lehmann E. L (1988) Theory of point estimation. John wiley & Sons
3. Rohatgi V.K (1984) An introduction to probability theory mathematical Statistics. Wiley eastern, New Delhi.
4. Zacks, S (1971) Theory of Statistical Inference. Wiley, Newyork.

Practical : PG86P202 : Theory of Point Estimation –Course Outcomes

On completion of this course, the candidate learns the technique of:

1) Computing various estimators under different situations.
2) Will learn different approaches to obtain estimators using various methods.

Any one of the Optional
PG86T203: DEMOGRAPHY – Special Paper

PG86T203A: Demography-Course Outcomes

On completion of this course, the candidate will:

- have information regarding sources and methods of demographic data.
- acquire in depth knowledge of various measures of mortality and fertility.

- have ability to conduct socio-economic survey using tools such as sample survey and vital statistics registration system.
- Acquire the knowledge of construction of life tables for various categories of demography.
- Study the importance and methodologies of population growth and projections.
- Develop the ability to understand and solve emerging research problems.

UNIT – 1:

Demography and its interdisciplinary nature, sources of demographic data, Coverage and Content errors. The use of balancing equation, Chandrasekaran and Deming formula to check completeness of registration data. Use of Whipple's, Myers's and UN Indices.

12T & 12P

UNIT – 2:

Measures of Mortality: Various measures of mortality, infant mortality rate, cause specific death rates and standardized death rates. Measures of Fertility: Period and cohort fertility measures, use of birth order statistics, child – women ratio, Brass P/F ratio to estimate current levels of fertility, Measures of reproduction and replacement. Sheps and Perrin stochastic human reproductive process.

15T & 16P

UNIT – 3:

Life Tables: Types of life tables, inter – relationships between life table functions, construction of life tables using Reed – merrel and Greville's Method. Probability distribution of life table functions and their optimum properties. Population estimation and Projections: Mathematical, Statistical and Demographic Methods, Component method.

15T & 12P

UNIT – 4:

Stable and Quasi – stable population: Derivation of Lotka's stable population model and its properties, Intrinsic growth rate and its derivation, age structure and birth rate of a stable population, mean length of generation, momentum of population growth, Quasi – stable population under changing fertility and mortality situations.

10T & 4P

(50 Lectures)

REFERENCES:

1. Shryock, Henry S, Jacob S, Siegel and Associates (1964) Methods and materials of demography (condensed edition) Academic press, London.
2. Barclay, George W. (1968) Techniques of population analysis, John Wiley and sons, New York.

3. Keyfitz N. (1968), Introduction to the Mathematics of Population. Addison-Wesley Publishing Co, Reading, Messachusetts.
4. Chiang C.L. (1968), Introduction to stochastic processes in Biostatistics, John Wiley and sons, New York.
5. R. Ramkumar (1986), Technical Demography, Wiley Eastern, New Delhi.
6. Sudhendu Biswas (1988), Stochastic Processes in Demography and Applications, Wiley Eastern, New Delhi.

Practical : PG86P203A: Demography-Course Outcomes

Provides framework of different sources and methods of demographic data and facilitates, the knowledge of various measures for data on births and deaths, also the applications of these measures in finding life expectancy, population projections, calculation growth rates etc.

PG86T205: ACTUARIAL STATISTICS – Special Paper

PG86T203B : Actuarial Statistics-Course Outcomes

On completion of this course, the candidate will:

- Learn various aspects of insurance and utility functions.
- Have knowledge on various insurance polices and calculation of their premiums.
- Have in-depth knowledge in computing life annuities, benefits premiums and benefit reserves.
- Help insurance companies to develop new advantageous polices.

UNIT – 1:

The Economics of insurance: Utility theory, insurance and utility, elements of insurance, optimal insurance. Individual risk models for a short term; Models for individual claim random variables, sums of independent random variables, approximations for the distribution of the sum, application to insurance.

10T & 12P

UNIT – 2:

Survival distributions and Life tables: Probability for the age at death, the survival function, time until death for a person age x, Curtate-Future-Life times, force of mortality, relation of life table functions to the survival function. The deterministic survivorship group, other life table characteristics recursion formulae, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.

10T & 12P

UNIT – 3:

Life Insurance: Insurance payable at the moment of death, level benefit insurance, Endowment insurance, Deferred insurance, Varying benefit insurance, insurance payable at the end of the year of death, Relationship between insurance payable at the moment of death and at the end of the year of death, Differential equations for insurance payable at the moment of death.

10T & 12P

UNIT – 4:

Life Annuities: Continuous Life annuities, discrete life annuities, life annuities with monthly payment.

Benefit Premiums: Fully continuous premium, fully discrete premiums, true monthly payment premiums.

Benefit Reserves: Fully continuous benefit reserves, other formulas for fully continuous benefit reserves.

10T & 8P

UNIT – 5:

Multiple Life Functions: Joint distribution of future Life times, the joint life status, the last- survivor status, copulas, special mortality assumptions, Gompertz and Makeham Laws.

Multiple Decrement Models: Two random variables, random survivorship groups, deterministic survivorship group. Basic relationships inform distribution assumption for multiple decrements.

Collective Risk Models for a Single Period: The distribution of aggregate plans, selection of basic distributions the distribution of N, the individual claim amount distribution.

10T & 4P

(50 Lectures)

REFERENCES:

1. Newton L Bowers, Jr; Gerber Hans, U; Hickman James, C; Jones Donald A; Nesbitt Cecil, J. (2000) – Actuarial Mathematics – The Society of Actuaries, Schaumburg, Illinois, U.S.A.

Practical : PG86P205 : Actuarial Statistic

The candidate will acquire skills :

1. of calculating increment, decrement, enmities, premiums and benefit reserves for various policies.
2. Of recognizing various actuarial models.

STET: 2.1: STATISTICAL METHODS
(OPEN ELECTIVE)

PG86T203C : Statistical Methods-Course Outcomes

On completion of this course, the candidate will learn:

- Various methods of collecting and organizing data
- Various statistical measures such as population mean and variance.

- Measures of association between two variables.
- Different tests which are applicable to other disciplines.

UNIT – 1:

Data: Introduction, collection of data, kinds of data, tabulation of data, diagrammatic and graphical representation of data with examples. Measures of central tendency: Introduction, arithmetic mean geometric mean, harmonic mean, median, mode, for grouped and ungrouped data with examples.

10 Hrs

UNIT – 2:

Measure of dispersion: Introduction, range, quartiles, interquartile range, mean deviation, variance, coefficient of variation for grouped and ungrouped data with examples. Skewness and Kurtosis: Introduction, measures of Skewness and Kurtosis with examples.

10 Hrs

UNIT – 3:

Concept of Probability: Introduction, different approaches to definition of probability, probability of composite event, addition rule, multiplication rule, Bayes formula. Theoretical probability distributions: Binomial, Geometric, Poisson, Normal, Exponential.

10 Hrs

UNIT – 4:

Correlation and regression: Scatter diagram, coefficient of correlation, fitting of linear regression, method of least squares, coefficient squares, coefficient of variation, relation between regression and correlation.

10 Hrs

UNIT – 5:

Testing of Hypothesis: Introduction, parametric tests, one sample and two sample z, t tests, paired t test, F test, X^2 test, test for correlation. Nonparametric tests: Run test, Sign test, Signed rank test, Wilcoxon's rank sum test, and Spearman's test for rank correlation.

10 Hrs

(50 Lectures)

REFERENCE:

1. Das, M.N. (1993) Statistical Methods and concepts, Wiley Eastern Ltd.
2. Medhi, J (1992) Statistical Methods, New Age International Ltd.
3. Miller, I, Freund J.E. and Johnson R.A. (1992) Probability and Statistics for Engineers. Prentice Hall of India Private Ltd.

Semester – III

PG86T301: ELEMENTARY STOCHASTIC PROCESSES

PG86T301: Elementary Stochastic Processes-Course Outcomes

After studying this course,

- The candidate will acquire knowledge of stochastic processes, modeling real life situations through stochastic processes.
- Study stochastic processes like Poisson, pure birth, Yule-Fuly, Birth and Death, Weiner, Branching processes.
- Know how better modeling can be made using stochastic processes.
- Develop critical Analysis capacity through stochastic processes.

UNIT – 1:

Introduction to stochastic processes (SP), classification of SP according to state space and time domain. Finite and countable state Markov chains (MC), Chapman – Kolmogorov's equations, calculation of n-step transition probabilities and their limits, stationary distribution, classification of states, transient MC, random walk and gambler's ruin problems.

16T & 16P

UNIT – 2:

Continuous time Markov processes: Kolomgorov-Feller differential equation, Poisson process, pure birth process, Yule – Furry process, birth and death processes, Weiner process as a limit of random walks, first passage time and other problems, diffusion process.

14T & 16P

UNIT – 3:

Renewal Theory: Elementary renewal theorem and applications, key renewal theorem and its uses, study of residual life time process, discrete time renewal theory.

Stationary process: weakly stationary and strongly stationary processes, spectral decomposition, moving average and auto regressive processes. 14T & 12P

UNIT – 4:

Branching process: Galton-Watson branching process, probability of ultimate extinction, distribution of population size, and statistical inference in MC and Markov process.

6T & 4P

(50 Lectures)

REFERENCES:
1. Medhi J (1994), Stochastic Processes, 2nd edn., Wiley Eastern Ltd., New Delhi.
2. Bhat U.N. (1984), Elements of Applied Stochastic processes, 2nd edn., Wiley, New York.
3. Basawa I.V. and Prakash Rao B.L.S. (1980) Statistical Inference for stochastic processes, Academic press, New York.
4. Karlin S and Taylor H.M. (1975), A first course in stochastic processes, 2nd edn., Academic press, New York.

Practical : PG86P301 : Elementary Stochastic Processes-Course Outcomes

Acquaint with use of stochastic Models in different areas of applications of statistics.

PG86T302: TESTING OF HYPOTHESES

PG86T302: Testing of Hypotheses-Course Outcomes

After studying this course, the candidate:

- Increases confidence in their ability to formulate different research problems
- Develops ideas and research skills
- Gets in-depth knowledge of various research tools in the form of parametric and non-parametric methods.
- Learns to construct UMA and UMAU confidence intervals, likelihood ratio tests, etc.
- Study the importance of sequential analysis using Wald's SPRT and its functions, OC and ASN.

UNIT – 1:

Introduction to testing of hypotheses: size and power of a test. Neyman-Pearson lemma, MP test, MLR Property and UMP test.

10T & 12P

UNIT – 2:

Generalization of NP-lemma, UMPU tests, Bounded completeness, Similar regions. Tests with Neyman structure, UMPU test for multi-parameter exponential families. Comparison of two binomial and Poisson populations.

10T & 8P

UNIT – 3:

Confidence intervals and their connection with the tests of hypotheses. UMA, UMAU confidence intervals, shortest length confidence intervals.

Likelihood ratio tests, large sample properties. Chi-square goodness-of-fit tests for simple and composite hypothesis.

10T & 12P

UNIT – 4:

Nonparametric methods-run test, sign test, signed-rank test, median test, Wilcoxon-Mann-Whitney test, Kolmogorov – Smirnov tests, Tests involving rank correlation, Linear rank statistics, Large sample properties and applications.

10T & 8P

UNIT – 5:

Sequential analysis, need for sequential tests, SPRT and its properties, termination property, fundamental identity and Wald's equation, OC and ASN functions. SPRT for testing hypothesis in binomial, Poisson, normal and exponential distribution-computation of OC and ASN functions.

10T & 8P

(50 Lectures)

REFERENCES:

1. Lehmann E.L. (1986)Testing Statistical Hypothesis, Wiley, New York.
2. Rohatgi V.K. (1984). An Introduction to Probability Theory and Mathematical Statistics. Wiley Eastern, New Delhi.
3. Dudewicz E.J. and Mishra S.N. (1988) Modern Mathematical Statistics, Wiley and Sons, New York.
4. Ferguson T.S. (1967), Mathematical Statistics- Decision Theoretic Approach. Academic Press, New York.
5. Kendall M.G. and Stuart A (1968) Advanced Theory of Statistics, Vol II, Charles Griffin and Co., London.
6. Rao C.R (1973). Linear Statistical inference. Wiley Eastern, New Delhi.
7. Wald A (1947) Sequential Analysis, Wiley New York.
8. Gibbons J.D. (1985). Non Parametric Statistical inference. Marcel Dekkar, New York.
9. Randles R.H. and Wolfe D.A. (1979) Introduction to Theory of Non-Parametric Statistics. Wiley, New York.
10. Cramer H. (1957) Mathematical Methods of Statistics. Princeton University Press, New Jersey.

Practical : PG86P302 : Testing of Hypotheses-Course Outcomes

It improves their ability to handle and address the research problems in Statistics, Biology, Economics, Sociology, Anthropology etc. Learn applications of parametric and non-parametric methods.

PG86T303 : STATISTICAL ORIENTED R – PROGRAMMING

PG86T303 : Statistical Oriented R-Programing-Course Outcomes

After completion of this course, the candidate will be able to:

- Know various aspect of R-Programming language.
- Write R-Programs for various statistical concepts.
- Carry out simulation to complex statistical problems.
- Use and interpret inbuilt tests in R-programming.

UNIT – 1:

Introduction to R: R as a Statistical software and language, R preliminaries, methods of data input, data accessing or indexing, built – in functions. Graphics with R, getting help, saving storing and retrieving data.

12T & 16P

UNIT – 2:

Analysis using R: problems based on descriptive statistics, probability distributions, statistical inference, correlation and regression, linear models and time series analysis.

13T & 32

(25 Lectures)

REFERENCES:

1. Goran Brostrom, Statistical Programming in R, Umea Universitet, Statistiska institutionen, Mandatory Reading instructions: Tillhandahalls elektroniskt.
2. D.M. Smith, W.N. Venables, The R Development Core Team, An Introduction to R.
3. John Braun, Duncan James Murdoch, A First Course in Statistical Programming with R, Cambridge, N.Y: Cambridge University Press: 2007:163s: ISBN: 978-0-521-87265-2 (inb.)
4. Brian D. Ripley, W.N.q (William N.) Venables, S Programming, New York: Springer: cop.2000:x,264s:ISBN: 0-387-98966-8(alk.paper).
5. John M. Chambers, Software for Data Analysis: Programming with R, New York, N.Y: Springer: cop. 2008: 498p: ISBN:978-0387-75935-7(hbk).
6. Sudha G. Purohit, Sharad D. Gore and Shailaja R. Deshmukh (2008) Statistics Using R, Narosa Publishing House.

Practical : PG86P303 : Statistical Oriented R-Programing-Course Outcomes

The candidate will be able to

1. Feed the data and carry out the analysis.
2. Import data from other sources.

Optional (any one)

PG86T304: OPERATIONS RESEARCH– Special Paper

PG86T304A : Operations Research-Course Outcomes

After completion of this course, the candidate will be able to:

- about linear programming and various methods to solve liner programming problem.
- About transportation problem and assignment problem and calculating minimum cost.
- About analyzing various kinds of quarries and their waiting times.
- About various inventory models and obtaining economic order quality under there models.
- To be helpful in various sectors like marketing research, industries, etc to detect the problems and give optimum solutions.

UNIT – 1:

Linear programming, Graphical methods, basic theorems, simplex method and simplex algorithm & two phase method, Charne's M –technique, revised simplex method, duality in LPP, duality theorems, dual simplex method, economic interpretation, sensitivity analysis.

15T & 16P

UNIT – 2:

Transportation and assignment algorithms, balanced and unbalanced transportation problems, degeneracy, Hungarian method of assignment.

10T & 8P

UNIT – 3:

Queuing Models chief characteristics. Analysis of M/M/1, M/M/C queues with steady state probabilities.

10T & 12P

UNIT – 4:

Inventory Models: Deterministic EOQ Models (without shortage costs), probabilistic single period model with instantaneous demand (No Set up cost Model), models with price breaks (one & two price breaks), (s, S) policy.

10T & 12P

(50 Lectures)

REFERENCES:

1. Ackoff R. L. & Sasieni M. W. (1991) Fundamentals of operations Research. Wiley Eastern.

2. Bazarre M.S.& Zarvis J.J. (1977) Linear Programming & Network flows. John Wiley.
3. Gross D and Harris C.M (1974) Fundamentals of Queueing Theory. Wiley, New York
4. Gupta R.K. (1993) Operations Research Krishna Prakashan Mandir, Meerut.
5. Kantiswarup Gupta P.K and Man mohan (1977) Operations Research. S. Chand and Sons, New Delhi.
6 Mittal K.V. (1990) Optimization Methods. Wiley eastern Ltd. New Delhi.
7. Murty K.G. (1983) Linear Programming, John Wiley & Sons.
8. Taha H .A (1998) Operations Research. Prentice-Hall of India.

Practical : PG86P304A : Operation Research-Course Outcomes

The candidate will learn the skills of

1. Practically solve various problems of linear programming, transportation problem and assignment problem.
2. To solve problem on queuing to analyze average queue, waiting time and inventory problems to calculate economic order quantity.

PG86T304B : ECONOMETRICS – Special Paper

PG86T304B : Econometrics-Course Outcomes

On completion of this course, the candidate will:

- develop professional competence in analysis of economic and time series data.
- be able to understand the evolutionary practices of Linear/Multiple linear regression models, assumptions and consequences of violations of the requirements of the model.
- be able to achieve professional competency in the field of analysis of econometric models through simultaneous equation models.
- Acquint with contemporary trends in estimation of econometrics models.

UNIT – 1:

Introduction: Origin, definition, methodology, scope and limitations of econometrics.

The two – variable linear regression model: Relationships between economic variables, two variable linear regression model, least squares estimators.

Multiple linear regression models: Model descriptions and assumptions, least squares estimators, selection of variables in multiple regression model.

10T & 12P

UNIT – 2:

Analysis of residuals: Presence of outliers, omitted variables, nonlinear relationship, correlated disturbances heteroscedasticity.

Multicollinearity: The plausibility of the assumption of non-multicolinear regresssors, consequences of multicollinearlty, tests for detecting multicollinearity, solutions for multicollinearity.

10T & 8P

UNIT – 3:

Autocorrelation: Introduction and plausibility of serial dependence, sources of autocorrelation, tests for autocorrelation, solutions for autocorrelation, methods for estimating the parameters of autocorrelation, serial correlation.

Autoregressive and Distributed Lag Models: Autoregressive model, distributed lag model, methods of estimation of lagged models.

10T & 12P

UNIT – 4:

Errors in variables: Introduction, solution for single equation models, reverse regression, instrumental variable method, proxy variables. Stochastic regressions: Introduction, bivariate normal distribution.

10T & 4P

UNIT – 5:

Simultaneous equation models: The problem of identification.

Single equation methods of estimation: reduced form method or indirect least squares (ILS), the method of instrumental variables (IV), two-stage least squares (2SLS), limited information maximum likelihood (LIML), k-class estimators.

System methods of estimation: Three-stage least squares (3SLS), full information maximum likelihood (FIML).

10T & 12P

50 Lectures

Reference:

1. Baltagi B.H. (2000) Econometrics, Springer.
2. Gujarati D.N. (2003) Basic Conometrics, McGraw-Hill.
3. Maddala G.S. (2002) Introduction to Econometrics, John Wiley.

Practical : PG86P304B : Econometrics-Course Outcomes

Able to understand practices in applications of Econometric Models in various economic problems.

PG86T304C: APPLIED STATISTICS

(OPEN ELECTIVE)

PG86T304C : Applied Statistics (OEC)- Course Outcomes

: On completion of this course students will be able to :

- Explain the concepts of Statistical Quality Control and associated techniques.

- Construct appropriate Quality Control Charts and Forecasting models useful in monitoring a process.
- Apply various samplings inspection plants to real world problems for both theoretical and applied research.
- Assess the ability of a particular process to meet customer expectations.
- Develop an appropriate quality assurance plan to assess the ability of the service to meet requisite national and international quality standards.
- Understand to identify whether a process is in statistical control or not.
- Understand to estimate Trend, Seasonal and Cyclic components of time series.
- Understand past and future behavior of phenomena under study.
- Understand how a product quality can be improved and elimination of assignable causes of variations.

UNIT – 1:

Time Series: Introduction, components of time series, measurement of trend, measurement of seasonal variations. Index Numbers: Introduction, price index numbers, quantity index numbers, chain index numbers, cost of living index number, time reversal test, factor reversal test.

8 Hrs

UNIT – 2:

Vital Statistics: Introduction, methods of obtaining vital statistics, mortality rates, fertility rates, measurement of population growth.

6 Hrs

UNIT – 3:

Analysis of Experiments: Introduction, principles of experimental design, ANOVA, completely randomized design, randomized block design, factorial experiments.

10 Hrs

UNIT – 4:

Sampling Theory: Introduction, simple random sampling, stratified random sampling, systematic sampling, sampling and non-sampling errors.

10 Hrs

UNIT – 5:

Control Charts (Process Control): Introduction, control charts for variables ($\bar{x}$ and R charts), control charts for attributes (P-chart), Control charts for number of defects per unit (C-chart), demerit control charts. Acceptance Sampling Plans (Product control): Basic terminologies: AQL, LTPD, AOQ, AOQL, ASN, OC curve, producer's risk, and consumer's risk. Single sampling plan, double sampling plan. 16 Hrs

(50 Lectures)

REFERENCES:

1. R. Ramkumar (1986) Technical Demography, Wiley Eastern, New Delhi.
2. J. Medhi (1992) Statistical Methods. New Age International (P) Ltd. New Delhi.
3. M.N. Das (1993) Statistical Methods and Concepts. Wiley Eastern Ltd.
4. Irwin Miller, John E Fread and Richard A Johnson (1992) Probability and Statistics for Engineers. Prentice Hall of India New Delhi.
5. D.C. Montgomery (1991) Design and Analysis of Experiment. John Wiley and sons.
6. D.C. Montgomery (1996) Introduction to Statistical Quality Control.

Semester – IV

ST PG86T401: MULTIVARIATE ANALYSIS

PG86T401 : Multivariate Analysis-Course Outcomes

Course Outcomes: On completion of this course students will be able to:

- Understand the concept of Multivariate analysis and its usefulness.
- Understand data requirements for Multivariate analysis.
- Perform exploratory analysis of multivariate data, such as plot multivariate data, calculating descriptive statistics, testing for multivariate normality.
- Conduct statistical inference about multivariate means including hypothesis testing and different types of confidence intervals estimation.
- Undertake statistical analyses using appropriate multivariate techniques, which include principal component, factor analysis and discriminant analysis.

UNIT – 1:

Random sampling from multivariate normal distribution, maximum likelihood estimators of parameters, distribution of sample mean vector. Wishart distribution and its properties, distribution of sample generalised variance. Null distribution of sample correlation coefficients, distribution of regression coefficients. Application in testing and interval estimation.

14T & 16P

UNIT – 2:

Hotelling's - T^2, Null distribution of Hotelling's T^2 - statistic. Applications in tests on mean vector for single and several multivariate normal populations.

6T & 4P

UNIT – 3:

Multivariate linear regression model, estimation of parameters, testing linear hypothesis about regression co-efficients. Likelihood ratio criterion. Multivariate analysis of variance of one - way and two-way classified data.

8T & 8P

UNIT – 4:

Classification and discrimination procedures for discrimination into one of two mulitvariate normal populations. Sample discriminant function, tests associated with discriminant function, probabilities of misclassification and their estimation, classification into more than two multivariate normal populations. Penrose size and shape factors.

12T & 18P

UNIT – 5:

Introduction to Principle component analysis, Factor analysis, Cluster analysis, Canonical Correlations and Multi dimensional scaling.

10T & 12P

(50 Lectures)

REFERENCES:

1. Anderson, T.W. (1983) An Introduction to Multivariate statistical Analysis. Wiley.
2. Johnson and Wichern (1986) Applied multivariate Analysis. Wiley
3. Kshirsagar, A.M. (1972) Multivariate Analysis, Marcel – Dekker.
4. Morrison, D.F. (1976) Multivariate Statistical Methods. McGraw Hill.
5. Muirhead, R.J. (1982) Aspects of multivariate statistical theory. Wiley.
6. Srivastava, M.S. and Khatri C.G. (1979) An introduction to Multivariate Statistics. Worth Holland
7. Mardia, K.V., Kent J.T. and Bibby J.M. (1979) Multivariate Analysis. Academic Press.

PG86T402: LINEAR MODELS

PG86T402: Linear Models-Course Outcomes

The course provides a thorough knowledge in various aspects of Linear Models

- Gain knowledge in basics of linear estimation
- Ability to understand important tools of linear estimation in Gauss-Markov set-up.
- Acquire the knowledge of application of multiple linear regression in various fields.
- Study the importance of analysis of variance (ANOVA) technique and its different methodologies.

- Ability to understand and solve different experimental designs such as RCBD, BIBD, PBIBD and Symmetric BIBD in emerging research problems.

UNIT – 1:

Gauss-Markov setup, estimability of linear parametric functions, normal equations and least squares estimation. Error and estimation spaces, variance and covariance of least square estimates. Estimation of Error variance, Linear Estimation in the correlated setup. Least squares Estimates with restriction on the parameters, simultaneous estimates of linear parametric functions.

10T & 12P

UNIT – 2:

Distibution of Quadratic Forms for normal variables, related theorem (without proof), Tests of hypotheses in general linear models, Tests of hypotheses for one and more than one linear parametric functions. ANOVA table, power of F – Test. confidence intervals and regions. multiple compararion procedures of, simultaneous confidence intervals.

8T & 8P

UNIT – 3:

Application of Gauss – Markov theory to the analysis of one-way, two – way classification without and with interaction with equal number of observations per cell. Estimation and related tests of hypoheses. Posthoc tests: Tukey, Scheffe and Bonferroni

12T & 8P

UNIT – 4:

General block designs: Two-way classification with unequal number of observations per cell without interaction. Concept of connectedness, balancedness and ortongonality and reted tests of hypotheses.

Balanced Incomplete bock designs (BIBD): Definition, parametric relationship, inter and intra-block analysis and Symmetric BIBD.

10T & 8P

UNIT – 5:

Missing Plot techniques and its application to RBD and LSD

Analysis of Covariance for one-way and two-way classification models, estimation of parameters and related tests of hypotheses and applications. Introduction to random effects models.

10T & 12P

(50 Lectures)

REFERENCES:

1. Chakravarthy M.C. (1971) Mathematics of Design and Analysis of Experiments. Asia Publishing House.
2. Joshi, D.D. (1987) Linear Estimation and Design of experiments. Wiley Eastern.
3. Kshirsagar, A.M. (1983) Linear Models, Marcel Dekker.
4. Das M.N. and Giri, N.C. (1988) Design and Analysis of experiments. Wiley Eastern. Ltd.
5. Montgomery D.C. (1991) Design and Analysis of experiments, John Wiley and sons.
6. Ogawa, J (1974) Statistical Theory of the analysis of the experimental design. Marcel Dekker.
7. Rao C.R. (1985) Linear Statistical Inference and its applications. Wiley Eastern.
8. Searle S.R. (1971) Linear Models. John Wiley & Sons.

Practical : PG86P402: Linear Models-Course Outcomes

Provides an idea of formulation of linear models and estimation of parameters. It facilitates the practical knowledge of ANOVA models and designs of experiments. Also gives the applications these tools in laboratory and agricultural experiments.

PG86T403: SQC AND RELIABILITY THEORY

PG86T403 : SQC & Reliability Theory-Course Outcomes

After completion of this course, the candidate

- will develop professional competence in applications of statistical tools in Industry.
- Will be able to develop control charts in various situations of quality improvement programs in industry.
- Will be able model and assess reliabilities of components/systems under different setups and configuration of components.
- Will be able to use these tools in finance, insurance, health science, etc.

UNIT – 1:

Process Control: Control charts for $\bar{x}$ and s, demerits, extreme values. Moving average control charts, geometric moving average control charts, group control charts, multivariate quality control charts, sloping control lines.

Use of sequential runs in constructing control limits, CUSUM charts and its relation with SPRT. Control charts versus ANOVA and Chi-square tests.

12T & 12P

UNIT – 2:

Product Control: single, double and multiple sampling plans for attributes, curtailed sampling plans. OC, AOQ, ASN and ATI functions for these plans. Designing single and double sampling plans. Chain sampling plans. Sampling plans by variables, Continuous sampling plans CSP1, CSP2, CSP3 and multilevel sampling plans.

10T & 12P

UNIT – 3:

Reliability Theory: Life distributions, survival functions, failure rate, Integrated hazard function, residual life time, mean residual life time. Common Life Distributions: binomial, negative binomial, Poisson, exponential, Weibull, gamma, Pareto and log-distributions. Notion of aging: IFR, IFRA, DMRL, NBU, NBUE classes of life distributions and their dual.

10T & 8P

UNIT – 4:

System reliabilities: Series, parallel, k-out-of-n, standby redundant systems and their reliabilities.

Maintenance policies: Age replacement policy and Block replacement policies and their characteristics. Reliability modeling: Introduction to shock models, stress-strength models and proportional hazard models.

8T & 8P

UNIT – 5:

Inference in Reliability: Type I and Type II Censoring schemes, likelihood functions based on these sampling schemes for exponential distribution. Reliability estimation (complete and censored samples) for exponential distribution, testing reliability hypotheses (exponential distribution).

12T & 8P

(50 Lectures)

REFERENCES:

1. Montgomery D.C. (1996) Introduction to Statistical Quality Control, Wiley, New York.
2. Grant E.L. (1980) Statistical Quality Control McGraw Hill, New York.
3. Weetherhill G.B. and Brow D.W. (1991) Statistical Process Control. Chapman and Hall, London.
4. Barlow R.E. and Proschan F (1975) Statistical Theory of Reliability and Life Testing. Holt-Rinhart and Winston, New York.
5. Sinha S.K. and Kale B.K. (1990) Life Testing and Reliability Estimation. Wiley Eastern, New Delhi.
6. Mann N.R, Schaffer R.F and Singpurwalla N.D. (1974) Methods for Statistical Analysis of Reliability and Life Data. Wiley New York.
7. Zacks S (1992) Introduction to Reliability Analysis. Springer - Verlag, New York.
8. J.V. Deshpande and Sudha G. Purohit (2005) Life time data: Statistical Models and Methods. World Scientific.

Practical : PG86P403 : SQC & Reliability Theory-Course Outcomes

Demonstrates the practices and working of control charts in different situations. Use of Professional knowledge of Acceptance sampling Plans and Reliability Theory in Industry and Health Science.

PG86P404 Project Work: Course outcomes

After completing the project work, the candidate will learn;

- Work in team, develop leadership quality, skill of information collection.
- Present the collected information with graphs, analyze and interpret the data, draw conclusions thereby helping administrators in framing policies.

KARNATAK UNIVERSITY, DHARWAD
DEPARTMENT OF STUDIES IN STATISTICS
SYLLABUS FOR

M.PHIL. IN STATISTICS

M.Phil Syllabus

M.Phil (Statistics)

The Course is of one term and 3 hours per week with one compulsory and one optional paper. Question paper shall have 6 questions of which 5 are to be attempted. Course emphasizes solving of-problem and critical thinking rather than routine derivation.

Codes	Title
MPHIL8601	Research and Teaching Methodology
MPHIL8602A	Nonparametric Inference
MPHIL8602B	Stochastic Models in Epidemiology
MPHIL8602C	Reliability Theory

Programme Outcomes:

The candidate will be prepared to

1. Know the foundations of research and research methodology.
2. Have rigorous review of literature in the area of specialization.
3. Understand writing of dissertation.
4. Prepare for further research.

Paper I: MPHIL8601

(Compulsory)

Paper – I : Research and Teaching Methodology :

Course Outcomes:

After studying this course, the candidate acquires knowledge of:

- Collecting data, literature review and dissertation writing.
- Some statistical softwares.
- Preobablity and its applications.
- Various sampling techniques and test procedures.

Collection of data from primary and secondary sources. Familiarity with RBI bulletin. Annual reports, statistical abstracts etc. Errors in the data types (sampling & non-sampling errors), detection and corrections. Fitting of courses goodness of fit, interpretation of empirical data. Uses and abuses of statistics. Writing of reports, research papers and theses.

Probability models of convergence, laws of large numbers central limit theorem. Markov chains and Martingales. Modelling analysis. Problem of validations. Estimates MLE and its properties, limitations, method of least squares.

Important principles of test procedure UMP, UMPU, LMP & UMP invariant tests. Some non-parametric tests, ARE, Bayes and minimax procedures, Sequential tests.

References:

1) B. K. Kale A First Course In Parametric Inference, Narosa Publishing House, 1999.
2) N. Balakrishnan And A Clifford Cohen Order Statistics And Inference: Estimation Methods, Academic Press, 1991.
3) E. L. Lahmann Testing Statistical Hypotheses, Wiley, 1986.
4) M. N. Murthy Sampling Theory And Methods, Statistical Publishing Society, 1977.
5) N.L. Johnson, S. Kotz And N. Balakrishnan Continuous Univariate Distributions, Vol. 1 And 2, John Wiley And Sons, 1994.

Paper – II: MPHIL02A **(Optional) Nonparametric Inference :**

After studying this course, the candidate will understand:

- Prilimanries of non-parametric inference.
- U-statistics and its applications
- Various non-pararmetric for different types of problems.
- Measure of performance of tests.

Introduction to nonparametric Inference. Empirical Distribution Function, Gllvenko Cantell theorems. Kolmogorov Goodness of fit test, Cramer Von-Mises test and Anderson – Darling test.

One sample U – Statistics, Kernel and Symmetric Kernel, two – sample U – Statistics, Asymptotic Distribution of U-Statistics, UMVUE property of U-Statistics, Asymptotic Distribution of linear function of order statistics.

Exchangeable almost surely distinct random variables and their rank vector. Joint and marginal distribution of ranks. Rank tests, locally most powerful rank test, linear rank statistics and their distributional properties under the null hypothesis.

One sample location problem, sign test, Wilcoxon signed rank test, two sample Kolmogorov – Sminov tests. Two sample location and scale problems, Wilcoxon - Mann – Whitney test, normal score test, median test.

Pitman's Asymptotic Relative Efficiency (ARE). ARE of vanous tests based on linear rank statistics.

Kruskal – Wallis K – sample test. Jonkheere – Terpestra test, Friedman's test and Pages test.

References :

1. Gibbons. J. D. (1985) : Nonparametric Statistical Inference, 2nd Edition, Marcel Dekker.
2. Hajek J and Sidak (1967): Theory of Rank Tests, Academic Press.
3. Fraser. D. A. S (1957) : Nonparametric Methods in Statistics, John Willey.
4. Randles R. H. And Wolfe D. A. (1979) : Introduction to the theory of Nonparametric Statistic, Wiley.
5. Hettmansperger T. P. (1984) Statistical Inference Based on Ranks, John Wiley and Sons.

Paper – II: MPHIL8602B **(Optional) Stochastic Models in Epidemiology:**

After studying this course, the candidate will be able to:

- Formulate of the model of epidemics.
- Learn stochastic control measures.
- Learn various simulation techniques.
- Estimate basic reproduction rates.

Unit – 1 : Introduction to Stochastic Dynamics and Stochastic Process :

Stochastic Dynamics, Stochastic Control : Covariance Control, PDF Control, Time Delayed Systems, FPK based Design, Optional Control.

Stochastic process : Definitions, Expectations, Vector process, Gaussian process; Stationary process; Scalar process, Vector process, Correlation Lenght ; Poisson process ; Compound Poisson process ; Markov process.

12 hrs

Unit – 2 : Stochastic Calculus :

Modes of convergence ; Stochastic Differentiation ; Statistical Properties of derivative process ; Stochastic Integration ; Statistical properties of Stochastic Integrals.

08 hrs

Unit – 3 Monte Carlo Simulation :

Introduction to Monte Carlo Simulation

Random to Monte Carlo Simulation; Linear Congruential methods, Transformation of uniform random numbers, Gaussian random numbers, Vector of random numbers.

Random Process; Gaussian white noise. Stochastic Differential Equation; Second order equations, State equation, Range-Kutta algorithm

10 hrs

Unit – 4: Introduction to Mathematical Epidemiology

History of Mathematical Epidemiology, Types of Epidemic models, Statistical significance of the infectious disease modelling.

05 hrs

Unit – 5 : Formulation of Epidemic Models and Parameterization

Introduction of Epidemic Model, Formulation of deterministic SIR model. The SIR model without demography, The Threshold phenomenon, Epidemic burnout, The SIR model with Demography, The equilibrium state, Stability properties, Oscillatory Dynamics, Mean age at infection, Infection induced mortality and SI models, Mortality throughout infection, dencity dependent transmission, Frequency dependent transmission, Mortality late in infection Fatal infection, Without immunity the SIS model, waning Immunity The SIRS Model, Sddition of latent period. The SEIR model, Discrete time models.

Parameterization, Estimation of Basic Reproduction number, Instantaneous reproduction number from reported case and surveillance data.

15 hrs

Total = 50 hrs

References :

1. Stochastic Dynamics and Control Jian-Qiao-Sun Volume-4, a monograph Series on Nonlinear Science and Complexity; Elsevier 2006.

2. Mathematical Approaches for emerging and re-emerging infectious diseases; The IMA volumes in Mathematics and its Application; Volume-126, Springer 2002.
3. Matt J. Keeling and P Rohani, Modeling Infectous diseases in Humans and Animals, Princeston University Press, 2008.
4. R. M. Anderson and R. M. May, Infectious Disease of Humans Dynamics and Control Oxford University Press, 2010.
5. Bailey N. J. T. (1975); The Mathematical Theory of Infectious Diseases and its Application, Griffin London.
6. Ross Sheldon M (2009), Simulation; Statistical Modeling and Decision Sciences, Academic Press.

Paper – III : MPHIL8602C **(Optional) Reliability Theory:**

Course Outcomes:

The candidate after completion of this course will be able to:

- Learn various failure models.
- Learn different life time distributions.
- Analyze and assess reliabilities of various systems.
- Know estimation procedures.

Reliability, Availability, Models of failure, IFR, IFRA, NBU, NBUE, DMRL, classes of life distributions. Their properties. Dual classes of these classes and their properties. Properties of Exponential, Gamma, Weibull, Lagnormal, Pareto, Truncated normal, Linear Failure rate, Makeham, Binomial families of life distributions.

Partial Ordering : Convex and Starrshaped orderings.

System Reliability: Coherent system, Series parallel, k-out-of-n, Standby systems. Application to uniform and exponential life distributions.

Replacement Policies; Ordinary, age and block replacement policies, their comparisons.

Reliability Models; Repair models, stress strength models, shock models, proportional hazard models, complies risks models.

Reliability Estimation; MLE, UMVUE, Bayes estimators of reliability. Non parametric estimation of reliability. Type I, II consoling, accelerated life resting.

Testing Reliability Hypotheses: Parametric and Non parametric tests for mean life and Reliability Hypotheses.

50 hrs

References :

1. Deshpande J. V. Purohit Sudha G. (2005) Life Time Data : Statisticsal Models and Methods World Scientific.
2. Klein J. P. And Moeschbereger M. L. (1999) Survival Analysis – Springer.
3. Baslow R. E. And Proschan P. F. (1975) Statistical Theory of Reliability – Holt Rinhalt.
4. Nelson W. B. (2004) Accelerated Testing Willy Series in Probability and Statistic

KARNATAK UNIVERSITY, DHARWAD
DEPARTMENT OF STUDIES IN STATISTICS
SYLLABUS FOR
PH. D. COURSE WORK

Program Outcomes:

The candidate will be prepared to

1. Find a specific problem to take up research.
2. Study previous research problems related to his/her area.
3. Write research papers and communicate the same for publication.
4. Organize and write thesis.

Codes	Title
PH8601	Research Methodology
PH8602	Cognate/ Core Subject: Statistics
AREA OF SPECIALIZATION	
PH8603A	Reliability Theory
PH8603B	Survival Models
PH8603C	Inferential Procedures And Applications
PH8603D	Applied Stochastic Models
PH8603E	Epidemic Models And Stochastic Modelling Of Epidemics
PH8603F	Stochastic Methods In Actuarial Science And Spatial Econometrics
PH8603G	Extreme Value Theory
PH8603H	Technical Demography
PH8603I	Stochastic Modeling And Optimal Control

Program Specific outcomes:

Candidate will be

1. Eligible to take up teaching and research.
2. Confident to work in private sectors.
3. Prepared to be a lifelong learner.
4. An asset to the society.

COURSE - I / PAPER - I

PH8601: RESEARCH METHODOLOGY

Course Objectives:

To equip the students with necessary statistical theory to undertake research in any area of statistics

Course Outcomes:

After studying this course, the candidate acquires knowledge of:

- How to select the problem, carryout review of literature, abstract and thesis writing.
- Finite sampling to collect data and some statistical software.
- Various distributions, estimation methods and test procedures, and their applications.

Unit – I

Concepts of Research: Review of literature, Problem selection, Reference work, writing abstract, Identifying key words, Thesis writing.

Sources of data, collection of data and data analysis with statistical softwares. Concepts of sampling: Stratified sampling, cluster sampling, multi – stage sampling. Randomized response techniques. 12hrs

Unit – II

Univariate distributions- Uniform, exponential, gamma, Weibull, logistic, extreme value, lognormal distributions. Distributions of order statistics from these distributions. Bivariate distributions- Exponentilal and normal, Multivariate normal distribution

Sampling Distributions: Central and Non – Central Chi – Square, t and F Distributions.

12 hrs

Unit – III

Consistency, unbiasedness, sufficiency and efficiency of estimators, completeness property, moment estimators, maximum likelihood estimators and their properties.

Shortest expected length, large sample and unbiased confidence intervals. Bayesian and fiducial intervals. 12 hrs

Unit – IV

NP lemma, MP test, MLR property, UMP, UMPU, α similar tests and tests with Neyman structure, LMP and UMP Invariant tests.

Wilcoxon signed rank test, Wilcoxon rank-sum test, Noether's Theorem and Pitman ARE.

12 hrs

References:

6) B. K. Kale A first course in parametric inference, Narosa Publishing House, 1999.
7) N. Balakrishnan and A Clifford Cohen Order statistics and inference: estimation methods, Academic press, 1991.
8) E. L. Lahmann Testing statistical hypotheses, Wiley, 1986.
9) M. N. Murthy Sampling Theory and methods, Statistical publishing society, 1977.
10) N.L. Johnson, S. Kotz and N. Balakrishnan Continuous univariate distributions, Vol. 1 and 2, John Wiley and sons, 1994.

COURSE - II / PAPER - II

PH8602: COGNATE /CORE SUBJECT: STATISTICS

Course Objectives:

To equip the students with probability concepts, stochastic process with their properties, aspects of multivariate analysis and linear models which are useful in modeling and analysis.

Course Outcomes:

In this Course the candidate will learn

- Various probability concepts.
- Various aspects of stochastic processes.
- Multivariate techniques and concepts of linear models.

Unit – I

Concepts of probability: Modes of convergence; characteristic functions, laws of large numbers, central limit theorem. Martingales. 12hrs

Unit – II

Finite and countable state Markov chains (MC), Chapman – Kolmogorov's equations, calculation of n-step transition probabilities and their limits, stationary distribution, classification of states.

Continuous time Markov processes: Kolomgorov-Feller differential equations, Poisson process, birth and death processes, Weiner process. 12 hrs

Unit – III

Principal component analysis (PCA), Factor analysis (FA), Canonical correlation analysis (CCA), Discriminant analysis and Cluster analysis. 12 hrs

Unit – IV

Gauss-Markov theorem, estimability of linear parametric functions, error and estimation spaces, application of Gauss-Markov setup to one- way, two-way (with one observation per cell and with interaction). Testing of general linear hypothesis.

12 hrs

References:

1) B. R. Bhat. Modern Probablity Theory, Wiley eastern, 1981.
2) K. Basu. Measure theory and probability, PHI, 1999.
3) S. Karlin and H. M. Taylor. A first course in stochastic process, academic press, 1975.
4) K. V. Mardia, J. T. Kent and J. M. Bibby. Multivariate Analysis, Academic press, 2000.
5) C. R. Rao. Linear statistical inference and its applications, Wiley eastern, 1985.

COURSE - III / PAPER - III
AREA OF RESEARCH
PH8603A: RELIABILITY THEORY

Course Objectives:

To know various reliability models, to assess reliabilities of these models and explore the applications of reliability models.

Course Outcomes:

The candidate after completion of this course will be able to:

Analyze and assess reliabilities of various systems. Can explore new applications of existing tools.

Unit-I

Reliability, availability, modes of failure, IFR, IFRA, NBU, NBUE, DMRL, classes of life distributions. Dual classes of these classes. Properties of Exponential, Gamma, Weibull, Lagnormal, Pareto, Truncated normal, Linear failure rate, Makeham, Binomial families of life distributions. Bivariate life distributions. 12 hrs

Unit-II

Structure functions, minimal path and minimal cut sets, reliability of systems of independent components, bounds on reliability functions – methods of inclusion and exclusion. System life as a function of component lives, expected system lifetime, upper bound on expected life of parallel System. Series models, repair models, stress strength models, shock models, proportional hazards models, competing risks models. 12 hrs

Unit-III

Truncation, convolution and mixture of life distributions. Poisson process, inter-arrival and waiting time distributions, conditional distribution of arrival times, estimating software reliability, non-homogeneous Poisson process, compound Poisson process, conditional and mixed Poisson process.

Simulation techniques for continuous random variables, discrete random variables, stochastic processes, non-homogeneous Poisson process, two dimensional Poisson processes. 12 hrs

Unit-IV

Reliability estimation: life testing experiments, Type I, II censoring, progressive censoring, accelerated life testing. MLE, UMVUE, Bayes estimators of reliability, non parametric estimation of reliability.

Testing Reliability Hypotheses: Parametric & Non parametric tests for mean life and Reliability Hypotheses. 12 hrs

References:

1) Cox, D. R. And Oakes, D (1990). Analysis of Survival Data. Chapman and Hall.
2) Deshpande J. V. Purohit Sudha G. (2005) Life Time Data: Statistical Models and Methods World Scientific
3) Johnson, N L, Kotz, S and Balakrishnan, N (1994). Continuous Univariate Distributions, Volumes 1 and 2. John Wiley and Sons.
4) Klein J. P. and Moeschberger M.L. (1999) Survival Analysis - Springer
5) Baslow R. E. and Proschan P. F. (1975) Statistical Theory of Reliability - Holt Rinhalt.
6) Nelson W. B. (2004) Accelerated Testing Willy Series in Probability and Statistic.
7) Ross, S. M. (2010) Introduction to Probability Models. 9th Edn. Academic Press.

PH8603B: SURVIVAL MODELS

Course Objectives:

To equip students with materials and techniques developed in several applied disciplines: vital statistics, epidemiology, demography, actuarial science, reliability theory, survival analysis, statistical methods, among others.

Course Outcomes:

After studying the course, students will have the knowledge of modeling survival data, its analysis and know its applications in different fields.

Unit-I

Survival Data: Sources of data, types of variables, exposure to risk, collection of survival data.

Ratios and Proportions: Rates of continuous processes - absolute rate, relative rate, average (central) rate, rates for repetitive events.

Mortality Measures: Concept of population exposed to risk, crude death rate, age specific death rates, cause specific mortality, standardized mortality ratio (SMR) - indirect standardization, direct standardization. Evaluation of person-years of exposed to risk in long-term studies.

Disease Risk and Ratio: Prevalence and incidence of a disease, association between disease and risk factor, relative risk and odds ratio. 12 hrs

Unit-II

Life Table: Basic definition and notations, force of mortality, mathematical relationships among life table functions, central death rates, interpolation for life table functions, approximate relationships between ${}_nq_x$and ${}_nm_x$, expected fraction of the last n years of life, exponential approximation, approximations to μ_x.

Concepts of Stationary and Stable Populations: Stationary population, stable population.

Construction of Life Tables: Construction of an abridged life table from mortality experience of a current population, estimation of ${}_nm_x$, ${}_nf_x$, ${}_nq_x$,evaluation of the life table functions, construction of a complete life table from an abridged life table, selection, select life tables, construction of select tables. 12 hrs

Unit-III

Survival Distribution Functions: Hazard function (force of mortality), conditional probabilities of death (failure), central rate, truncated distributions, expectation and variance of future lifetime, median of future lifetime, transformations of random variables, location-scale families of distributions, some survival distributions, some models of failure, series and parallel systems.

Empirical Survival Function: Estimation of survival function from grouped mortality data, joint distribution of the numbers of deaths, Greenwood's formula for the (conditional) variance of survival function, estimation of curve of deaths, estimation of central death rate and force of mortality . 12 hrs

Unit-IV

Theory of Competing Causes: Causes of death, basic assumptions, "Times Due to Die", overall and crude survival functions, crude and net hazard rates, crude probability distribution for cause, equivalence and non-identifiability theorems in competing risks, equivalent models of survival distribution, proportional hazard rates, heterogeneous populations: mixture of survival functions.

Multiple Decrement Life Tables (MDLT): Definitions of MDLT functions, relationships among functions of MDLT, crude forces of mortality, construction of MDLT from population (cross-sectional) mortality data, evaluation of ${}_naq_x$ and ${}_naq_{ax}$.

Simulation techniques for continuous random variables, discrete random variables, stochastic processes, non-homogeneous Poisson process, two dimensional Poisson processes.

12 hrs

References:

1) Basu, A. P. and Ghosh, J. K. (1978). Identifiability of the multinormal and other distributions under competing risk model. *J. Mult. Anal.* 8,413-429.
2) Chiang, C. L. (1968). *Introduction to Stochastic Processes,* Wiley, New York.
3) Cox, D. R. And Oakes, D (1990). Analysis of Survival Data. Chapman and Hall.
4) Deshpande, J V and Purohit, Sudha (2005) Life Time Data: Statistical Models and Methods. World Scientific
5) Eland Johnson and Johnson, N L (1999), Survival Models and Data Analysis, JOHN WILEY & SONS, INC. New York.
6) Gehan, E. A. (1969). Estimating survival functions from the life table. *J. Chron, Dis. 21,* 629-644.
7) Johnson, N L, Kotz, S and Balakrishnan, N (1994). Continuous Univariate Distributions, Volumes 1 and 2. John Wiley and Sons.
8) Ross, S. M. (2010) Introduction to Probability Models. 9th *Edn.* Academic Press.
9) Shryock, H., Siegel, J. S., and Associates (1973). *The Methods and Materials in Demography,* Chapter 14. U. S. Department of Commerce. Washington. D.C.

PH8603C: INFERENTIAL PROCEDURES AND APPLICATIONS

Course objectives:

To enable students with different tools in Bayesian inference, nonparametric inference, regression analysis and statistical quality control.

Course Outcomes:

In this course the candidate learns:

- Use of prior information to solve problems using Bayesian approach.
- Various concepts and procedures of nonparametric inference.
- Order statistics and their applications.
- Concepts and applications of regression analysis.
- Basics of statistical quality control.
- Various control charts for monitoring process characteristics.

Unit – I

Preliminaries of Bayes' principle, Types of loss functions, various priors, Bayes estimators under different loss functions, Bayesian interval estimation, Evaluation of estimate in terms of Bayes' risk, Prior odds, posterior odds, Bayes factor, Bayesian calculations, MCMC methods and other computer simulation methods. 12 hrs

Unit – II

Order statistics – distribution theory, Moments of order statistics, Recurrence relations between moments of order statistics, Probability integral transformation, Equal in distribution technique, Distribution – free statistics over a class, Counting statistics, Ranking statistics, Statistics utilizing counting and ranking. U – Statistics and it's limiting distribution, Linear rank statistics, distributional properties, asymptotic normality under the null hypothesis. Tests for one and two – sample location and scale problems, Pitman ARE. 12 hrs

Unit – III

Simple linear regression model, Least square estimation, hypothesis testing on slope and intercept, multiple regression model, Estimation of model parameters, Polynomial regression in one variable, nonparametric regression, kernel density estimator, robust regression, M-estimators, properties of robust estimators. 12 hrs

Unit – IV

Basics of statistical process control. Parametric, nonparametric and Bayesian control charts for process average and process variance, Synthetic control charts, use of sequential runs in constructing control charts, CUSUM charts, ARL, ATS, and measures of process capability ratio. 12 hrs

References:

1) Berger J.O. (1986) Statistical decision theory and Bayesian analysis. Springer – Verlag.
2) Ferguson T.S. (1967) Mathematical Statistics Decision Theoretic approach. Academic press, New York.
3) Gibbons J.D. (1971) Nonparametric Statistical Inference, McGraw Hill.
4) Grant E.L. (1980) Statistical Quality Control, Mc GrawHill.
5) Montgomery D.C. (1996) Introduction to Statistical Quality Control, Wiley, New York.
6) Montgomery D.C, Peck E.A and Vining C.G (2003) Introduction to Linear regression analysis, John Wiley and Sons.
7) Randles R.H. and Wolfe D.A. (1979) Introduction to theory on Nonparametric Statistics, John Wiley and Sons.

PH8603D : APPLIED STOCHASTIC MODELS

Objectives of the Course:

Objectives of the course is study the stochastic models and their developments.

Course Outcomes:

The course gives

- comprehensive knowledge about various stochastic population growth models.
- ability to understand research problems in stochastic demography.
- knowledge on some basic epidemic and competitive risks models.
- idea of stochastic optimal control, stochastic mortality models.
- ability of formation of research problems in their area of research.

Unit – I: Stochastic Population Models

Poisson process, birth and death process and Chiang's illness death process Deterministic and stochastic population growth model, deterministic and stochastic logistic growth models , deterministic and stochastic generalized logistic growth models, deterministic and stochastic gompertz growth models, deterministic and stochastic negative exponential growth models, deterministic and stochastic linear growth models.

Waiting Times and Their Statistical Estimation: General Waiting Time, Childbearing as a Repeatable Event, Poisson Process Model of Childbearing, Effect of Parity on Pure Period Measures, Multiple Births and Effect of Pregnancy on Exposure Time, Poisson Character of Demographic Events and Simulation of Waiting Times and Counts. Singh's waiting time distribution on the first birth and modification to the Singh's model. 12 hrs

Unit – II: Competing Risks and Life Tables

Measurement of competing risks and their inter-relationships. Independent and dependent risks, analysis of censored data: type – I and type – II censoring, progressive censoring.

Mortality in a cohort with competing risks of death, models of competing risks based on latent life spans, simple parametric models of competing risks, equivalent models of competing risks, eliminating causes of death and nonidentifiability.

Estimating a multiple decrement life table from period data, estimating single decrement life tables from multiple decrement life tables. 12 hrs

Unit – III: Stochastic Models with Optimal Control Theory

Stochastic Integration: The Itô Integral and One-Dimensional Itô Formula. Brownian Motion, Standard Brownian Motion, BM as a Markov Process, Constructing BM, BM Constructed from N(0, 1) Random Variables, BM as the Limit of Symmetric Random Walks and White Noise Process.

Continuous time maximum principle: model, constraints, objective function and optimal control problem. Dynamic programming: HJB equation, adjoint equation and economic interpretation.

Discrete time maximum principle. Models of optimal economic growth and stochastic optimal control of consumption-investment problem. Deterministic and stochastic epidemic models (SI and SIR), model of optimal epidemic control and solution by Green's theorem.

12 hrs

Unit – IV: Stochastic mortality models and estimation

Mortality models: Lee-Carter model, Lee-Carter model under a Poisson setting, Lee-Carter with cohort effects, age-period-cohort (APC) model, general APC model, model fitting and goodness of fit. Forecasting and simulation with stochastic mortality models

Estimation: Bayesian and Markov Chain Monte Carlo methods, Bayesian computations, Monte – Carlo simulation. Gibbs sampler, Metropolis – Hastings algorithm and hybrid approach.

12 hrs

REFERENCE:

1) Byron J.T. Morgan, Applied Stochastic Modeling, Arnold Publishers, London, 2000.
2) B.R. Bhat, Stochastic Models : Analysis and Applications, New Age International Publishers, New Delhi, 2000
3) S.M. Ross, Introduction to Probability Models, Sixth Edition, Academic Press, New York, 1997.
4) Taylor, H. M., Karlin, S.: An Introduction to Stochastic Modeling, 3rd edn. Academic, San Diego (1998)
5) Panik, M. J. Stochastic Differential Equations, John Wiley and Sons, 2017.

PH8603E: EPIDEMIC MODELS AND STOCHASTIC MODELLING OF EPIDEMICS

Objectives of the Course:

The purpose of the course is to get detailed knowledge of various epidemic models and their deterministic and stochastic formulations, solutions and estimation.

Outcome of the course are:

- learn different forms of epidemic models.
- acquire the knowledge of age-structured epidemics
- able to develop the epidemic models for vector-borne diseases
- learn discrete and continuous markov chain epidemic models
- develop the knowledge of deriving solutions for models of epidemic and endemic diseases.

Unit I: Epidemic Modelling

the early Kermack–Mckendrick model: basic model, threshold theorem and the final size equation. Applications- transmission by environmental contamination, virus dynamics, asymptomatic transmission model

Infection-age-dependent model: linear invasion phase and r_0, asymptotic behavior, the intensity of epidemic and its lower bound, pandemic threshold theorem, the initial value problem, the final size equation of the limiting epidemic, traveling wave solutions, endemic threshold phenomena.

The SIS model without demography, the SIR model with demography, vaccination and reinfection model. vector-transmitted diseases, basic model and invasion threshold, backward bifurcation of endemic steady states.

Some aspects of epidemiology in temporal and spatiotemporal domains. 12 hrs

Unit II: Age-Structured Epidemic Models

The SIR epidemic model with age structure, epidemic in a demographic steady state, horizontal transmission and its R_0, local stability of endemic steady state, epidemic in a stable population, threshold condition for invasion and endemicity, local stability of steady states, threshold principle and R_0, horizontal transmission, vertical transmission, threshold number in the normalized system, endemic threshold condition, infection-age dependency, the basic reproduction number and integral equation approach. Numerical methods for age-structured models: numerical method for the Mckendrick–Von Foerster model, numerical method for the age-structured sir model. 12 hrs

Unit III: Models in Vector-Borne Diseases

The vectors, the pathogen, epidemiology of vector-borne diseases, simple models of vector-borne diseases, deriving a model of vector-borne disease, reproduction numbers, equilibria, and their stability. Delay-differential equation models of vector-borne diseases: reducing the delay model to a single equation, oscillations in delay-differential equations, the reproduction number of the model with two delays and a vector-borne disease model with temporary immunity.

12 hrs

Unit IV: Stochastic Epidemic Models

Formulation of stochastic SIS and SIR epidemic models, numerical examples and properties of stochastic SIS and SIR epidemic models. probability of an outbreak, quasistationary probability distribution, final size of an epidemic, expected duration of an epidemic. Epidemic models with variable population size and numerical example. Other types of DTMC epidemic models, chain binomial epidemic models and epidemic branching processes.

Time series models: time domain: ACF and ARMA, frequency domain and wavelets. time series SIR model (TSIR): Stochastic variability, estimating parameters in dynamic models, estimation using the TSIR. 12 hrs

References:

1) Allen, L. J. S.: An Introduction to Stochastic Processes with Applications to Biology. Prentice Hall, Upper Saddle River, NJ (2003)
2) Brauer, F., Castillo-Ch´avez, C.: Mathematical Models in Population Biology and Epidemiology. Springer, Berlin Heidelberg New York (2001)
3) Diekmann, O., Heesterbeek, J. A. P.: Mathematical Epidemiology of Infectious Diseases: Model Building, Analysis and Interpretation. Wiley, New York (2000)
4) Hethcote, H. W.: The mathematics of infectious diseases. SIAM Rev., 42, 599–653 (2000).
5) Inaba, H. Age-structured population dynamics in demography and epidemiology, Springer, 2017.
6) Bailey, N.T. The Mathematical Theory of Infectious Diseases and its Applications (Charles Griffin & Co. Ltd, London, 1975).

PH8603F: STOCHASTIC METHODS IN ACTUARIAL SCIENCE AND SPATIAL ECONOMETRICS

Objectives of the Course:

Objective of the course is to acquire the detail knowledge of various stochastic methods in actuarial science and spatial econometrics.

Course Outcomes:

Outcomes the course includes

- detailed information about risks models and ruin theory.
- ability to understand competing risks models and formulation in research problems.
- basic knowledge on spatial econometrics.
- learning of spatial econometric models and their estimation.
- acquire knowledge of proposing research problems in their area of research.

Unit -I : Risk Models and Ruin Theory

On the distribution of surplus immediately after ruin under interest force, the risk model, on the distribution of surplus immediately before ruin under interest force, exponential claim size. Lundberg bound, asymptotic estimates of the low and upper bounds for the distribution of the surplus immediately after ruin under sub-exponential claims.

On the ruin probability under a class of risk processes - the risk model, the laplace transform of the ruin probability with finite time. 12 hrs

Unit -II: Compound Risk Models and Copula Decomposition

Individual risk model and compound risk model: the link between the compound risk model and the individual risk model, one theorem on excess-of-loss reinsurance, recursive calculation of compound distributions, one-dimensional recursive equations and bivariate recursive equations.

The compound Poisson random variable's approximation to the individual risk model: the existence of the optimal Poisson random variable, the joint distribution and evaluating the approximation error, the approximation to functions of the total loss , the uniqueness of the Poisson parameter.

Bi-variate copula decomposition: copula decomposition and application of the copula decomposition. 12 hrs

Unit -III: Spatial Econometrics

Characteristics of spatial data: spatial autocorrelation and spatial heterogeneity,the classical linear regression model and violation of typical assumptions, endogeneity, spatial autocorrelation of error term and heteroskedastic variance. The generalized linear model, the additive model, the basics of Bayesian statistics, Bayes' theorem , the markov chain monte carlo method, bayesian estimation of the classical linear regression model

Spatial weight matrix : specification of the spatial weight matrix, standardization of the spatial weight matrix.

Testing for global spatial autocorrelation, local spatial autocorrelation and spatial heterogeneity.

12 hrs

Unit -IV: Spatial econometric models

Spatial lag model and spatial error model, spatial durbin model and generalized spatial model, impact measures, models for spatial heterogeneity: varying coefficient models in space, parameter estimation of the spatial econometric models: ordinary least squares method, maximum likelihood method, bayesian method, conditional autoregressive model, spatial discrete choice models, spatial panel models. spatiotemporal autoregressive model.

Geographically weighted regression models. extended geographically weighted regression models, fast geographically weighted regression modelling and fast eigenvector spatial filtering modelling. 12 hrs

References:

1) Boland, P. J.: Statistical and probabilistic Methods in Actuarial Science, CRC Press, 2007.
2) Yamagata, Y. and Seya, H. Spatial Analysis Using Big Data, Academic Press, 2020.
3) Anselin, L. Saptial Econometrics: Methods and Models, Kluwer Academic Publishers, 1988.
4) Haining, R. Spatial Data Analysis: Theory and Practice, Cambridge University Press, 2003.
5) Dikson, D.C.M., Hardy, M. R. and Waters, H. R. Actuarial Mathematics for Life Contingent Risks, Cambridge University Press, 2009.

PH8603G: EXTREME VALUE THEORY

Objectives of the Course:

The candidates will have

- an introduction to the basics of modern extreme value theory and extreme value statistics.

- different methods of estimation including graphical methods of tail index.
- ability to model extremes in the various fields such as insurance, finances, meteorology, hydrology etc.

Course Outcomes:

Candidate will have

- Knowledge of order statistics
- Knowledge of extreme value theory for applying various fields such as insurance, finance, hydrology, meteorology etc.

Knowledge of estimation techniques for estimating parameters of extreme value models.

Unit-I: Order Statistics

Introduction, Joint distribution of order statistics, Marginal distribution of a single order statistics, Joint distribution of two order statistics, Distribution of range and other measures, Conditional distributions of order statistics. 12 hrs

Unit- II: Univariate Extreme Value Theory

Fluctuations of univariate maxima, Fluctuations of univariate upper order statistics, Some statistical models for univariate maxima, Limit distributions and domain of attraction**.** Limit distributions for the maximum (Frechet, Weibull, and Gumbel), Generalized Extreme Value (GEV) distributions. 14 hrs

Unit- III : Statistical Methods for Extremal Events;

Introduction, exploratory data analysis for extremes, Probability and quantile plots, The mean excess function, The Gumbel's method of exceedences, The return period, The parameter estimation of GEV Distribution; maximum likelihood estimation, Tail and quantile estimation.

14 hrs

Unit -IV : Applications of Extreme Value Theory:

Applications of extreme value theory in Insurance, Finance, Meteorology and Hydrology.

8 hrs

References:

1) Arnold B.C., Balakrishnan N.and Nagaraja, H. N.(1992). A First Course in Order Statistics. John Wiley, New York.

2) Cols, S.(2001). An Introduction to Statistical Modeling of Extreme Values. Springer Verlag, London.
3) Galambos, j.,(1987). The asymptotic theory of extreme order statistics. John Wiley, New York.
4) Samuel Kotz and Sarala Nadaraja (1999). Extreme Value Distributions. Imperial College Press, London.
5) Embrechts P., Kluppelberg C., and Mikosch T.(1997)Modelling extremal events for insurance and finance, Springer, Newyork.

PH8603H: TECHNICAL DEMOGRAPHY

Course Objectives:

The purpose of this course is to provide advance knowledge in the area of Fertility and Mortality, Urbanization, Migration and estimation & projection of these concepts. Students will get acquitted with new and advanced method of Demographic characteristics. An emphasis is also given on existing theories and their critical review.

Course Outcomes:

On completion of this course the student is able handle research problems on Fertility, Mortality, Migration and Urbanization and also students are trained to different method of Estimation and Forecasting.

Unit I : Population Dynamics

Definitions and concepts used in demography-rates ratios population growth population structure and composition. Population pyramid, Sources of Demographic data in India. Census, Sample registration System (SRS), Sample surveys, Vital registration, Fertility Surveys, National Family Health Surveys, Trends in Fertility, Mortality, Migration and Urbanization in India, Demographic Transition Policy Implications. 6 hrs

Unit II: Indirect Estimation of Fertility, Mortality and Life Table

Coale's fertility indices; Coale's-Trussel model of natural fertility; Singulate Mean Age at Marriage (SMAM), Parturition / Fertility (P/F) Method to estimate fertility; Decomposition of fertility; Age-pattern of Fertility, Estimating fertility through Parity Progression Ratio (PPRs), Calculation of Bongaarts' Indices, Rele's method of estimating fertility, Reverse survival method of estimating fertility. **Estimation of Mortality** – Estimation of infant and Child mortality from information on children ever born and children surviving (Brass, Sullivan, Trussel and Pathak). Estimation of Adult Survivorship probabilities from information on Orphanhood and widowhood, estimation of adult mortality using successive census age distribution. **Life Table -** Concepts, Assumptions, Construction of Life tables- Complete and Abridged -Various types – Force of Mortality, Uses of Life Tables. Single Decrement Associated Life tables, Multiple Decrement Life table – Multi State Life table, Applications Nuptiality Tables, Contraceptive Effectiveness. Working Life Tables. 18 hrs

Unit III : Migration and Urbanization

Introduction and Concepts, Measures of urbanization Level trend of Urbanization, problems associated with policies and programme affecting urbanization, Migration, Measures of Urbanization : Degree, Tempo and Concentration, Population and Distribution. Centrality and Hierarchy. Basic concepts, definitions, types of migration – Internal and International migration, Theories of Migration, Indirect method of estimating the Migration : Growth Rate method, Vital Statistics method, Life table and Census survival methods. 12 hrs

Unit IV : Population Estimation and Projections :

Methods of Population estimation and Projection – Mathematical and Cohort Component methods, Assumptions, on fertility, Mortality and Migration, Sub-National Population Projections – Various Methods, Urban Rural Growth Difference (URGD), Auto Regressive Integrated Moving Average (ARIMA) model, probabilistic projection model – Bayesian hierarchical model, Projection based on Artificial Neural Network and Fuzzy logic. Test for accuracy – Akaike's Information Criteria (AIC), Bayesian Information Criterion (BIC), Mean Absolute percentage error and Mean Algebraic Percentage Error. 12 hrs

References:

1) Asis Kumar Chattopadhayay and Anuj Kumar Saha (2012), Vinod Vasishtha, Books, Pvt. Ltd, New Delhi
2) Bogue, Donald J., Eduardo E. Arriaga, and Douglas L. Anderson, eds. (publication editor George W. Rumsey) (1993) Readings in Population Research Methodology. Chicago: United Nations Population Fund. Volume 3: Fertility Research, (All three chapters but selected pages).
3) Chiang C L (1993), The Life Table and its Applications, Krieger Pub Co.,
4) Coale A J & Trussell (1979), Model Fertility Schedule Variations in the Age Structure of Child Bearing in Human Population, Population Index, vol.40 Keyfitz N, Introduction to Mathematics of Population
5) Coale AJ and P Demeny (1983), Regional Model Life Tables and Stable Populations,

Academic Press, New York
6) K. Srinivasan, Analytical Models for the Study of Closed and Open Intervals United Nations, Manual IV
7) Keyfitz N (2005),Applied Mathematical Demography, DOI https://doi.org/10.1007/b139042
8) Palmore, James A. and Gardner, Robert W. (1983) Measuring Mortality, Fertility and Natural Increase: a Self-Teaching Guide to Elementary Measures. Honolulu: East-West Population Institute, East-West Center.
9) Pathak K B & Ram F (2016), Techniques of Demographic Analysis, Himalaya Publishing House, New Delhi.
10) Pollard, A.H., Yusuf, Farhat and Pollard, G.N. (1990) Demographic Techniques (third edition). Sydney: Pergamon Press.
11) Ramakumar R (1986), Technical Demography, John Wiley, New Delhi
12) Rogers, A (1975), Introduction to Multiregional Demography, Wiley and Sons, New York.
13) Rowland, Donald T. (2006), Demographic Methods and Concepts. New York: Oxford University Press.
14) Shryock,H. S., Siegel J S and Associates (1976), The Methods and Materials of Demography, ACADEMIC PRESS, INC. 1250 Sixth Avenue San Diego, California 92101

PH8603I: STOCHASTIC MODELING AND OPTIMAL CONTROL

Course Objectives:

The main objective of the course is to

- Critically read and analyze research articles featuring mathematical modeling-based epidemiological studies.
- Understand the concepts of Brownian motion and white noise.
- Manipulate and solve simple SDEs and understand the relationship between SDEs and PDEs.
- Demonstrates knowledge about the more complex simulation skills used for mathematical modelling in epidemiology.

Course Outcomes:

At the end of the course, the scholars should be able to:

- Describe the philosophy of model-building and the relationships between modeling and other forms of scientific investigation.

- Describe the defining features of infectious diseases, including incubation and latent periods, virulence, communicability, the "basic reproductive number", serial intervals, and concepts relevant to immunity.
- Provide the general ideas for constructing and analyzing stochastic models of epidemic spread and control.
- Interpret models outputs as information that help guide public health decision making.

Unit – I: Introduction to Stochastic Models and Stochastic Differential Equations

The basic theory and applications of stochastic models. Specification of Stochastic Processes. Markov chains: Classification of states and chains. Markov processes with discrete state space: Poisson process, Compound Poisson process, Renewal process. Branching processes. Markov processes with continuous state space: Wiener process, Ornstein-Uhlenbeck process. Ito Integrals, Stochastic Integrals and the Ito Formula, Stochastic Differential Equations, Existence and uniqueness theorem for stochastic differential equations, Weak and strong solutions.

18 hrs

Unit – II: Optimal Control Theory

Controllability, bang-bang principle, Linear time-optimal control, The Pontryagin Maximum Principle, Dynamic programming. Introduction to stochastic control theory, Optimal Control of Stochastic Partial Differential Equations: The Hamilton-Jacobi-Bellman (HJB) equation.

10 hrs

Unit -III: Stochastic Analysis of Epidemic models

History of Mathematical Epidemiology, Types of Epidemic models, Statistical significance of the infectious disease modeling. Formulation and analysis of deterministic epidemic models. Formulation and analysis of stochastic epidemic models. 10 hrs

Unit – IV: Simulation

Introduction to Monte Carlo Simulation, Markov Chain Monte Carlo Simulation, Gibbs sampler, Metropolis – Hastings algorithm. Bayesian computations through Markov Chain Monte Carlo Simulation. 10 hrs

References:

1) R M Anderson and R M May, Infectious Disease of Humans Dynamics and Control; Oxford University Press, 2010.
2) Bailey N J T The Mathematical Theory of Infectious Diseases and its Application, Griffin London, 1975.

3) Bernt Øksendal, Stochastic Differential Equations: An Introduction with Applications, Third Edition, Springer-Verlag Berlin Heidelberg GmbH, New York, 1992.
4) Bernt Øksendal , Optimal Control of Stochastic Partial Differential Equations, Stochastic Analysis and Applications Pages 165-179, 2006, doi.org/10.1081/SAP-200044467
5) B. R. Bhat, Stochastic Models: Analysis and Applications, New Age International Publishers, New Delhi, 2000.
6) Fleming,W.H. and Rishel,R.W., Deterministic and Stochastic optimal control, Springer Verlag, New York, 1975.
7) Gani J., Epidemic modelling and simulation, *Mathematics and Computers in Simulation* 32(1-2): 3-12, 1990.
8) Byron J.T. Morgan, Elements of Simulation, Chapman and Hall/CRC Press, 1984.
9) J. Medhi, Stochastic Process, New Age International Publishers, New Delhi, 2009.
10) B. D. Ripley, Stochastic simulation, J. Wiley, New York, 1987.
11) Ross Sheldon M, Simulation: Statistical Modeling and Decision Sciences, Academic Press, 2009.