HIMALAYAN GARHWAL UNIVERSITY UTTARAKHAND

A STUDY AND EVALUTION SCHEME
OF
MASTER OF SCIENCE - STATISTICS

M.Sc. (STATISTICS)

SUMMARY

Programme	M.Sc. (Statistics)
Duration	Two year (Four Semester)
Medium	English

HIMALAYAN GARHWAL UNIVERSITY, UTTARAKHAND

## SCHEME AND SYLLABUS OF M.Sc. STATISTICS (CBCS)

1. Duration : Two Academic Years –divided into four semesters.

2. Eligibility : B.A. / B.Sc./ BStat. with Mathematics as a subject. Reservation will be applicable as per university norms.

3. Course Structure: The courses will be based on Choice Based Credit System (CBCS) structure developed by the University. There will be four compulsory or elective core courses of MSTAtistics in each semester. Apart from these, one or more open electives / foundation course/ practical course will also be taken by a candidate according to CBCS regulations of the University.

4. Examination & Evaluation: The examination and evaluation patterns in each course will be according to the CBCS regulations of the University. The credit system shall be applicable in each course as follows:

- For each core course there will be 6 credits divided into L: T: P where L: Lecture; T: Tutorial; P: Practical. For example, courses can be assigned credits such as 6:0:0; 4:2:0; 4:0:2 etc. Each credit of lecture corresponds to one hour class per week. Tutorial and Practical will have one credit equal to two hours class work per week.
- Each open elective/ foundation course shall normally be of four credits.
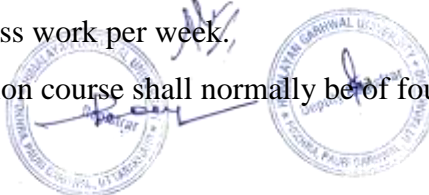
HIMALAYAN GARHWAL UNIVERSITY, UTTARAKHAND

BRIEF SCHEDULE OF THE COURSES

First Semester:

MSTA-101 Computer Fundamentals and statistical Programming using C Language
MSTA -102 Design of Sample Survey
MSTA -103 Measures and Probability Theory
MSTA -104 Discrete and Continuous statistical Distributions

Second Semester:

MSTA -201 Linear Estimation and Design of Experiments
MSTA -202 Theory of Estimation and Testing of Hypothesis
MSTA -203 Theory of Matrices, Quadratic forms and Linear Difference Equations
MSTA -204 Any one of the following:
    (a) Real & Complex Analysis
    (b) Stochastic Process & Survival Analysis

Third Semester:

MSTA -301 Industrial statistics: statistical Quality Control & Reliability Engineering
MSTA -302 Interval Estimation, Sequential Analysis & Non-Parametric Inference
MSTA -303 Operations Research
MSTA -304 Any one of the following:
    (a) Decision Theory & Bayesian Inference
    (b) Actuarial Science and Official statistics

Fourth Semester:

MSTA -401 Multivariate statistical Analysis
MSTA -402 Time Series Analysis and Population Studies
MSTA -403 Advanced Operations Research
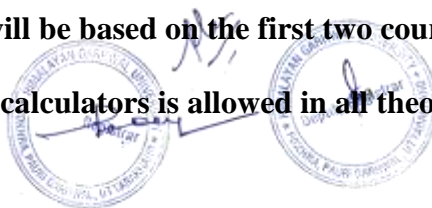**MSTA -404** Any one of the following:
    (a) Statistical Programming using R- Language
    (b) Information Theory
    (c) Econometrics

NOTE :- (I) Practical problems will be based on the first two courses mentioned above in each semester.
(II) The use of electronic calculators is allowed in all theory papers as well as practical exams.

HIMALAYAN GARHWAL UNIVERSITY, UTTARAKHAND

Marks Evaluation of M.Sc. STATISTICS

SEMESTER – I

Course Code	Title of Paper	L	T	P	Credits	Continuous evaluation marks	External Evaluation Marks	Total marks
MSTA 101	Computer Fundamentals and statistical Programming using C Language	4	0	2	6	30	70	100
MSTA 102	Design of Sample Survey	4	0	2	6	30	70	100
MSTA 103	Measure and Probability Theory	6	0	0	6	30	70	100
MSTA 104	Discrete and Continuous statistical Distributions	6	0	0	6	30	70	100
	TOTAL					120	280	400

SEMESTER – II

Course Code	Title of Paper	L	T	P	Credits	Continuous evaluation marks	External Evaluation Marks	Total marks
MSTA 201	Linear Estimation and Design of Experiments	4	0	2	6	30	70	100
MSTA 202	Theory of Estimation and Testing of Hypothesis	4	0	2	6	30	70	100
MSTA 203	Theory of Matrices, Quadratic forms and Linear Difference Equations	6	0	0	6	30	70	100
MSTA 204	Elective- I	6	0	0	6	30	70	100
	TOTAL					120	280	400

SEMESTER – III

Course Code	Title of Paper	L	T	P	Credits	Continuous evaluation marks	External Evaluation Marks	Total marks
MSTA 301	Industrial statistics: statistical Quality Control & Reliability Engineering	4	0	2	6	30	70	100
MSTA 302	Interval Estimation, Sequential Analysis & Non-Parametric Inference	4	0	2	6	30	70	100
MSTA 303	Operations Research	6	0	0	6	30	70	100
MSTA 304	Elective - II	6	0	0	6	30	70	100
	TOTAL					120	280	400

SEMESTER - IV

Course Code	Title of Paper	L	T	P	Credits	Continuous evaluation marks	External Evaluation Marks	Total marks
MSTA 401	Multivariate statistical Analysis	4	0	2	6	30	70	100
MSTA 402	Time Series Analysis and Population Studies	4	0	2	6	30	70	100
MSTA 403	Advanced Operations Research	6	0	0	6	30	70	200
MSTA 404	Elective - III	6	0	0	6	30	70	100
	TOTAL					120	280	400

DETAILED COURSES OF STUDY FOR M. Sc (STATISTICS)

FIRST SEMESTER

Paper 1: MSTA-101

Title: Computer Fundamentals and Statistical Programming using C Language

Need of the Course- In the modern age of computing, statistician uses computers for large and fast calculations. The advanced knowledge of computers and a scientific programming language is must for a student of Statistics.

Objective of the Course- The objective of this course is to introduce a student with basic know how of a computer system and to train him in the middle level computer programming language 'C'.

Learning Outcomes- After this course a student will be fully equipped with the techniques of developing his own computer programmes for most of the mathematical as well as Statistical methods.

Details of the syllabus and lecture division-

Contents of the Course	No. of Lectures
Unit-I **Basic Computer Structure :** Overview Of Computer System, Memory, C.P.U, I/O Units, Higher and Lower Levels Computer Languages. Basic Concepts of Computer Software, Compilers, Operating Systems and Statistical Software packages.	10
Unit-II **Programming Methods:** Problem analysis, Algorithms, Flow charts, Programming Designs, Criteria for a good programming method. **C Programming Language :** Basic features Of C Language, constants, Variables and data types, operators and expressions Arithmetic, relational and logical, input and output Statements with their formats, decision making Statements, branching and looping, Arrays, user and system defined functions, structures and pointers .	10
Unit-III **C Language Programs For :** (a) **Statistical Methods:** Measures of central tendency and Dispersion. Moments, Correlation, Regression, Curve fitting. Test of significance, t-test and Chi-Square test for given data. (b) **Matrix Algebra:** Addition, Multiplication, Transpose, Determinant and Inverse of Matrices. Solution of system of Linear Equations.	10
Unit-IV (c) **Numerical Analysis:** Types of errors in computation, roots of algebric and transcendental equations by Bisection and Newton-Rapson methods. Difference table, Newton's forward, backward, Lagranges formulae for interpolation, Numerical integration, Trapezoidal, Simpson's 1/3 rd and 3/8 th rules, Weddle rule.	10
Unit-V (d) **Properties of Statistical Distributions:** Calculating pmf and cdf of Uniform, Binomial, Poission, Normal, Cauchy, Gamma, Beta, Students' t and Chi-square distributions, Generation of random numbers from these distributions.	10

Total No. of Lectures- 50

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, Surprise Class Tests- The continuing evaluation process through home assignments, quizzes, and surprise tests will be done by the concerned teacher teaching that course at regular interval of time.

BOOKS RECOMMENDED:
 1. Balagurusamy E.: Programming in ANSI C , Tata Mc-Graw Hill Publishing
     company,Ltd. New Delhi (1998)
 2. Kanetkar Yashwant P.: Let us C , BPB Publications, New Delhi (1999)
 3. Kernighan B.W and :   The C Programming Language, Prentice Hall of India Pvt Ltd.
     Ritchie Dennis M.,   New Delhi (1997).
 4.   Raja Raman V.: Computer Programming In C, Prentice Hall of India Pvt. Ltd. New
                             Delhi (1999)
 5.   Gottfried Byron S.: Programming with C, (Schaum's Outline) Tata Mc Graw Hill
                           Publishing company Ltd. New Delhi (1999).

Paper 2: MSTA-102
Title: Design of Sample Survey

Need of the Course- Sampling is that part of Statistical practice concerned with the selection of individual observations intended to yield some knowledge about a population of concern, specially for the purpose of Statistical Inference.

Objective of the Course- The course aims to defining the population under study, its sampling frame, studying various sampling methods, determining the sample size and collecting data.

Learning Outcomes- The course will equip a student with the knowledge of adopting a suitable sampling plan in a variety of situations and develop Statistical inferences about the population.
Details of the syllabus and lecture division-

Contents of the Course	No. of Lectures
Unit-I **Introduction:** Census and sample surveys, advantages and disadvantages of sample surveys, Limitations of sampling, Basic principles of sample survey, Principle steps in sample survey, Sampling and non-sampling errors, Inter-penetrating, Sub-samples, Pilot survey. **Simple Random Sampling:** Simple random sampling, Sampling from finite populations with and without replacement, Unbiased estimation and confidence intervals for population mean and total, Simple random sampling of attributes.	10
Unit-II **Stratified Random Sampling:** Reasons for stratification , choice of strata , choice of sampling unit, stratified random sampling, estimation of population mean and its variance, choice of sample sizes in different strata, variances of estimates with different allocation, effects of deviation from optimum allocations, estimation of the gain in precision due to stratification, cost function, construction of strata.	10
Unit-III	

Systematic Sampling : Estimation of sample mean and its variance, comparison of systematic sampling with simple random and stratified sampling. **Ratio and Regression Estimation :** Ratio and regression methods of estimation, variances of the estimates, optimum property of ratio estimates, comparison among ratio and regression and simple and biased estimates.	10
Unit-IV **Cluster Sampling:** Estimates of mean and its variance for equal and unequal clusters, efficiency in terms of intra- class correlation, optimum unit of sampling, sampling with replacement, estimation of mean and its variance. **PPS Sampling:** Sampling techniques with varying probabilities for simple random sampling with and without replacement. Herwits Thompson Estimator, Mid Zuno Sen Sampling Scheme.	10
Unit-V **Multistage and Multiphase Sampling:** Introduction of Multistage sampling, Two Stage sampling with equal MSTAge units, Estimation of its mean and variance, Introduction of Multiphase sampling, double sampling for stratification.	10

**Total No. of Lectures-**   50

Teaching Method –
         The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizes, Surprise Class Tests - The continuing evaluation process through Home Assignments, Quizes, Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

BOOKS RECOMMENDED:
1. Chocran W.G., " Sampling Techniques" –Wiley Eastern Ltd. ,New Delhi.
2. Sukhatma P.v., "Sampling Theory of Survey with Applications"-Piyush Publications, New Delhi.
3. Raj D. Sampling Survey Theory- Narasa Publication House,New Delhi.
4. Murthy M.N. Sampling Theory and Methods- Statistical Publishing Society, Calcutta.
5. Daroga Singh and F.S.Chaudhary. Sampling Survey Design-Wiley Eastern Ltd.New Delhi.
6. Mukhopadhayay Parimal. Theory and Methods of Survey Sampling-Prentice Hall of India Ltd. New Delhi.
7. Foreman E.K. Survey Sampling Principles-Dekker Vol. 120.
8. Kish L. Survey Sampling.
9. Ravindra S.and Naruang S. Elements of Survey Sampling-Kluwar Academic Press.
10. Goon Gupta and Das Gupta. Fundamentals of Statistics . Vol. I. The world Press Pvt. Ltd. Calcutta.
11. Thomson M.E. Theory of Sample Survey. Chapman and Hall London.
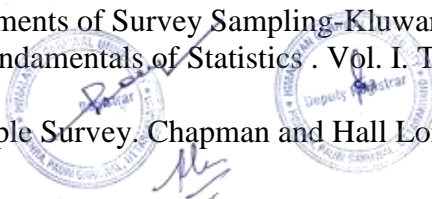
Paper 3: MSTA-103
Title: Measure and Probability Theory

Need of the Course- In our day-to-day lives, we deal with the uncertainties. Scientists and Researchers cope-up with these doubts by using the concept of probability. Probability theory and its models serve as a link between the descriptive and inferential Statistics, methodologies for assessing and quantifying chance.

Objective of the Course- The purpose of the course is to develop knowledge of the fundamental probability tools for quantitatively determining the risk. The application of these tools lies with the problems encountered in decision making.

Learning Outcomes- The students will be able to distinguish between probability models appropriate to different chance events and calculate probability according to these methods.

Details of the syllabus and lecture division-

Contents of the Course	No. of Lectures
Unit-I Classes of Sets, Fields, Sigma-Fields, Minimal Sigma Field, Borel Sigma Field, Sequence of Sets, Lim_sup & Lim_inf of Sequence of Sets, Measure, Proabability Measure, Conditional Probability, Bayes Theorem and Independent Events. Monotone classes, Measurable functions & properties, Lebseque measure	10
Unit-II Random Variables, Distribution Function of Random Variables, Joint distribution of two Random Variables, Marginal & Conditional Distributions, Expectation, Moment Generating Function, Probability Generating function, Characteristic Functions & their properties, Uniqueness, Inversion & Continuity Theorems of Characteristic Function.	10
Unit-III Chebychev's, Markov's, Basic, Kolmogorov's, Jenson's Inequalities. Three Series Criterion, Borel Zero-One Law, Schwartz inequality	10
Unit-IV Convergence of Sequences of Random Variables, Convergence in Distribution, Convergence in Probability, rth mean and Almost Sure, Borel-Cantelli Lemma	10
Unit-V Weak Law & Strong Law of Large Numbers for iid sequences, Bernoulli's, Khintchine's Theorems of Large Numbers, CLT for Sequence of Independent Random Variables under Lindeberg's & Liaounoff's Conditions, and CLT for iid Random Variables.	10

Total No. of Lectures- 50

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, Surprise Class Tests- The continuing evaluation process through home assignments, quizzes, and surprise tests will be done by the concerned teacher teaching that course at regular interval of time.

BOOKS RECOMMENDED:

1. Rohatgi V.K., "An Introduction to Probability Theory & Mathematical Statistics", Wiley Eastern Ltd. , New Delhi.
2. Mukhopadhyay Parimal., "Theory of Probability"-New Central Book Agency , Calcutta.
3. Hogg R.V.& Craig A.T., "Introduction to Mathematical Statistics"- Macmillion Publications, New York.
4. Mukhopadhyay P., "Mathematical Statistics"-New Central Book Agency Calcutta.
5. Srinivasan & Mehta., "Probability & Random Process"- Tata Mc-Graw Hill ,New Delhi.
6. Cramer H., "Mathematical Methods of Statistics"- Princeton University Press.
7. Baner H., "Probability Theory"- Narosa Publication House, New Delhi.
8. Parzen E., "Modern Probability Theory & Applications"- Willey Eastern Ltd. New Delhi.
9. Bhatt B.R., "Modern Probability Theory"- Wiley Eastern Ltd. New Delhi.
10. Pitman J., "Probability" –Narosa Publishing House, New Delhi.
11. Schaum Series, "Probability and Statistics"-Wiley Eastern Ltd. New Delhi.
12. Mukherjee K.K., Probability & Statistics- New Central Book Agency ,Calcutta
13. Mood, Graybill & Boss., "Introduction to the Theory of statistics".Mc-Graw Hill.
14. Bhatt V.N., "Elements of Applied Stochastic Process". John Wiley and Sons, New York.
15. Chandra,T.K. & Chatterjee:"A first course in probability".
16. Ross Sheldom. M.: "Introduction to probability models".
17. Richard,A. Johnson : "Probability and Statistics for engineers".

Paper 4: MSTA-104
Title: Discrete and Continuous Statistical Distributions

Need of the Course- After studying the concept of random variable; in probability theory, the knowledge of Statistical distributions is of prime need. It gives the idea, how the total probability is distributed among the possible values of random variables.

Objective of the Course- The main objective of the course is to provide the detailed knowledge of the characterization of all the useful discrete and continuous distributions.

Learning Outcomes- The students will be able to formulate the mathematical/Statistical models for real data set arising in various fields in order to analyse in respect of various useful characteristics of the populations.

Details of the syllabus and lecture division-

Contents of the Course	No. of Lectures
Unit-I Study with examples and applications of uniform, Binomial, Poisson , Geometric distributions. Their means, variances, measures of skewness, characteristics functions, moment and probability generating functions, r^{th} descending factorial moments and mode. The various important properties with their proofs related to these distributions including truncated and compound.	10

Unit-II Generations and applications of Negative Binomial, Multinomial and hyper geometric distributions. Their characteristics functions, moment and probability generating functions and descending factorial moment. Mean vectors, variance covariance matrix, marginal and conditional distributions of multinomial. Limiting compound and mode of negative binomial and hyper-geometric distributions. Theory of exceedency of hyper-geometric distribution.	10
Unit-III Distributions of rectangular, exponential, Gamma, Weibul, Beta, Cauchy and Log normal with their properties including proofs. Their mean variance, and characteristic functions. The characterizations related to above distributions along with their truncated and compound.	10
Unit-IV Sampling distributions of mean and variance, student's t, $\chi 2$, F and sample correlation coefficient (r) when population correlation is zero. Their means, variances, measures of skewness, characteristics and moment generating functions, limiting distributions and important properties with their proofs.	10
Unit-V Bivariate normal distribution with its applications and important properties. Standard bivariate normal distribution. Development of the formula of recurrence relation for moments and other important related problems to this distribution. Distributions of order Statistics, sample range, sample median, joint distributions of rth & s^{th} order Statistics. Distributions of minimum and maximum observations. Curve fitting by Orthogonal Polynomials.	10

Total No. of Lectures-   50

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizes, Surprise Class Tests - The continuing evaluation process through Home Assignments, Quizes, Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

BOOKS RECOMMENDED:
1. Rohtagi V.K., "An Introduction to Probability Theory and Mathematical Statistics".- Wiley Eastern Ltd., New Delhi.
2. Hogg R.V. , Carig A.T.," Introduction To Mathematical Statistics"- Mac-Millan Publication Ltd. New York.
3. Johnson N.L., Kotz, "Continuous Univariate Distribution V-Ist" –John Wiley & Sons , New York.
4. Johnson N.L., Kotz, "Continuous Univariate Distribution V-IInd" –John Wiley & Sons , New York.
5. Johnson N.L., Kotz , "Discrete Distributions" – John Wiley & Sons, New York.
6. Goon Gupta and Das Gupta, "Fundamentals of Statistics V-I" – The World Press Private Ltd., Calcutta.
7. Mood, Grabill & Bose, "Introduction To The Theory of Statistics" –Mc-Graw Hill.
8. Biswas S., "Topics in Statistical Methodology"- Wiley Eastern Ltd., New Delhi.

9. David H.A., "Order Statistics" – John Wiley and Sons , New York.
10. Mukhophadhyay Parimal. "Mathematical Statistics". New Central Book Agency. Calcutta.
11. Fawlkes, E.B., "A falio of distributions".

SECOND SEMESTER

Paper 5: MSTA-201
Title: Linear Estimation and Design of Experiments

Need of the Course- In many areas like Industrial, Biological, Agricultural, etc, the prime focus is to formulate the layout of the design of experiment so that appropriate information regarding the population can be gathered and analyzed. Thus, it is must to have the knowledge of the experimental techniques such as CRD, RBD, LSD, BIBD and factorial designs.

Objective of the Course- To provide background of the fundamental theories and practices of Statistical modeling and the analysis of observational, experimental and survey data, including continuous, binary and categorical data.

Learning Outcomes- Students should be able to understand the random behavior of experimental processes, particularly, scientific, engineering and industrial.

Details of the syllabus and lecture division-

Contents of the Course	No. of Lectures
Unit-I & II **Linear Estimation Theory:** Linear Estimation, Gauss-Markov set-up, Random & Mixed Models, Error & Estimation Space, Gauss-Markov Theorem, Least Square Estimates, Normal Equations, Residual Sum of Squares, BLUE, Conditions for Quadratic forms to be Chi-Square distributed, and Cochran's Theorems.	20
Unit-III **Design of Experiments** Analysis of Variance, One-way ANOVA, Two-way ANOVA and Three-way ANOVA with their layout and Statistical analysis, Analysis of Covariance for a one-way layout with concomitant variable, Analysis of Covariance for a RBD layout with concomitant variable.	10
Unit-IV Principles of design of experiments, Uniformity trials, completely randomized, Randomized block and Latin square designs including missing plot techniques and their efficiency comparison, Split plot and strip plot designs	10
Unit-V Factorial experiments (2^n , 3^2, 3^3 systems only), Complete and Partial confounding, balanced incomplete block designs with parametric relations and analysis under a fixed effect model.	10

Total No. of Lectures-   50

Teaching Method –
      The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, Surprise Class Tests- The continuing evaluation process through home assignments, quizzes, and surprise tests will be done by the concerned teacher teaching that course at regular interval of time.

BOOKS RECOMMENDED:

1. Biswas Suddendu, A Linear Model Approach To Regression Analysis & Its Application- New Age International Publication.
2. Bapot R.B. , Linear Algebra and Linear Model- Cambridge University Press.
3. Goon Gupta and Das Gupta, Fundamentals Of Statistics- S. Chand & Company, New Delhi
4. Das and Giri, Design Of Experiments- Wiley Eastern Ltd. New Delhi.
5. Chochran W.G. and G.M. , Experimental Design- John Wiley and Sons New York.
6. Waynee Lee, Experimental Design and Analysis- W.H. Freema and Company San Francisco
7. Kempthorne, O , The Design and Analysis Of Experiment- Wiley Eastern Ltd, New Delhi .
8. Winer B.J. , Statistical Principles In Experimental Design- Tata Mc-Graw Hill Publishing Co.
9. Federer W.T , Experimental Design- Oxford & IBM Publishing Company.

Paper 6: MSTA -202
Title:Theory of Estimation and Testing of Hypothesis

Need of the Course- In Statistics population parameters describe the characteristics under study. These parameters need to be estimated on the basis of collected data called sample.

Objective of the Course- The purpose of estimation theory is to arrive at an estimator that exhibits optimality. The estimator takes observed data as an input and produces an estimate of the parameters.

Learning Outcomes- This course will make a student learn the various properties of a good estimator as well as techniques to develop such estimators from both classical and Bayesian point of view.

Details of the syllabus and lecture division-

Contents of the Course	No. of Lectures
Unit-I & II **Properties of good estimators:** consistency, unbiasedness, efficiency, sufficiency and completeness, minimal sufficiency, Crammer Rao-Inequality its applications and examples, Characterization of distribution admitting sufficient Statistics, Rao-Blackwell theorem and Lehman-Scheffe' theorem, Uniformly minimum variance unbiased estimation. Exponential and Pitman family of distributions.	20
Unit-III **Methods of Estimation**: Method of maximum likelihood, Moments, Minimum Chi-Square, properties of M.L.E, existence of a best asymptotically normal estimate under regulatory conditions, Hazor Bazar theorem.	10
Unit-IV & V **Testing of Statistical Hypothesis**: Simple & Composite Hypothesis, Concept of Critical Regions, Test Functions, Two Types of Error, Power of the Test, Level of Significance, Neyman-Pearson Lemma & its Generalization, Uniformly Most	20

| Powerful Tests, UMP Test of One-sided Hypothesis for Distributions with Monotone Likelihood Ratio Test, Randomized Tests, UMPU, Types A, A1 Critical Regions, Likelihood Ratio Test, Similar Test. | |

Total No. of Lectures-   50

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizes, Surprise Class Tests - The continuing evaluation process through Home Assignments, Quizes, Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

BOOKS RECOMMENDED:
1. Goon A.M. , Gupta M.K., & Das Gupta B. An Outline of Statistical Theory V-II- The World Press Private Ltd., Calcutta.
2. Rohtagi V.K. An Introduction to Probability Theory and Mathematical Statistics- Wiley Eastern Ltd., New Delhi.
3. Hogg R.V. & Craig A.T. Introduction to Mathematical Statistics- Mac-Millan Publications Ltd. New York.
4. Lehmann E.L. Theory of Point Estimation – John Wiley & Sons New York.
5. Mood Grabill & Bose Introduction to the Theory Of Statistics- Mc-Graw Hill
6. Rohtagi V.K. Statistical Inference- Wiley Eastern Ltd. New Delhi.
7. Kalbfleiseh J.G. Probability and Statistical Inference Vol-I & II- Springer- Verlag New York
8. Saxena & Surendran Statistical Inference – S.Chand & Co Ltd., New Delhi.
9. Jacks S. The Theory Of Statistical Inference- Chapman & Hall London.
10. Kale B.K. Parametric Inference – Narosa Publishing House , New Delhi.
11. Mukhopadhyay P. Mathematical Statistics- New Central Book Agency , Calcutta.

Paper 7: MSTA-203
Title: Theory of Matrices, Quadratic forms and Linear Difference Equations

Need of the Course- This course forms the mathematical background for courses such as multivariate analysis, design of experiments, quadratic forms etc. So, the study of the course is of prime need.

Objective of the Course- To enable the readers to have a proper appreciation of the subject matter and to fortify their confidence in the understanding and application of methods

Learning Outcomes- After studying this course the students will be able to understand the basic concepts of matrices, their types and their mathematical operations leading to the estimation of parametric models.

Details of the syllabus and lecture division-

Contents of the Course	No. of Lectures
Unit-I **Matrices:** Algebra of matrices, matrices associated with a given matrix. Symmetric, Skew-symmetric, Hermitian and Skew–Hermitian matrices with their properties, Inverse of a matrix and the related theorems, Trace of a matrix, Idempotent, Involutory and Nilpotent matrices.	10
Unit-II Definition of rank, Elementary transformations and their impact on rank, Elementary matrices and their inverse, Normal form of a matrix and related important theorems, rank of a product of two matrices. Vector and Vector–space, linearly dependent and independent set of vectors and the related theorems, Sub-Space of an n-vector space, Basis of a sub space.	10
Unit-III System of linear homogeneous and non homogeneous equations, Necessary and sufficient conditions for the consistency of a system of non-homogeneous equations. Characteristic matrix, equation and roots of a matrix, Caley Hamilton theorem, Unitary and Orthogonal matrices, Inner product of vectors and length of a vector , orthogonal vectors.	10
Unit-IV Quadratic forms, Congruence of quadratic forms, Canonical form, Definite, semi-definite and indefinite quadratic forms, Orthogonal reduction of a real symmetric matrix, Simultaneous reduction of a pair of quadratic forms.	10
Unit-V **Linear Difference Equations:** Difference equation with its applications and properties in various fields. Solutions of the first order linear homogeneous/non-homogeneous difference equations with conMSTAnt coefficient by operator and trial methods. Solutions of the linear homogeneous difference equations with variable coefficients.	10

Total No. of Lectures- 50

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, Surprise Class Tests- The continuing evaluation process through Home

Assignments, Quizzes, Surprise Tests will be done by the concerned teacher teaching that course at

regular interval of time.

BOOKS SUGGESTED:
1. Vashishtha A.R, "Matrices:", Krishna Prakashan Media Pvt.Ltd.
2. Narayan, S., "A Text Book Of Matrices", S Chand & Co Ltd., New Delhi.
3. Bishwas S., "A Text Book Of Matrix Algebra", Khanna Publications, New Delhi.
4. Goel & Mittal, " Numerical Mathematics"
5. Saran,N., "Introduction to matrices"
6. Sharma, M.M., "Linear Difference Equations." Krishna Prakashan
7. Goel and Mittal, "Numerical Methods."

8. Gupta and Aggarwal, "Linear Difference Equations."

Any one of the following:
Paper 8: MSTA-204 (a)
Title: Real and Complex Analysis

Need of the Course- It is a branch of mathematical analysis dealing with the set of real and complex numbers which plays the vital role to follow the complexities of Statistical topics in their research studies.
Objective of the Course- The main object of studying the course is to follow up various properties and important formulae related to real and complex numbers with their proofs.
Learning Outcomes- The students will be able to apply the tools studied in the course in his further studies of Statistical courses and research investigation.
Details of the syllabus and lecture division-

Contents of the Course	No. of Lectures
Unit-I **Real Analysis:** Concepts of continuity and differentiability , Roll's theorem with its geometric interpretation, Lagrange's and Cauchy's mean value theorems, Taylor's development of a function in a finite form with Lagranges's, Cauchy's and Roche's forms of remainders.	10
Unit-II Double and Multiple integrals, Change of order of integration, Beta and Gamma functions, Dirichlet's multiple integrals and its Liouville's extension. Convergence of Improper integrals.	10
Unit-III Laplace and Laplace-Stieltjes transforms with their important properties. Inverse Laplace-transform and various methods to obtain it. Mean and Variance in terms of L.T. Solution of simple differential and differential-difference equations by using L.T.	10
Unit-IV **Complex Analysis:** Fundamental operations of complex numbers, Properties of the moduli and arguments, Geometric representation of algebric operations. Limites, continuity and differentiability of a complex valued function. Analytic function, Cauchy-Riemann equations. Harmonic function, Methods for construction of analytic function.	10
Unit-V Complex integration, Cauchy's fundamental theorem, Cauchy's integral formula and its extension, Cauchy's integral formula for the first and nth derivative of analytic function, Liouville's , Taylor's and Laurent's theorems. Zeros and various types of singularities of an analytic function. Contour integration.	10

Total No. of Lectures- 50

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, Surprise Class Tests- The continuing evaluation process through Home

Assignments, Quizzes, and Surprise Tests will be done by the concerned teacher teaching that course at

regular interval of time.

BOOKS RECOMMENDED :
1.Shanti Narayan : A course of mathematical analysis.
2. Rudin, W. : Principles of mathematical analysis.
3. Richardson, C.H.: An Introduction to calculus of finite differences.
4.Goel & Mittal : Numerical mathematics.
5.Sharma ,J.N. : Infinite series.
6. Phillips, E.G. : Functions of a complex variable.
7. Sharma, J.N. : Functions of a complex Variable.
8. Sharma,J.N. & Vasishtha,A.R.: Real analysis.
9. Gupta,R.K.: Theory of functions of a complex variables.
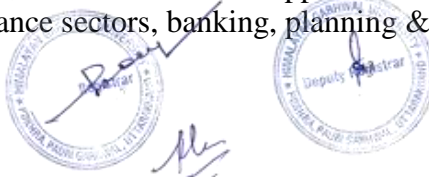10. Spiegel, M.R.: Complex variables.

Paper 8: MSTA 2 04(b)
Course Title: Stochastic Process & Survival Analysis

Need of the Course- The mathematical description of a random phenomenon as it changes in time is a stochastic process. Since the last century there has been greater realization that stochastic (or non-deterministic) models are more realistic than deterministic models in many situations, the knowledge of the course contents is essential.

Objective of the Course- Keeping in view the need of the course, the aim is to study the different types of stochastic process, random walk, renewal theory with their wide applicability in social science, economics and management sciences.

Learning Outcomes- The knowledge of the course can be applied in various diverse fields such as operations research, finance and insurance sectors, banking, planning & forecasting.

Details of the syllabus and lecture division-

Contents of the Course	No. of Lectures
Unit-I **Stochastic Process:** Markov Chain, Champman Kolmogorov equation, classification of States, criteria for ergodic, persistent null and transient States, Stationary distributions, limit theorems on transient and persistent null States.	10
Unit-II Pure birth process, pure death process, birth and death processes, Yule-Furry process, Stationary process, Kolmogorov forward and backward equations, Counting Process, Poisson process, Generalized, filtered and compound Poisson process,	10
Unit-III Random walk, Wiener processes, Gaussion processes, mean function and covariance, Kernal strictly Stationary and covariance Stationary processes, Processes with independent increments, Renewal equations.	10
Unit-IV & V **Survival Analysis:** Definition of survival function, Failure-rate and hazard function, Mean residual life and their relationship, Problems of life testing, Estimation of average life and survival function with type-I and type-II censored experiments, Discussion of different procedures followed in life testing experiments, Estimation of survival parameters with Exponential, Weibull, Normal, Log-normal and Gamma models for failure data.	20

Total No. of Lectures- 50

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, Surprise Class Tests- The continuing evaluation process through home assignments, quizzes, and surprise tests will be done by the concerned teacher teaching that course at regular interval of time.

BOOKS RECOMMENDED:

1. Cox, D.R. and Miller,H.D. : The Theory Of Stochastic Processes.
2. Deeb, J.L.   : Stochastic Processes.
3. Srinivasan, S.K. and   : Stochastic Processes.
   Menata,K.K.

4. Bartlett, M.S.   : Introduction to Stochastic Processes.
5. Prabhu, N.U.   : Stochastic Processes.
6. Sinha, S. K.: Reliability and Life Testing.
7. Lawless, J. F.: Statistical Models and Methods for Life Time Data.
8. Mann Scheffer   : Methods for Statistical Analysis of Reliability and Life Data.
    and Singupurwalla

THIRD SEMESTER

Paper 9: MSTA -301
Title: Industrial Statistics: Statistical Quality Control & Reliability Engineering

Need of the Course- In engineering and manufacturing, the knowledge of this course deals with assurance and failure testing in design and production of products or services to meet or exceed customer requirements.

Objective of the Course- The objective of the course is to have the knowledge of various methods to control the quality of a product and to increase the reliability of a device/system.

Learning Outcomes- The students will be able to apply the fundamental tools/methods in various industrial plants.
Details of the syllabus and lecture division-

Contents of the Course	No. of Lectures
Unit-I **Quality Control:** Concept of quality and meaning of control, Product and Process controls. Concept of 3-sigma limits. Modified and Specifications limits. Different types of control charts like $\bar{X}$, R, np, p and c with their applications in industry.	10
Unit-II 100% inspection sampling, sampling inspection v/s 100% inspection. Single, Double, Multiple and sequential sampling plans for attributes. OC, AOQL, ASN and ATI curves. Concept of producer's and consumer's risk, AQL and LTPD. Variable sampling plans.	10
Unit-III **Reliability Theory:** Concepts of reliability, point wise and steady State availabilities, hazard rate, failure and bath-tub failure rate curve. Constant, linearly increasing and non-linear increasing hazard models.	10
Unit-IV Gamma, normal, log-normal and truncated normal failure laws. Mean time to system failure (MTSF) and mean time between failures. Series, parallel, k-out of n, series-parallel, parallel-series, and non-series parallel configurations. Concept of redundancy, comparison of component, unit and Standby redundancies	10
Unit-V Analysis of reliability and MTSF of n-unit Standby redundancy. Concepts of repair and preventive-maintenance (P.M.). Analysis of-n non-identical unit series system	10

with constant failure and repair rates, two identical unit active and passive redundant systems with constant failure and repair rates. Concepts of imperfect switching device, priority and non-priority repairs, preemptive repeat and preemptive resume repairs.

Total No. of Lectures: 50

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizes, Surprise Class Tests- The continuing evaluation process through Home

Assignments, Quizes, Surprise Tests will be done by the concerned teacher teaching that course at

regular interval of time.

BOOKS RECOMMENDED:

1. Barlow R.F. and Proschan F. Mathematical Theory of Reliability- John Wiley and Sons.
2. Sri Nath L.S. , Mathematical Theory Of Reliability- Affiliated East West Press Pvt. Ltd.
3. Balagurusamy , E. , Reliability Engineering- Tata Mc- Graw Hill Publications , New Delhi.
4. Govil A.K. , Reliability Engineering.
5. Duncan A.J., Quality Control and industrial Statistics
6. Ekambaram , Acceptance Sampling
7. Bowkder A.K. and Goode H.P. , Sampling Inspection by Variables- Mc-Graw Hill Edition.
8. Montogomary, Introduction to Statistical Quality Control- John Wiley and Sons , New York
9. Goon Gupta and Das Gupta, Fundamentals Of Statistics Vol-II . The World Press Pvt. Ltd.
10. Dimitri Kececioglu, Reliability and Life Testing Hand Book- Prentice Hall PTR , New Jersey
11. Suddendu Biswas, Statistics Of Quality Control- Prentice Hall Of India , Pvt. Ltd.
12. Ernest,G.Frankel : System reliability and risk analysis.

Paper 10: MSTA-302
Title: Interval Estimation, Sequential Analysis & Non-Parametric Inference

Need of the Course- Sometimes, the number of observations required by the procedure to reach a decision is not fixed in advance of the experiment. In such cases, inferences can be drawn by the use of the sequential procedure. More so, when we do not know the form of the population, non-parametric Statistical tools like Sign, Run, Median, Mann-Whitney, K-S and Chi-squire tests are used to infer about the characteristics of the population.

Objective of the Course- The aim of the course is to provide deeper knowledge of the inferential Statistics such as sequential estimation, OC and ASN functions, loss and risk functions, one, two and k-samples non-parametric tests.

Learning Outcomes- The students will be able to demonstrate knowledge and understanding of the principles and theory of Statistical inference and the ability to formulate Statistical hypothesis and to use theory to estimate model parameters.

Details of the syllabus and lecture division-

Contents of the Course	No. of Lectures
Unit-I **Interval Estimation:** Confidence Regions, Best Confidence Intervals, Shortest Confidence Intervals, General Method of finding Confidence Interval, Tolerance confidence interval and Relationship with the Testing of Hypothesis. Examples based on Normal, Poisson, Exponential and Gamma distributions.	10
Unit-II & III **Sequential Analysis:** Sequential probability ratio test and their applications to Binomial, Poisson, Normal, Exponential and Gamma. O.C. and A.S.N. functions and their applications, termination theorem of SPRT with probability one. Wald's fundamental identity and its uses.	20
Unit-IV & V **Non-Parametric Inference :** Probability Integral Transformation, Estimation Of Quantiles, Construction of Confidence Interval for Population Quantiles, Estimation & Testing, Test for Randomness, Test based on Runs & Sign for one & two samples problems, Median test, Wilcoxon and Mann-Whitney tests. Kolmogorov-Smrinov test for one and two samples.	20

Total No. of Lectures- 50

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, Surprise Class Tests-
The continuing evaluation process through home assignments, quizzes, and surprise tests will be done by the concerned teacher teaching that course at regular interval of time.

BOOKS RECOMMENDED:
1. Wald A, "Sequential Analysis"- John Wiley and Sons New York
2. Gibbons J.D., "Non- parametric Statistical Inference". McGraw Hill International Edition.
3. Siegel S, "Non Parametric Statistics for Behavioral Sciences"- Mc Graw Hill Edition.
4. Mood Grabill and Boss, "Introduction to the Theory of Statistics".-Mc-Graw Hill .
5. Goon A.M.,Gupta M.K. and Das Gupta B. "An Outline of Statistical Theory V-II".-The World Press Private Ltd. Calcutta.
6. Rohatgi V.K., "An Introduction to Probability Theory and Mathematical Statistics- Wiley Eastern Ltd. New Delhi.
7. Wald A. Statistical Decision Functions"- John Wiley and Sons, New York.
8. Ferguson T.S., "Mathematical Statistics-A Decision Theoretic Approach"- Academic Press.

Paper 11: MSTA -303
Title: Operations Research

Need of the Course- It is purely applied course having wide applicability towards business/industries.

Objective of the Course- To provide the ideas of formulating mathematical modeling and their optimum solution in the context of practical problems belonging to Govt./Pvt. Sectors.

Learning Outcomes- The knowledge of the contents of this course will help businessman/industrial managers to take optimum decisions/solutions to the executive type of problem.

Details of the syllabus and lecture division-

Contents of the Course	No. of Lectures
Unit-I	
Introduction: Definition and scope of operations research, Different types of models used in OR. Various phases of OR. **Allocation Problems:** Mathematical formulation of L.P.P, Graphical method to solve a L.P.P, Convex set, Convex combination and extreme points. Simplex method to solve a L.P.P with slack, Surplus and Artificial variables. Construction of dual of a L.P.P.	10
Unit-II	
Inventory Control: Problems of inventory and the various costs associated with inventory control. EOQ models with uniform/non-uniform rate of demands when shortages are allowed and not allowed while the replenishment of inventory is instantaneous. EOQ models with uniform rate of demands when shortages are allowed/not allowed and replenishment of the inventory is non-instantaneous. Single period inventory models with no set up cost and demand rate is discrete/continuous r.v. Newspaper Boy problem.	10
Unit-III	
Transportation Problem: Mathematical formulation of a transportation problem, Northwest corner rule, unit cost penalty method and method of matrix minima. Optimality test, Unbalanced transportation problem, Degenerecy in transportation problems. **Assignment Problems:** Assignment problems, formulation of these problems and their solutions, Unbalanced Assignment problems.	10
Unit-IV	
Game Theory: Criteria of pure and mixed strategies, pay-off matrix and saddle point. Solution of zero sum two person games- 2×2, $2 \times n$, $m \times 2$ and $m \times n$ by minimax and maximin technique, arithmetic method, algebraic method, dominance principle, graphical method matrix method, sub-game method and linear programming techniques.	10
Unit-V	
Queueing Theory: Introduction of the queuing system, Various components of a	10

queueing system. Pure Birth Process; Pure Death Process, Birth and Death Process,	

M/M/1 , M/M/1(Generalised), M/M/1 FCFS/K/∞, M/M/C, Ample Server models, Erlang's loss model, Machine repair problem.	

Total No. of Lectures- 50

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes and Surprise Class Tests- The continuing evaluation process through Home Assignments, Quizzes and Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

BOOKS RECOMMENDED:

1. Gass, S.I , A Linear Programming Methods and Applications- Mc-Graw Hill Publishing Co.
2. Taha , Operations Research and Introduction- Mac-Millan Publishing Co., New York.
3. Churchman C.W., Ackoff R.L. and Arnoff E.L., Introduction To Operations Research- John Wiley and Sons , New York.
4. Saaty T.L., Mathematical Methods Of operations Research, Mc-Graw Hill Book Co., New York.
5. Satty, T.L., Elements Of Queueing Theory – Mc-Graw Hill Book Co.,. New York.
6. Yaspan A., Sasieni M.,& Fiedman L., Linear Programming methods and Applications- John Wiley and Sons New York.
7. Churchill R.V. , Operation Mathematics-Mc- Graw Hill Kogakusha Ltd., Calcutta.
8. KantiSwaroop and Manmohan, Operations Research- S.Chand and Co. , New Delhi.
9. Sharma S.D., Operations Research- Pragati Prakashan, Meerut.
10. Gupta R.K., Linear Programming- Krishna Prakashan Media Pvt.Ltd., Meerut.
11. Jones A.J., Games Theory- John Wiley and Sons- New York.
12. Straffin E.D., Games Theory and Strategy- The Mathematical Association Of America.
13. Thomas L.C., Games Theory and Applications- John Wiley and Sons, New York.
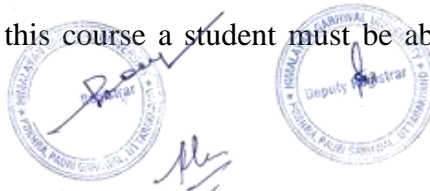
Any one of the following:

Paper 12: MSTA -304 (a)
Title: Decision Theory & Bayesian Inference

Need of the Course- A part from estimating parameters, Statistics also attempts to test the conventional wisdom or guesses or conjectures made by experienced experimenters. Testing of hypothesis does exactly that.

Objective of the Course- The course aims to include the methods of testing of hypothesis and its counterpart interval estimation both in classical as well as Bayesian frame work.

Learning Outcomes- After learning this course a student must be able to develop tests and confidence intervals for population parameters.

Details of the syllabus and lecture division-

Contents of the Course	No. of Lectures
Unit-I **Decision Theory**: Loss function, Risk function, Randomised and Non-Randomised Decision Rules, Admissible Decision Rule, Complete, Essential complete and minimal complete classes of decision rules and their relationship, Minimax and Bayes decision rules, Estimation testing viewed as decision rule problem, Bayes and minimax estimators. Minimax and Bayes tests in simple cases.	10
Unit-II & III **Bayes Estimation:** An outline of Bayesian framework, Bayes Theorem, Types of priors, Conjugate prior, proper and improper prior, subjective prior etc., Methods of obtaining priors, Types of loss functions, Squared error loss function, Absolute error loss, O-1 loss, Asymmetric loss functions such as LINEX and Entropy loss functions, Mixture of loss functions, Computation of posterior distribution, Bayesian calculations, Monte Carlo Technique, Approximation methods, Emperical method, Gibbs sampler.	20
Unit-IV **Bayesian Interval Estimation:** Credible Intervals, Highest Posterior Density Regions, Interpretation of the Confidence Coefficient of an Interval & its Comparison with the Coefficient of Classical Confidence Intervals.	10
Unit-V **Bayesian Hypothesis testing**: Specification of the Appropriate Form of the Prior Distribution for a Bayesian Testing of Hypothesis Problem, Prior Odds, Posterior Odds, Bayes Factor, Bayesian Information Criterion(BIC).	10

Total No. of Lectures-   50

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, Surprise Class Tests- The continuing evaluation process through Home Assignments, Quizzes, Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

BOOKS RECOMMENDED:
1.   Mood Grabill and Boss, "Introduction to the Theory of Statistics"-Mc-Graw Hill .
2 . Goon A.M.,Gupta M.K. and Das Gupta B., "An Outline of Statistical Theory V-II"-The World Press Private Ltd. Calcutta.

3. Rohatgi V.K., "An Introduction to Probability Theory and Mathematical Statistics" Wiley Eastern Ltd. New Delhi.
4. Hogg R.V. and Craig A.T., "Introduction to Mathematical Statistics"-Macmillion Publications.
5. Wald A., "Statistical Decision Functions"- John Wiley and Sons.New York.
6. Ferguson T.S., "Mathematical Statistics"-A Decision Theoretic Approach- Academic Press.
7. Robert, C.P., Casella, "Monte Carlo Statistical methods" G. Springer, New York.
8. Berger, J.O., "Statistical Decision Theory and Bayesian Analysis", Springer Series.

Paper 12: MSTA-304 (b)
Course Title: Actuarial Science& Official Statistics

Need of the Course- One needs to develop and apply Statistical tools to study the aging variables and there covariates so that optimum financial policies for human life security can be formulated.

Objective of the Course- To introduce and expose students to application of Statistics in Actuarial field and to make them aware of various government Statistical offices, their policies for there functioning with optimization.

Learning outcomes- After studding this course the students will be able to understand theories and methodologies related to population and survival analysis as applied to Actuarial Science.

Details of the syllabus and lecture division-

Contents of the Course	No. of Lectures
Unit-I Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curate future lifetime, force of mortality. Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.	10
Unit-II Multiple life functions, joint life and last survivor Status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws	10
Unit-III Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.	10
Unit-IV Distribution of aggregate claims, compound Poisson distribution and its applications. Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous Compounding.	10
Unit-V Present official Statistical system in India relating to population, agriculture, industrial production, trade and prices, methods of collection of official Statistics, their reliability and limitation and the principal publications containing such Statistics, various official agencies responsible for data collection and their main functions. Functions and organization of CSO and NSSO, Agricultural Statistics, area and yield Statistics. National income and its computation, utility and difficulties in estimation of national income.	10

Total No. of Lectures-   50

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, Surprise Class Tests- The continuing evaluation process through Home Assignments, Quizzes, Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

BOOKS RECOMMENDED:
1. N.L. Bowers, H. U. Gerber ,J. C. Hickman, D.A. Jone and C.J. Nesbitt, (1986), 'Actuarial Mathematics,'
   Society of Actuarias, Ithaca, Illiois, U.S.A. Second Edition (1997). Section 1- Chapters: 1,2,8,9,11.
2. Spurgeon E.T. Life Continuances, Cambridge University Press.
3. Neil, A. Life Continuances, Heinemann.
4. M.R. Saluja: Indian Official Statistics . ISI publication.
5. Basic Statistics relating to the Indian Economy (CSO) 1990.
6. Statistical system in India (CSO) 1975.
7. Guide to official Statistics (CSO) 1999.
8. Principles and accommodation of National Populations Census UNIESCO.
9. Panse, V.G., Estimation of crop Fields (FAO).

FOURTH SEMESTER

Paper 13: MSTA-401
Title: Multivariate Statistical Analysis

Need of the Course- Due to the multi-dimensional nature of the data arising from the various fields, it is then primary need to infer about the multivariate techniques such as factor analysis, discriminate analysis, cluster analysis, and principal component analysis, etc. which are used in reduction, factorization and classification and analysis of the high-dimensional data.

Objective of the Course- To provide practical training and experience in the application of the theory to the Statistical modeling of data from real applications, including model identification, estimation and interpretation.

Learning Outcomes- The students should be able to demonstrate knowledge and understanding of parametric and non-parametric tests, discriminate analysis, factor analysis, and principal component analysis in medical, industrial, engineering, business and many other scientific areas.

Details of the syllabus and lecture division-

Contents of the Course	No. of Lectures
Unit-I Multivariate Normal Distribution, Distribution of Random Vector $Y = CX$ when C is a Non-Singular Matrix, Distribution of p-variate Random Vector $Z = DX$ when D is a qxp matrix of rank q(<p), Marginal & Conditional Distributions of a Sub-Vector of a Normally Distributed Vector, Moment Generating Function & Characteristic Function of a Normally Distributed Random Vector, Additive property of a p-variate Normal Distribution.	10
Unit-II Maximum Likelihood Estimators of Mean Vector and Co-Variance Matrix,	10

Distribution of the Sample Mean Vector, Distribution of the Quadratic Form, $Y'T^{-1}Y$ when $Y \sim Np\,(0, T)$, and T is Non-Singular, Tests & Confidence Regions for μ when Λ is known, Sufficient Statistics for μ and Λ.	
Unit-III	
Hotelling's T^2 Statistic as a function of Likelihood Ratio Criterion, its Distribution, Applications and Invariant property, Mahalanobis D^2 Statistic, Wishart Distribution with derivation & its properties.	10
Unit-IV	
Problem of Classification into one of two categories, Procedures of Classification into one of two populations with known density functions, Priori probabilities & costs of misclassification, Best Regions of Classification into one of two known Multivariate Normal Populations, Fisher's Discriminant Functions.	10
Unit-V	
Multiple regression Analysis, Multiple & Partial Correlations and their Estimation, Distributions of Partial & Multiple Correlation Coefficients in Samples from Multivariate Normal Populations in the Null cases only. Concepts of MANOVA and Principal Component Analysis.	10

Total No. of Lectures- 50

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, Surprise Class Tests- The continuing evaluation process through home assignments, quizzes, and surprise tests will be done by the concerned teacher teaching that course at regular interval of time.

BOOKS RECOMMENDED:

1. Anderson T.W., "Multivariate Analysis"- Wiley Eastern Ltd., New Delhi.
2. Giri N.C., "Multivariate Statistical Inference" – Charles Griffin and Co.Ltd. London
3. Rao, C.R, "Advanced Statistical Methods In Biometric Research"- John Wiley and Sons.
4. Morrison , D.F. "Multivariate Statistical Methods" Mcgraw Hill .International Edition.
5. Roy, S.N. "Some aspects of Multivariate analysis".
6. Singh,B.M. "Multivariate Statistical analysis".

Paper 14: MSTA-402
Title: Time Series Analysis and Population Studies

Need of the Course- Time series is a sequence of data points measured at, often uniform, intervals. It is needed to forecast the future events. For social and economic purposes one needs to study the societies or groups in view of their birth and mortality rates. Demography studies the measurement of population processes.

Objective of the Course- The course aims to study various models and components of time series analysis for forecasting purposes. It also gives the study of distribution of population with respect to birth, migration, aging and death.
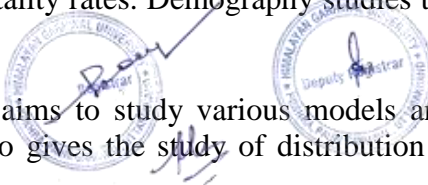
Learning Outcomes- After studying this course one learns the most important technique of forecasting used in economic analysis. It will also equip a student with tools used in population studies.

Details of the syllabus and lecture division-

Contents of the Course	No. of Lectures
Unit-I & II **Time Series Analysis:** Objects, Decomposition, Tests of Randomness, Trend Component, Polynomial, Logistic, Gompertz, Log-normal trend functions, Smoothing of Moving average , Spencer's formulae and effects, Variate Difference method, Measurement of Seasonal and Cyclical functions, Peridogram and Harmonic Analysis.	20
Unit-III **Stationary and Non Stationary Time Series:** Concepts, Auto regression, Autocorrelation, Partial Autocorrelation and Correlogram analysis.	
Unit-IV and V **Population Studies:** Sources of Demographic data, Limitations and uses of demographic data, Vital rates and ratios, Definition, Construction and uses, life	
tables, Complete and Abridged construction of life table from vital Statistics and census returns, Uses of life tables. Logistic and other population growth curves, Measure of fertility, Gross and Net reproduction rates, Stationary and Stable population theory. Uses of Lotka's Stable population theory in estimation of demographic parameters, Methods of Inter-censal and Post-censal estimation.	30

Total No. of Lectures-   50

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines.   Finally he/she will make a quick revision of today's new contents taught.

 Home Assignments, Quizzes, Surprise Class Tests- The continuing evaluation process through Home Assignments, Quizzes and Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

BOOKS RECOMMENDED:
1. Goon Gupta and Das Gupta, Fundamentals Of Statistics V-II, The World Press , Pvt.Ltd.,
2. Kendall M .G.., The Advanced Theory Of Statistics Vol-I & II- Charles Griffin & Co Ltd.,
 3. Wald H, Demand Analysis- The Academic Press
4. Johnsonton J, Economic Models –John Wiley and Sons , New York.
5. Cox P.R., Demography- Cambridge University Press.
6. Biswas, S : Stochastic processes in demography and applications.

Paper 15: MSTA-403
Title: Advanced Operations Research

Need of the Course- The course is designed to introduce students to idea of various types of programming, sequencing and replacement problem of items that deteriorate.

Objective of the Course- To give students a firm foundation in the advanced optimization techniques for the solution of the problems covered in course contents.

Learning Outcomes- To develop the ability to formulate fairly complex optimization problems in the context of practical problems.

Details of the syllabus and lecture division-

Contents of the Course	No. of Lectures
Unit-I	
Integer Linear Programming: Concept of integer linear programming problems, Gomory's all IPP techniques, Branch and Bound method for solving IPP, Applications of IPP.	10
Unit-II	
Quadratic Programming: Structure of quadratic programming, Kuhn-Tucker conditions, Wolfe's modified simplex and Beale's methods for solving a Q.P.	10
Unit-III	
Revised Simplex Method: Standard forms for revised simplex method, computational procedure for Standard form-1 and Standard form-2.	10
Unit-IV	
Job Sequencing : Assumptions, Solution of sequencing problems, Processing n jobs through two machines, Processing n jobs through three machines, Processing two jobs through n-machines, Processing n-jobs through n-machines.	10
Replacement Problem: Replacement policy of items whose maintenance cost increases with time constant and varying scrap value.	
Unit-V	
CPM-PERT: Development of CPM/PERT techniques, events and activities, application of CPM/PERT techniques . Network diagram representation, rules for drawing Network diagram, Critical Path Analysis, Project evaluation and review technique (PERT).Updating of the project, resource allocation.	10

Total No. of Lectures- 50

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes and Surprise Class Tests- The continuing evaluation process through Home Assignments, Quizzes and Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

BOOKS RECOMMENDED:
1. Gass, S.I , A Linear Programming Methods and Applications- Mc-Graw Hill Publishing Co.
2. Taha , Operations Research and Introduction- Mac-Millan Publishing Co., New York.
3. Churchman C.W., Ackoff R.L. and Arnoff E.L., Introduction To Operations Research-
   John Wiley and Sons , New York.

4. Saaty T.L., Mathematical Methods Of operations Research, Mc-Graw Hill Book Co., New York.
5. Satty, T.L., Elements Of Queueing Theory – Mc-Graw Hill Book Co.,. New York.
6. Yaspan A., Sasieni M.,& Fiedman L., Linear Programming methods and Applications- John Wiley and Sons New York.
7. Churchill R.V. , Operation Mathematics-Mc- Graw Hill Kogakusha Ltd., Calcutta.
8. KantiSwaroop and Manmohan, Operations Research- S.Chand and Co. , New Delhi.
9. Sharma S.D., Operations Research- Pragati Prakashan, Meerut.
10. Gupta R.K., Linear Programming- Krishna Prakashan Media Pvt.Ltd., Meerut.
11. Jones A.J., Games Theory- John Wiley and Sons- New York.
12. Straffin E.D., Games Theory and Strategy- The Mathematical Association Of America.
13. Thomas L.C., Games Theory and Applications- John Wiley and Sons, New York.

Any one of the following-
Paper 16: MSTA 404(a)
Title: Statistical Programming using R- Language

Need of the Course- The primary needs are to acquaint students with the functionalities of the components of the computer and to abreast them with the latest developments in the computing world thereby enabling them to perform data analysis effectively and efficiently in any specialized Statistical software.

Objective of the Course- The objective of the course is to enhance the programming skills and working knowledge of available numerical and Statistical software.

Learning Outcomes- The students will be able to use advanced Statistical software's such as R, S-Plus, SPSS, etc. for the analysis of complex Statistical data coming from the various fields like industry, marketing, finance, agriculture and business.

Details of the syllabus and lecture division-

| Contents of the Course	No. of Lectures
Unit-I & II	20
Introduction & Data Handling in R: Introduction to the Statistical software R, Data objects in R, Creating vectors, Creating matrices, data frame, Manipulating data, Accessing elements of a vector or matrix, Lists, Addition, Multiplication, Subtraction, Transpose, Inverse of matrices. Functions operated on data objects. Merging of two or more data frames, Importing data, Read and Write files. Boolean operators. Handling of missing and duplicated cases/observations. Writing own functions.	
Unit-III	10
R-Graphics: Types of plotting functions and their applications. Histogram, Box plot, Steam and leaf plot, Scatter plot, marplot, Plot options; Multiple plots in a single graphic window, Adjusting graphical parameters. **Looping:** For loop, repeat loop, while loop, if command, if else command.	
Unit-IV & V	20
Statistical Methods: Univariate and Multivariate Statistics; Mean, Median, Variance, Covariance, Correlation, Distribution functions in R, maximum likelihood estimation using R-functions. Model fitting, Parametric and Non-parametric tests, Chi-square tests: goodness of fit, Contingency tables, Normality tests in R. Analysis of Variance (ANOVA): Factor variables, ANOVA table, Multiple comparisons; Simple and Multiple Linear regression analysis, Generalized linear model: logistic and Poisson regressions, A simulation application: Monte Carlo Integration, Random sampling, Bootstrapping.	

Total No. of Lectures- 50

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, Surprise Class Tests- The continuing evaluation process through home assignments, quizzes, and surprise tests will be done by the concerned teacher teaching that course at regular interval of time.

BOOKS RECOMMENDED:

1. Alain F. Zuur, Elena N. Ieno, and Erik Meesters, "A Beginner's Guide to R", Springer, 2009, ISBN:978-0-387-93836-3.
2. Michael J. Crawley, "Statistics: An Introduction using R", Wiley, 2005, ISBN 0-470-02297-3.
3. Phil Spector, "Data Manipulation with R", Springer, New York, 2008, ISBN 978-0-387-74730-9.
4. Maria L. Rizzo, "Statistical computing with R", Chapman & Hall/CRC, Boca Raton, FL, 2008, ISBN 1-584-88545-9.
5. W. John Braun and Duncan J. Murdoch, "A first course in Statistical programming with R", Cambridge University Press, Cambridge, 2007, ISBN 978-0521872652.
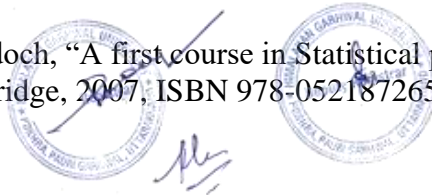
Paper 16: MSTA 404(b)
Title: Information Theory

Need of the Course- Information theory studies the quantification storage and communication of information. In the era of information technology, the flow of information is huge. We therefore need tools to filter and analyze the information.

Objective of the Course- To introduce information theoretic concepts for the transmission, processing, utilization and extraction of information. To impart the knowledge of coding, theory for increasing the efficiency and reducing the error of data communication.

Learning Outcomes- After studding this course a student will be equipped with the concepts of entropy, uncertainty and coding that can be applied to numerous fields of modern technology.

Details of the syllabus and lecture division-

Contents of the Course	No. of Lectures
Unit-1 Concept of Entropy and information measures, Formal requirements of the average uncertainty, Shanon's measure of information and its properties, Joint and Conditional Entropy, Relative entropy and mutual information, Uniqueness of the entropy function Jensen's Inequality and its consequences, Fano's Inequality, Asymptotic Equipartition Property, Entropy Rate.	10
Unit-II Elements of encoding, redundancy and efficiency, binary codes , Shanon Fano Encoding ,Necessary and sufficient condition for noiseless coding, Average length of encoded message Kraft Inequality, McMillan Inequality, Optimal Codes, Huffman Code, Fundamental theorem of discrete noiseless coding.	10
Unit-III & IV Differential Entropy, Joint and Conditional Differential Entropy, Properties of Differential and Relative Entropy, Differential Entropy of distribution, Relationship of Differential Entropy to Discrete Entropy, Differential entropy bound on discrete entropy Entropy Optimization Principles, Maximum Entropy Principle, MaxEnt Formalism, Maximum Entropy Distribution.	20

Contents of the Course	No. of Lectures
Unit-V	10
Channel capacity, symmetric channels, Binary symmetric channel, Binary Erasure channel, Properties of channel capacity. Joint AEP theorem, channel coding theorem (Statement only), Fano's inequality and converse to the coding theorem, Hamming codes.	

Total No. of Lectures- 50

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, Surprise Class Tests- The continuing evaluation process through home assignments, quizzes, and surprise tests will be done by the concerned teacher teaching that course at regular interval of time.

BOOKS RECOMMENDED:

1. Robert Ash   Information Theory
2. Reza, F.M.   An Introduction to Information Theory
3. Mathai, A.M. and Rathie, P.N.   Basic Concepts in Information Theory and Statistic.
4. Kullback, S.   Information Theory and Statistic.

Paper 16: MSTA 404(c)

Course Title: Econometrics

Need of the course- One needs to develop and apply Statistical methods to study the economic policies of an organizations or Government. Econometrics combines economic theory with Statistics to analysis and test economic relationships.

Objective of the course- The purpose of this course is to give students a solid foundation in econometric techniques, various functions for economic analysis and future forecasting.

Learning outcomes- After studding this course one learns to develop models for economic forecasting both from micro as well as macro economics points of views. This course will help to rigorously understand issues in connecting data, Statistics and economic theory.

Details of the syllabus and lecture division-

Contents of the Course	No. of Lectures
Unit-I	10
A review of least squares and maximum likelihood methods of estimation of parameters in classical linear regression model and their properties (BLUE), Generalized Least Square Models, construction of confidence regions and tests of hypothesis, prediction, use of extraneous information in the form of exact and stochastic linear constraints, Restricted regression and mixed regression methods of estimation and their properties. Testing of extraneous information.	
Unit-II	10
Multicollinearity, its effects and deletion, Remedial methods including the ridge regression. Specification error analysis, inclusion of irrelevant variables and deletion of dominant variables, their effects on the efficiency of optimization procedure.	

Unit-III	
Hetroscedasticity, consequences and tests for it, estimation procedures under hetroscedastic disturbances. Auto correlated disturbances, Effects on estimation of parameters, Cochran Orcutt and Prais-Winston transformation, Durbin-Watson test. Errors-in-varables model, Inconsistency of least squares procedures, Consistent estimation of Parameters by instrumental variables.	10
Unit-IV & V	
Seemingly unrelated regression equation model, Ordinary least squares and feasible generalized least squares methods and their asymptotic properties.Simultaneous equation model, problem of indentification, A necessary and sufficient condition for the identifiability of Parameters in a structural equation, Ordinary Least squares, indirect least squares, two Stage least squares and limited information maximum likelihood method, K-class estimators, Asymptotic properties of estimators.	20

Total No. of Lectures- 50

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, Surprise Class Tests- The continuing evaluation process through home assignments, quizzes, and surprise tests will be done by the concerned teacher teaching that course at regular interval of time.

BOOKS RECOMMENDED:

1. Tinburger, J.   : Economic Policy, Principles and Design Chs. 1 and 3.
2. Baumel, W.J.   : Economic Theory and Operations Analysis.
3. Henderson, R.E. and Quandt, J.M.   : Micro- Economic Theory, A Mathematical Approach.
4. Louis Phlips   : Applied Consumption Analysis.
5. Kelvin Lancester   : Mathematical Economics.
6. Dorfman, Samulsob and Solow   : Linear Programming & Economic Analysis.
7. Allen, R.G.D.   : Macro- Economic Theory.
8. Klein and Goldburger   : An Econometric Model for the U.S. Economy.