M.Sc.(Statistics) Degree Programme
Regulations and Course Structure (w.e.f. 2018 Admission)

1. Name of the Programme: M.Sc. (Statistics)

2. Scope and Objectives: Statistics has emerged as an important branch of Science and it helps in strengthening research in almost all disciplines of study.The M.Sc. (Statistics) course is an interdisciplinary post graduate course combining the applications of Mathematics, Statistics and Computer programming inbiological and social sciences. The primary objective of the course is to bring out trained hands in Statistics to serve various research and development organizations in the country. The course is so planned to make the candidate a professional in the related field such that he/she can serve as Statisticians, consultants, statistical programmers, data analysts and research associates in various industries as well as in teaching and research institutions, in addition to taking up teaching and research activities in Colleges and Universities.

3. Eligibility for admission: Bachelors degree with Mathematics as main subject and Statistics as subsidiary (complementary) or Statistics as main subject and Mathematics as subsidiary (complementary) or triple main with Mathematics and Statistics as subjects, or its equivalent from a recognized University with minimum 55%marks (50% for SC/ST candidates).

4. Intake capacity **:** 10

5. Selection Process : On the basis of Common Entrance Test conducted by KUFOS (50%),Qualifying mark (30 %) and interview (20 %).

6. Duration of the programme: 2 year (Four Semesters)

7. Structure of the programme: The course is offered under credit and semester system. The minimum credits for the successful completion of the program is 85. Out of the total, 73 credits will be for compulsory papers (including Dissertation) and 12 credits is for elective courses. The elective courses are to be selected from the list of electives appended. There will be six papers in each of the first three semesters and three papers & Dissertation work (9 credits) in the fourth semester. There shall be five modules in a paper.

8. Scheme of Evaluation: The performance of the students will be evaluated through continuous evaluation and external assessment**.** Each paper shall carry a maximum of 100 marks. The ratio of continuous assessment and external assessment will be 50: 50**. C**ontinuous evaluation shall be done through internal examinations, assignments, student seminars etc. by the course teacher concerned. The University shall conduct end semester examination. The evaluation and grading shall be done as per University regulations in force.

9. Dissertation/Project work:

The Project Report/Dissertation shall carry a maximum of 300 Marks of which 150 mark shall be by continuous (internal) evaluation and 150 marks by external evaluation. For continuous (internal) evaluation 100 marks shall be for project report and 50 for the presentation of the report. The external evaluation shall be conducted by two examiners of which at least one shall be an external examiner.

COURSE STRUCTURE (Revised)

Approved in the 22 nd Academic Council Meeting held on 25.06.2019 (Item No.255)

Semester – I

Sl. No.	Course Code	Course Title	Marks allotted			Credits *
			Internal	External	Total	
1	MSTC 111	Statistical Methods	50	50	100	4
2	MSTC 112	Mathematics for Statistics	50	50	100	4
3	MSTC 113	Computer Oriented Statistical Methods	50	50	100	4
4	MSTC 114	Probability Theory	50	50	100	4
5	MSTC 115	Survey Sampling	50	50	100	4
6	MSTC 116	Practical - I	100	-	100	3
		Total	350	250	600	23

Semester – II

1	MSTC 121	Probability Distributions	50	50	100	4
2	MSTC 122	Theory of Estimation	50	50	100	4
3	MSTC 123	Statistical Quality Control	50	50	100	4
4	MSTC 124	Research Methodology	50	50	100	4
5	MSTC 125	Stochastic Processes	50	50	100	4
6	MSTC 126	Practical - II	100	-	100	3
		Total	350	250	600	23

Semester – III

1	MSTC 211	Testing of Statistical Hypothesis	50	50	100	4
2	MSTC 212	Multivariate Analysis	50	50	100	4
3	MSTC 213	Design and Analysis of Experiments	50	50	100	4
4	MSTE	Elective I	50	50	100	3
5	MSTE	Elective II	50	50	100	3
6	MSTC 214	Practical - III	100	-	100	3
		Total	350	250	600	21

Semester – IV

1	MSTE	Elective III	50	50	100	3
2	MSTE	Elective IV	50	50	100	3
3	MSTC 221	Project/Dissertation	150	150	300	9
4	MSTC 222	Practical - IV	100	-	100	3
		Total	350	250	600	18

*** Total credits for the Program: 85; One credit = 1 hour of teaching for theory & project work and two hrs for practical. Practical shall be based on all the courses offered in the respective Semester.**

Elective Papers

Sl. No.	Course Code	Course Title	Marks allotted			Credits
			Internal	External	Total	
1	MSTE 101	Econometric Methods	50	50	100	3
2	MSTE 102	Time Series Analysis and Statistical Forecasting	50	50	100	3
3	MSTE 103	Official Statistics	50	50	100	3
4	MSTE 104	Reliability Modeling and Analysis	50	50	100	3
5	MSTE 105	Actuarial Statistics	50	50	100	3
6	MSTE 106	Survival Analysis	50	50	100	3
7	MSTE 107	Stochastic Finance	50	50	100	3
8	MSTE 108	Statistical Genetics	50	50	100	3
9.	MSTE 109	Operations Research	50	50	100	3

Semester I

MSTC 111 STATISTICAL METHODS (4 credits)

Module I

History and scope of Statistics, Variables and attributes, types of data, descriptive statistical measures, normal distribution. Bivariate data, measures of association, linear correlation – simple, partial and multiple correlations, rank correlation, association of attributes. (14 hrs.)

Module II

Regression – simple and multiple, linear and non-linear regressions, fitting regression lines using least square method, coefficient of determination, standard error of estimate, Multicollinearity. (14 hrs.)

Module III

Time series, components of time series, Mathematical models, methods of measuring trend – moving average method and least square method, curvilinear trend – fitting of parabola, exponential and Gompertz curves. (14 hrs.)

Module IV

Index numbers, types of index numbers – simple and weighted, methods of constructing index numbers, tests for adequacy of an index number- time reversal test, factor reversal test and circular test, cost of living index numbers, indices of industrial production .

(14 hrs)

Module V

Vital statistics, methods of collecting vital statistics- registration method, census enumeration, survey method, analytical methods. Measures of fertility – CBR,SFR,GFR and TFR. Measures of mortality – CDR,SDR,S_TDR. Measures of population growth - GRR and NRR. Life Table – concept and uses, construction of life table. (16 hrs.)

Suggested Readings :

1. Agarwal,B.L.(2013). Basic Statistics. 6 th ed. New Age International Publishers.
2. Croxton,F.E. and Cowden,D.J. (1967). Applied General Statistics,Prentice-Hall.
3. Gupta,S.C. and Kapoor,V.K. (2014). Fundamentals of Mathematical Statistics, 11 th ed. Sultan Chand & Sons.
4. Gupta,S.C. and Kapoor,V.K. (1978). Fundamentals of Applied Statistics, 11 th ed. Sultan Chand & Sons.
5. Levin ,R.L. and Rubin,D.S. (1983). Statistics for Management. Prentice Hall.
6. Simpson,G. and Kafka,F. (1969). Basic Statistics,Oxford& IBH.
7. Zar,J.H. (2003).Biostatistical Analysis, 4 thed.,Pearson Education.
8. Kendall M.G.&Stuart,A (1961), The Advanced theory of Statistics Vol I, Charles Griffin & Co., London.

9. Kendall M.G.&Stuart,A (1961), The Advanced theory of Statistics Vol II, Charles Griffin & Co., London

MSTC 112 MATHEMATICS FOR STATISTICS (4 credits)

Module I

Real Analysis:- limits, continuity, uniform continuity, functions of bounded variation, Sequences and series of functions, Uniform convergence ; Riemann - Stieltjes Integral**s**, Mean value theorems of Riemann-Stieltjes integrals, limit and continuity of multivariable functions, total derivative, directional derivatives, continuity and differentiation of composite functions, Taylor's Theorem for a multivariable function (statement only), optima of a multivariable function.

(14 hrs.)

Module II

Measure theory:- Sequences of sets, fields, sigma fields, Borel fields, measures (Lebesgue and Lebesgue-Stieltjes), properties of inverse functions, measurable functions, measure spaces.

(16 hrs.)

Module III

Integration: Lebesgue Integrals, Lebesgue - Stieltjes Integrals, Integrability of functions with respect to measures, Statement and applications of Monotone and Dominated convergence theorems, absolutely continuous measures, Radon-Nykodym theorem (statement only).

(16 hrs.)

Module IV

Linear Algebra:- Vectors and Vector spaces, subspaces, basis and dimensions, Simultaneous linear equations, Inner products, orthogonalization of vectors.

(12 hrs.)

Module V

Matrices and Quadratic forms:- Matrix operations, Rank, Inverse, Reduction by elementary transformations, Determinants, Generalized inverse, eigen values and vectors, Quadratic forms and their classification, spectral decomposition. (14 hrs.)

Suggested Readings:

1**. S. R. Athreya and V. S. Sunder (2008) Measure and Probability, University Press.**
2. Basu, A.K. (1999), Measure Theory and Probability, Prentice-Hall.
3. **Apostol, T.M. (1996),** ***Mathematical Analysis*****, NarosaPublshing House, New Delhi, Second Edition**.
4**. Rao, C.R. (2002) Linear statistical inference and its applications, Second edition**
5. Sastry, S.S. (1998) *Introductory methods of numerical analysis*, Third edition, Prentice Hall, New Delhi.
6. Gupta, S.L. and Gupta, N.R. (2003) Principles of Real Analysis, Second edition, Pearson Education (Singapore) Pvt. Ltd.
7. Widder, D.A. (1996) Advanced Calculus, Second Edition, Prentice Hall, Inc., Delhi.
8. Nanda, S. and Saxena, V.P. (2000) Real Analysis, Allied Publishers Ltd.
9. Shanti Narayan (1991) *A text of book of matrices*, S. Chand & Company, Delhi.
10. Royden, H. L. ((1968). Real Analysis. Mcmillan& Co. New York.

11. Kingman, J.F.C. and Taylor, S.J. (2008). Introduction to Measure and Probability. Cambridge University Press.

MSTC 113 COMPUTER ORIENTED STATISTICAL METHODS (4 credits)

Module I

Computer fundamentals, number systems –binary, octal, decimal and hexadecimal. Algorithm, Flow chart.

(12 hrs.)

Module II

Basics of C $^{++}$: Structure of a program, variables, data types, constants, operators, basic input / output , control structures, functions.Compound data types : arrays, character sequences, pointers, dynamic memory, data structures. Object oriented programming: introduction to classes, inheritance, polymorphism. (14 hrs.)

Module III

Introduction to operating systems. Data analysis using Excel and SPSS.

(14 hrs.)

Module IV

Introduction to SAS: SAS variables , libraries, windows, parts of a SAS program. Data sets – creation, reading data from an external file. Data step statements - CARDS, DATA, Assignment, Do-loops, DROP, KEEP, INPUT, OUTPUT, SET, STOP, IF-THEN-ELSE.SAS operators, functions, arrays. . (16 hrs.)

Module V

Elements of R programming : Introduction to statistical software R, data objects in R, manipulating vectors, matrices, lists, importing of files, data frame, computation of descriptive statistical measures. R Graphics – Histogram, Box plot, stem and leaf plot, scatter plot, plot options, multiple plots in a single graphic window, frequency table, plotting of probability distributions and sampling distributions. (16 hrs.)

Suggested Readings:

1. Balagurusaamy E. (1997). Object – oriented Programing with C++, Tata McGraw-Hill Publishing Company Ltd.
2. Der, G. and Everitt, B.S.(2006). A Hand Book of Statistical Analysis Using SAS, CRC press.
3. Der, G. and Everitt, B.S.(2006). Statistical Analysis of Medical Data Using SAS, CRC Press.
4. Littell R.C., Stroup W.W. & Freud R.J. (2002). SAS for Linear Models, SAS institute Inc.
5. Lora, D. and Susan, S. (2009) The little SAS, Support.sas.com.
6. Purohit, S.G., Gore,S.D. and Deshmukh,S.R. (2008). Statistics using R, Alpha Science
7. Peter Norton (2008). Introduction to computers, 6 th ed., Tata McGraw-Hill, New Delhi

8. Bjarne,S.(2013). The C ++ programming Language, 4 th ed.

MSTC 114 PROBABILITY THEORY (4 credits)

Module I

Fields, sigma fields, Borel fields, Simple, non-negative and real-valued Random variables, Induced sigma fields. Axioms of Probability, Discrete probability space, General probability space, Induced probability space. (12 hrs.)

Module II

Distribution function of a random variable, Decomposition of distribution functions, Distribution function of random vectors, Expectations and moments, Moment inequalities (C_r-, Holder, Markov, Jenson and basic inequalities), Moment generating functions.

(14 hrs.)

Module III

Characteristic functions, Inversion and uniqueness theorems, Independence of events and random variables, Multiplication properties, Zero-one laws. Conditional expectation and its properties, Conditional probabilities, Baye's theorem. (16 hrs.)

Module IV

Modes of convergence: Convergence in probability, in distribution, in r th mean, almost sure convergence and their inter-relationships, convergence theorem for expectation.

(14 hrs.)

Module V

Limit Laws **:** Covergence of series of independent random variables, Kolmogorov's inequality, Weak law of large numbers (Kninchine's and Kolmogorov's), Kolmogorov's strong law of large numbers, Central limit theorems for i.i.d random variables, Lindberg – Levy and Liaponov's CLT, Lindberg-Feller CLT (statement only). (16 hrs.)

Suggested Readings:

1. **Bhat B.R.(1985), Modern Probability Theory 2nd edition, Wiley Eastern.**
2. Basu, A.K. (1999), Measure Theory and Probability, Prentice-Hall.
3. **Rohatgi, V.K. and A.K.E. Salah (2001). Introduction to Probability and Statistics, John Wiley and Sons.**
4. Feller, W. (1966), An Introduction to Probability Theory and Its Applications, Vol.II, Wiley Eastern.
5. Rao, C.R. (1973). Linear Statistical Inference and Its Applications, Wiley.
6. Billingsley, P. (1986). Probability and Measure, 2nd Ed., John Wiley.
7. Laha. R.G. and Rohatgi V.K. (1979), Probability Theory, John Wiley.
8. Hoffmann – Jorgensen J. (1994). Probability with a View Towards Statistics, Chapman

& Hall.
9. Loeve M. (1977). Probability Theory, Vol.I, 4th edition, Springer-Verlag.
10. Loeve, M. (1978). Probability Theory, Vol.II, 4th edition, Springer-Verlag.

MSTC 115 SURVEY SAMPLING (4 credits)

Module I

Census and sampling methods, probability sampling and non-probability sampling, principal steps in sample surveys, sampling errors and non-sampling errors, bias, variance and mean square error of an estimator, simple random sampling with and without replacement, estimation of the population mean, total and proportions, properties of the estimators, variance and standard error of the estimators, confidence intervals, determination of the sample size.

(14 hrs.)

Module II

Stratified random sampling, estimation of the population mean, total and proportion, properties of estimators, various methods of allocation of a sample, comparison of the precisions of estimators under proportional allocation, optimum allocation and srs. Systematic sampling – Linear and Circular, estimation of the mean and its variance. comparison of systematic sampling, srs and stratified random sampling for a population with a linear trend.

(14 hrs.)

Module III

Ratio method of estimation, estimation of the population ratio, mean and total, first order approximate expression for bias,mse of ratio estimates, comparison with srs estimation. Unbiased ratio type estimators- Hartly- Ross estimator, regression method of estimation, first order approximate expression for bias and mse of linear regression estimators, large sample comparison with mean per unit estimator and ratio estimators. (16 hrs.)

Module IV

Cluster sampling, single stage cluster sampling with equal and unequal cluster sizes, estimation of the population mean and its standard error. Two- stage cluster sampling with equal and unequal cluster sizes, estimation of the population mean and its standard error.

` (14 hrs.)

Module V

Unequal probability sampling, PPS sampling with and without replacement, cumulative total method, Lahiris method, Midzuno-Zen method, estimation of the population total and its estimated variance under PPS wr sampling, ordered and unordered estimators of the population total under PPS wor, Horwitz – Thomson estimator and its estimated S. E, Des-Raj's ordered estimator, Murthy's unordered estimator (properties of these estimators for n=2 only) .

(14 hrs.)

Suggested Readings :

1. Cochran W. G. (1999) Sampling Techniques, 3rd edition, John Wiley and Sons.
2. Mukhopadyay P. (2009) Theory and Methods of Survey Sampling, 2nd edition, PHL, New Delhi.
3. Singh D. and Choudhary F. S. (1986) Theory and Analysis of Sample Survey Designs, Wiley Eastern Ltd.

4. Des Raj (1967) Sampling Theory, Tata McGraw Hill, New Delhi.
5. Sampath S. C. (2001) Sampling Theory and Methods, Alpha Science International Ltd., India.

6. Cassel CM, Sarndal CE &Wretman JH. 1977. *Foundations of Inference in survey sampling*. John Wiley
7. Chaudhari A&Stenger H. 2005. *Survey Sampling Theory and Methodes*. 2nd Ed. Chapman & Hall.
8. Chaudhari A & Voss JWE. 1988. *Unified Theory and Strategies of Survey Sampling*. North Holland
9. Hedayat AS &sinha BK. 1991. *Design and Inference In Finite population Sampling.* John Wiley.
10. Kish L . 1965. *Survey Sampling. John Wiley*

MSTC 116 PRACTICAL - I (3 credits)

Practicals based on all the courses offered in the first semester.

Semester II

MSTC 121 PROBABILITY DISTRIBUTIONS (4 credits)

Module I

Preliminaries: Random variables and probability distributions, Generating functions, Characteristic functions, Random vectors, Joint, marginal and conditional distributions, conditional expectation, concepts of compound, truncated and mixture distributions.

(12 hrs.)

Module II

Discrete distributions: Binomial, Poisson, Negative Binomial, Geometric, Uniform and Multinomial distributions. Properties, moments and applications of the models, power series family of distributions.

(14 hrs.)

Module III

Continuous distributions: Rectangular, Gamma, Exponential, Cauchy, Beta, Weibull, Normal, Log-normal and Pareto models. Properties, moments and applications pertaining to distributions. Bivariate Normal distribution. (14 hrs.)

Module IV

Sampling distributions: Sampling distributions of mean and variance of samples taken from Normal population, independence of sample mean and variance, chi-square, student's t and F distributions. Properties and inter-relationships among these distributions, Non-central forms.

(16 hrs.)

Module V

Order Statistics: Distribution of order statistics, marginal, joint and conditional distributions, distribution of range, markov property of order statistics from continuous distributions, distribution of order statistics from uniform and exponential distributions, moments of order statistics (single and product moments). (16 hrs.)

Suggested Readings:

1. Rohatgi, V.K. (1976) An introduction to Probability Theory and Mathematical Statistics, Wiley Eastern, New Delhi.
2. Ord J.K. (1972) Families of frequency distributions, Griffin
3. Johnson N.L., Kotz,S. and Kemp A.W (1992) Univariate Discrete Distributions, John Wiley.
4. Johnson N.L., Kotz, S and Balakrishnan, N. (1994), Continuous Univariate Distributions

(2nd ed.) Vol. I and II, John Wiley.

5. Arnold Balakrishnan,N. and Nagaraja,H.N. (1992). Introduction to Order Statistics, John Wiley
6. David,H.A. and Nagaraja,H.N. (2003). Order Statistics. Wiley

MSTC 122 THEORY OF ESTIMATION (4 credits)

Module I

Point Estimation – Basic concepts of parameter estimation, Properties of Estimators: unbiasedness, consistency, sufficiency, efficiency, Minimum Variance unbiased estimators, Cramer-Rao lower bound, Bhattacharya bound (statement only). (12 hrs.)

Module II

Methods of Estimation - Method of moments, Method of maximum likelihood , properties of maximum likelihood estimators, minimum variance estimation, least square method. (14 hrs.)

Module III

Fisher's information measure and its properties – measuring the intrinsic accuracy of a distribution, improvement of unbiased estimators, minimal sufficient statistics, complete statistics, Rao – Blackwell theorem, UMVUE estimation. (14 hrs.)

Module IV

Interval Estimation – Confidence intervals, construction of confidence intervals, problems in large samples, shortest length class intervals, geometrical interpretation, one sided confidence intervals, significance level, determination of confidence for the parameters of normal, exponential and uniform distributions. (16 hrs.)

Module V

Bayesian procedures: Prior distributions, determination of prior distribution, different types of prior distribution, Bayes' theorem for distributions, loss functions, prior – posterior analysis in respect of Binomial and Normal distributions using uniform prior and conjugate prior under squared error loss functions, Bayesian estimation. (16 hrs.)

Suggested Readings :

1. Keeping, E.S. (1964). Introduction to Statistical Inference. Affiliated East West Press Pvt Ltd.
2. Kendall, M.G. & Stuart A(1961). The Advanced Theory of Statistics, Vol. II,., London, Charles Griffin& Co.
3. Fisher, R.A.(1958). Statistical Methods for Research workers, 13th ed. Edinburgh, Oliver & Boyd.
4. Rajagopalan, M andDhanavanthan, P. (2012).Statistical Inference, PHI Learning Private Limited, New Delhi.
5. Rao,C.R.(1983).Linear Statistical Inference and its Applications, 2nd ed. Wiley Eastern Limited, New Delhi..
6. Casella G. and Berger R.L.(2002), Statistical Inference, 2nded, Thomson Publ.

7. Berger,J.C.(1985).Statistical Decision Theory and Bayesian Analysis, Springer.
8. Kale,B.K. (2005). A First course on Parametric Inference. Alpha Science International.
9. Lehman,E.L. and Casella,G. (1998). Theory of Point Estimation. Springer.

MSTC 123 STATISTICAL QUALITY CONTROL (4 credits)

Module I

Statistical Quality Assurance, methods of quality assurance, I.S.O. certification, Statistical aspects of six-sigma philosophy, concept of TQM. (12 hrs.)

Module II

Control charts for attributes- 'np', 'p', 'c' and 'u' charts. (12 hrs.)

Module III

Control charts for variables- mean, standard deviation and Range Charts, extreme value control charts, Statistical basis, rational subgroups. (16 hrs.)

Module IV

Fundamental concepts of acceptance sampling plans, acceptance sampling for attributes -single sampling, double sampling, multiple sampling and sequential sampling plans. Sampling inspection tables for selection of single and double sampling plans, rectifying inspection plans, measuring performance of the sampling plans – OC, AOQ, ASN and ATI Curves.

(18 hrs.)

Module V

Control charts with memory- CUSUM charts, EWMA- mean charts, OC and ARL for control charts, process capability analysis, process capability indices – C_p and C_{pk}.

(14 hrs.)

Suggested Readings:

1. Grant EL & Leaven worth RS. 1996. *Statistical Quality Control*. 7th Ed. McGraw Hill.
2. Montgomery DC. 2005. Introduction to Statistical Quality Control. 5th Ed. John Wiley.
3. Wetherhil GB. 1977. Sampling Inspection and Quality Control. Halsted Press.
4. Cowden DJ. 1957. *Statistical Methods in Quality Control* . Prentice Hall of India.
5. Dodge HF &Romig HG. 1959. *Sampling Inspection Tabels*. John Wiley.
6. Duncan A. J. 1986. *Quality Control And Industrial Statistics*. 5th Ed. Irwin Book Co.

MSTC 124 RESEARCH METHODOLOGY (4 credits)

Unit-I – **Meaning,Objectives and types of research:** Meaning, Definition, Motivation and objectives – Research methods vs Methodology. Types of research – Descriptive vs. Analytical, Applied vs.Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical. Research Formulation – Defining and formulating the research problem - Selecting the problem - Necessity of defining the problem - Importance of literature review in defining a problem – Literature review– Primary and secondary sources – reviews, treatise, monographs-patents – web as a source – searching the web - Critical literature review – Identifying gap areas from literature review - Development of working hypothesis. (16 hrs)

Unit-II - Research design and methods – Research design – Basic Principles- Need of research design — Features of good design – Important concepts relating to research design – observation and Facts, Laws and Theories, Prediction and explanation, Induction, Deduction, Development of Models. Developing a research plan - Exploration, Description, Diagnosis, Experimentation. Determining experimental and sample designs. (14 hrs)

Unit-III - Data Collection and analysis: Execution of the research - Observation and Collection of data - Methods of data collection – Sampling Methods- Data Processing and Analysis strategies - Data Analysis with Statistical Packages - Hypothesis-testing - Generalization and Interpretation. (14 hrs)

Unit-IV - Reporting and thesiswriting – Structure and components of scientific reports - Types of report – Technical reports and thesis – Significance – Different steps in the preparation – Layout, structure and Language of typical reports – Illustrations and tables - Bibliography, referencing and footnotes - Oral presentation – Planning – Preparation – Practice – Making presentation – Use of visual aids - Importance of effective communication. (14 hrs)

Unit-V - Application of results and ethics - Environmental impacts - Ethical issues - ethical committees - Commercialisation – Copy right – royalty - Intellectual property rights and patent law – Trade Related aspects of Intellectual Property Rights – Reproduction of published material – Plagiarism - Citation and acknowledgement - Reproducibility and accountability. (14 hrs)

REFERENCES

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
2. Kothari, C.R., 1990.Research Methodology: Methods and Techniques. New Age International. 418p.
3. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, EssEss Publications. 2 volumes.
4. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.

5. Wadehra, B.L. 2000.Law relating to patents, trade marks, copyright designs and geographical indications. Universal Law Publishing.
6. Day, R.A.,1992.How to Write and Publish a Scientific Paper,Cambridge University Press.

MSTC 125 STOCHASTIC PROCESSES (4 credits)

Module I:
Concept of stochastic process, Examples, Specification of process. Markov chains-Chapman – Kolmogorov equations –Classification of states – limiting probabilities, Gamblers ruin problem – Mean time spent in transient states –Branching processes (Discrete parameter only).
(12 hrs.)

Module II:
Point process & Counting process, Poisson process, inter arrival time and waiting time distributions. Properties of Poisson processes – Conditional distribution of arrival times. Generalization of Poisson processes;Non –homogenous Poisson process, Compound Poisson process, Conditional Mixed Poisson process. (14 hrs.)

Module III:
Continuous time Markov Chains – Birth and death processes – transition probability function-limiting probabilities.Special cases of Birth and Death process and applications.
(14 hrs.)

Module IV:
Renewal processes-limit theorems and their applications. Renewal reward process. Regenerative processes, semi-Markov process. The inspection paradox, Insurers ruin problem. (16 hrs.)

Module V:
Basic characteristics of queues – Markovian models – Network of queues. The M/G/1 system. The G/M/1 model, Brownian motion Process – hitting time – Maximum variable – variations on Brownian motion – Pricing stock options; Stationary and weakly stationary processes.
(8 hrs.)
(16 hrs)

Suggested Readings:

1. **Ross, S.M**.(2007). Introduction to Probability Models. IXth Edition, Academic Press.
2. **Medhi,J**. (1996). Stochastic Processes.Second Editions. Wiley Eastern, New-Delhi**.**
3. **Karlin and Taylor** (1975). A First Course in Stochastic Processes.2 nd. Ed. Academic Press. New-York.
4. **Cinlar, E.** (1975). Introduction to Stochastic Processes.Prentice Hall. New Jersey.
5. **Basu, A.K**.(2003), Introduction to Stochastic Processes. Narosa, New-Delhi.

MSTC 126 PRACTICAL - II (3 credit)

Practical based on all the courses offered in the second semester.

Semester III

MSTC 211 TESTING OF STATISTICAL HYPOTHESES (4 credits)

Module I

Basics of statistical testing, Hypothesis, critical region, acceptance region, power and OC functions, concept of p value, Neyman- Pearson theory of testing of hypothesis.

(12 hrs.)

Module II

Neyman – Pearson Lemma and its generalization, Most Powerful tests, Locally Most Powerful tests, unbiased tests, UMP tests, Monotone Likelihood Ratio property.

(12 hrs.)

Module III

Likelihood Ratio Test, asymptotic distribution of the LR test criterion, test consistency, relationship between testing of hypothesis and confidence interval estimation. (16 hrs.)

Module IV

Non parametric tests, Introduction, Single Sample problems, Kolmogorov – Smirnov test, Sign test, Wilcoxon Signed Rank Test, Two sample problems, Wald – Wolfowitz Run Tests, Mann – Whitney U-test, Chi-square test, Median test, Kruskal – Wallis test, Friedman's test.

(18 hrs.)

Module V

Sequential Probability Ratio Test – introduction, sequential hypothesis, OC and ASN Functions of the SPRT, SPRT for composite hypotheses, basics of statistical decision theory, estimation and testing of hypothesis as special cases of statistical decision theory.

(14 hrs.)

Suggested Readings :

1. Kendall M.G. & Stuart A.(1961). The Advanced Theory of Statistics, Vol. II, London, Charles Griffin & Co.
2. Rajagopalan, M andDhanavanthan, P. (2012).Statistical Inference, PHI Learning Private Limited, New Delhi.
3. Rao,C.R.(1983).Linear Statistical Inference and its Applications, 2nd ed. Wiley Eastern Limited, New Delhi
4. Lehmann, E.L.(1976). Testing Statistical Hypotheses,.,Wiley Eastern Ltd., New Delhi.

5. Keeping, E.S. (1964). Introduction to Statistical Inference, , Affiliated East West Press Pvt. Ltd.
6. Berger,J.C.(1985).Statistical Decision Theory and Bayesian Analysis, 2 nd ed. Springer.

MSTC 212 MULTIVARIATE ANALYSIS (4 credits)

Module I

Notion of multivariate normal distribution, Marginal and conditional distributions, Characteristic function, Estimation of Mean vector and Co-variance matrix. (12 hrs.)

Module II

Wishart distribution and its properties, Hotelling's T^2 and Mahalanobis' D^2 statistic, Properties of T^2 and D^2, Distribution of rectangular co-ordinates, Distributions of simple, partial and multiple correlations based on samples from Normal populations (statement only), distribution of quadratic forms and Cochran's theorem. (14 hrs.)

Module III

Testing problems for multivariate normal distributions: Testing independence of sets of variables, testing equality of means, Sphericity tests, testing hypothesis that a covariance matrix is equal to a given matrix, testing whether two distributions are identical. (16 hrs.)

Module IV

Classification problem, standards of good classification, procedures for classification into one of two known multivariate normal populations, classification into several populations. (15 hrs.)

Module V

Introduction to Canonical variables and canonical correlations, principal component analysis, Factor analysis, Multivariate analysis of variance and covariance. (15 hrs.)

Suggested Readings:

1. Anderson T.W. (1984), An Introduction to Multivariate Statistical Analysis, 2nd Ed., John Wiley.
2. Kshirsagar A.M. (1972), Multivariate Analysis, Marcel – Dekker.
3. Seber G.A.F. (1977), Multivariate Observations, Wiley
4. Giri N.C. (1977), Multivariate Statistical Inference, Academic Press.
5. Rao, C.R. (1983), Linear Statistical Inference and its Applications 2nd Ed., Wiley Eastern

MSTC 213 DESIGN AND ANALYSIS OF EXPERIMENTS (4 credits)

Module I

Elements of linear estimation, Gauss-Markov theorem, orthogonality, contrasts, mutually orthogonal contrasts, tests of linear hypotheses, Analysis of variance. (10 hrs.)

Module II

Planning of experiments, Principles of experimentation , Basic designs- Completely randomized design (CRD), Randomised block design (RBD) and Latin square design (LSD), Greaco Latin Square. (16 hrs.)

Module III

Incomplete block designs, balanced incomplete block (BIB) designs, incidence matrix, parametric relation, intra and interblock analysis of BIBD, basic ideas of partially balanced incomplete block design (PBIBD), Youden square and Lattice designs. (14 hrs.)

Module IV

Factorial experiments, symmetrical factorial experiments ($2^n$and 3^n series), Yates procedure, confounding in symmetrical factorial experiments, fractional factorials, asymmetrical factorials. Basic ideas of response surface design, cross–over design, split plot and strip plot designs, transformation of data, missing plot and mixed plot technique. (16 hrs.)

Module V

Principle of Biological assays, parallel line and slope ratio assays, choice of doses and efficiency in assays. Quantal responses, probit and logit transformations. Epidemiological models.

(16 hrs.)

Suggested Readings :

1. Cochran WG & Cox DR. 1957. *Experimental Designs.*2_{nd} Ed. John Wiley.
2. Das,MN and Giri, NC (1994) Design and Analysis of Experiments,Wiley Eastern Ltd.
3. Dean AM & Voss D. 1999. *Design and Analysis of Experiments.* Springer.
4. Dey A &Mukerjee R.1999. *Fractional Factorial Plans.* John Wiley.
5. Hall M Jr. 1986. *Combinatorial theory.*John Wiley.
6. Kempthrone, O.1976. *Design and Analysis of Experiments*. John Wiley.
7. Raghavarao D. 1971. *Construction and Combinatorial Problems in Design of Experiments*.John Wiley.
8. Design Resources Server. Indian Agricultural Statistics Research Institute (ICAR), New Delhi- 110012, India.www.iasri.res.in/design.
9. Finney,D.J.(1981).Statistical Methods in Biological Assays, Charles Griffin
10. Fisher, R.A. 1935, The Design of Experiments, Oliver & Boyd, Edinburgh.

MSTE ELECTIVE I(3 credits) (To be chosen from the list of Electives)

MSTE ELECTIVE II (3 credits)(To be chosen from the list of Electives)

MSTC 214 PRACTICAL - III (3 credits)

Practical based on all the courses offered in the third Semester

Semester IV

MSTE --- ELECTIVE III(3 credits)(To be chosen from the list of Electives)

MSTE --- ELECTIVE IV(3 credits) (To be chosen from the list of Electives)

MSTC 221 Project/Dissertation[1] (9credits)

MSTC 222 PRACTICAL – IV (3 credits)

Practical based on all the courses offered in the fourth Semester

1. The students have to undertake a research project in theoretical/applied statistics under the guidance of an assigned supervising faculty/guide and submit a report.

ELECTIVE COURSES

MSTE 101 ECONOMETRICS METHODS (3 credits)

Module I

Consumer & Producer Behavior. Derivation of Demand functions and theoretical restrictions and estimation of demand functions – Elasticies – Engel curve. Producer's Behavior – Specification and estimation of Production functions – Cobb-Douglas production function.

(12 hrs.)

Module II

Econometric Modeling-Traditional Econometric Methodology-Alternative Econometric Methodology. (14 hrs.)

Module III

Single Equation Regression Models - two variable Regression Models-Estimation and Inference-Multivariable Analysis- Multivariate Normal Distribution- Multiple Regression Analysis-problems of Estimation: Multicollinearity- Autocorrelation and Heteroscedasticity.

(16 hrs.)

Module IV

Dummy variables – Errors in variables – Instrument variables, Regression with Lagged dependent Variables-Distributed Lag Models. (16hrs.)

Module V

Simultaneous Equation Models-Problems of Identification-Methods of Two stage and Three Stage Least Squares. (14 hrs.)

Suggested Readings:

1. Dougherty Christopher, 1995, Introduction to Econometrics, Oxford University Press, London.
2. Madalla, G.S. 1994, Econometrics, McGraw Hills
3. **DamodarGujariti, Econometrics, 2000**.
4. Walter Enders, Applied Econometrics, John Wiley & Sons, 2004.
5. William.H.Greene, Econometric Analysis, Pearson , 2003.
6. Koutsoyiannis.A, Theory of Econometrics, Palgrave, 2004.

MSTE 102 TIME SERIES ANALYSIS AND STATISTICAL FORECASTING

(3 credits)

Module I

Regression models, estimation and testing of regression coefficients, model selection techniques, problem of correlated errors, auto correlation, Durbin Watson statistics, detection and correction of multicollinearity, indicator variables. (12 hrs.)

Module II

Method of least squares for curve fitting, concept of weighted least squares, non-linear regression and fitting of quadratic, exponential and power curves, forecasting using regression models. (14 hrs.)

Modulel III

Time Series:- Components of time series, Exploratory time series analysis, test for trend and seasonality, exponential and moving average smoothing, Holt-winter smoothing, forecasting based on smoothing. (14 hrs.)

Module IV

Stationary time series, Auto correlation, partial auto correlation functions, Linear stationary models: autoregressive, moving average and mixed processes. Linear non-stationary models : Autoregressive integrated moving average (ARIMA) models. (16hrs.)

Module V

Forcasting using ARMA and ARIMA models: MMSE methods, using different forms of the ARIMA models, Estimation: Yule-Walker methods and least squares methods, correlogram and periodogram analysis. (16 hrs.)

Suggested Readings :

1. Abraham, B. and Ledolter,J.(1983). Statistical Methods for forecasting, John Wiley and Sons, New York.

2. Box,G.E.P.andJenkins,G.M.(1976). Time Series Analysis : Forecasting and Control, Holden Day
3. Brockwell,P.J. and Davis,R.A.(2002).Introduction to Time Series and Forecasting, 2 nded.,,Springer
4. **Draper, N.R. and Smith,H. (1998).Applied Regression Analysis, 3 rded.John Wiley**
5. Ezekiel, M. (1963).Methods of correlation and Regression Analysis. John Wiley
6. Kleinbaum, D.G.,Kupper,L.L.,Muller,K.E.andNizam,A.(1998).Applied Regression Analysis and Multivariable Methods,Duxbury Press.
7. Kutner,M,.H.,Nachtsheim, C.J. and Neter,J.(2004). Applied Linear Regression Models, 4 thed.with student CD.McGraw Hill.
8. Makridakis,S. and Wheelwright,S.C. Forecasting Methods and Applications, John Wiley and Sons.

MSTE 103 OFFICIAL STATISTICS (3 credits)

Module I

Introduction to Indianand International Statistical systems.Role, function and activities of Central and State Statistical organizations.Organizationof large-scale sample surveys.Role of National Sample Survey Organization.General and special data dissemination systems.

(12 hrs.)

Module II

Population growth in developed and developing countries, Evaluation of performance of family welfare programmes, projections of labor force and man power. Scope and Content of population census of India. (16 hrs.)

Module III

Statistics related to Industries, foreign trade, balance of payment, cost of living, inflation, educational and other social statistics. (14 hrs.)

Module IV

Economic development: Growth in per capita income and distributive justice indices of development, human development index. National income estimation- Product approach, income approach and expenditure approach. (16 hrs.)

Module V

Measuring inequality in incomes: Gini Coefficient, Theil's measure; Poverty measurements: Different issues, measures of incidence and intensity; Combined Measures: Indices due to Kakwani, Senetc. (14 hrs.)

Suggested Readings:

1. Basic Statistics Relating to Indian Economy (CSO) 1990
2. Guide to Official Statistics (CSO) 1999
3. Statistical System in India (CSO) 1995
4. Principles and Accommodation of National Population Census, UNEDCO.
5. Panse, V.G.: Estimation of Crop Yields (FAO)
6. Family Welfare Year Book. Annual Publication of D/O Family Welfare.
7. MonthlyStatistics of Foreign Trade in India, DGCIS, Calcutta and other Govt. Publications.
8. CSO (1989)a: National Accounts Statistics- Sources and Methods.
9. Keyfitz, N (1977): Applied Mathematical Demography- Springer Verlag.
10. Sen, A (1977): Poverty and Inequality.
11. UNESCO: Principles for Vital Statistics Systems, Series M-12.
12. CSO (1989)b: Statistical System in India
13. Chubey, P.K (1995): Poverty Measurement, New Age International.

MSTE 104. RELIABILITY MODELLING AND ANALYSIS (3 credits)

Module I

Life distributions, reliability function, hazard rate and mean residual life function, one-one correspondence of these functions. (12 hrs.)

Module II

System reliability, series and parallel systems, k out of n systems and its reliability, coherent systems, reliability of coherent systems, cuts and paths, bounds on system reliability. (14 hrs.)

Module III

Study of reliability characteristics associated with exponential, Weibull, Lognormal, Pareto, Gamma, Makeham and Reliegh distributions, proportional hazard models and their characteristics. (14 hrs.)

Module IV

Notions of ageing – IFR, IFRA, NBU, NBUE,DMRL,HNBUE, NBUC etc and their mutual implications, TTT transforms and characterization of ageing classes. (16 hrs.)

Module V

Reliability estimation using MLE - Exponential, Weibull and Gamma distributions based on censored and non-censored samples, Kaplan-Meier estimates of the distribution function, stress-strength reliability and its estimation. (16 hrs.)

Suggested Readings:

1. Barlow R.E. and Proschan F. (1965) Mathematical Theory of Reliability, Wiley, New York.
2. Sinha S. K. (1986) Reliability and Life Testing, Wiley Eastern.
3. Barlow R.E. and Proschan F. (1985) Statistical Theory of Reliability and Life Testing, Holt Rinehart and Winston, New York.
4. Rao S.S. (1992) Reliability-based design, McGraw Hill, New York.
5. Lai C.D and Xie M. (2006) Stochastic ageing and dependence in reliability, Springer.

MSTE 105 ACTUARIAL STATISTICS (3 credits)

Module I

Insurance and utility theory, model for Individual claims and their sums, survival function, curtate future lifetime, force of mortality. Life table and its relation with survival function, examples, assumptions for fractional ages, analytical laws of mortality, select and ultimate tables. (12 hrs.)

ModuleII

Multiple life functions, joint life and last survivor status, insurance and annuity benfits through multiple life functions evaluation for special mortality laws. Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net premiums and their numerical evaluation. Distribution of aggregate claims, compound Poisson distribution and its applications

(16 hrs.)

Module III

Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding. Insurance payable at the moment of death and at the end of the year of death- level benefit insurance, recursions, commutation functions. (14 hrs.)

Module IV

Life annuities: single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments , commutation functions, varying annuities, recursions, complete annuities-immediate and apportionable annuities – due. Net premiums: continuous and discrete premiums, true monthly payment premiums,apportionable premiums , commutation functions, accumulation type benefits. Payment premiums, apportionable premiums, commutation functions, accumulation type benefits. (16 hrs.)

Module V

Net premium reserves: continuous and discrete net premium reserve, reserves on a semi – continuous basis, reserves based on true monthly premiums, reserves at fractional durations, allocations of loss to policy years, recursive formulas and differential equations for reserves , commutation functions. practical considerations. (14 hrs.)

Suggested Readings :

1. Atkinson M.E. & Dickson D.C.M.2000. *An Introduction to Actuarial Studies.* Elgar

Publ. Bedford T & Cooke .R. 2001. Probabilistic Risk Analysis. Cambridge.
2. Booth P.M.,ChadburnRG,Cooper DR ,Haberman S & James D.E. 1999.*Modern Actuarial Theory and practice.* Chapman & Hall.
3. Borowiak Dale S. 2003. *Financial and Actuarial Statistics : An Introduction*. 2003.Marcel Dekker.
4. Bowers NL, Gerber HU, Hickman JC, Jones DA, Nesbitt CJ. 1997. *Actuarial Mathematics.*2 nd Ed. Society of Actuaries, Ithaca, Illinois
5. Daykin Cd, Pentikainen T &persnenM . 1994. *Practical risk Theory for Actuaries* chapmen& Hall.
6. Klugman SA, Panjer HH, Willmontand GE & Venter GG.1998. *Loss Models: From data to Decisions*. John Wiley.
7. Medina PK & Merino S.2003. *Mathematcal Finance and Probability*: A Discrete Introduction. Basel, Birkhauser.
8. Neil A.1977. *LifeContigencies*. Butterworth-Heinemann.
9. Rolski T, Schmidli H, Schmidt V &Teugels J.1998. *Stochastic Process for insurance and finance*. John Wiley.
10. Rotar VI. 2006 .*Actuarial Models . The Mathematics of insurance.* Chapman & Hall CRC.
11. Spurgeon ET.1972. *Life Contigencies*. Cambridges. Cambrige Univ. Press.

MSTE 106 SURVIVAL ANALYSIS (3 credits)

Module I

Basic quantities and models – survival function, hazard function, mean residual life function and median life, common parametric models for survival data, description of the above characteristic models – weibull, gamma, log normal and exponential. (12 hrs.)

Module II

Concepts of time , order and random censoring- right and left, likelihood in these case, survival function- actuarial estimator, Kaplan- Meier (K-M) estimator, graphical display for survival, median survival time and confidence interval for median survival, hazard ratio, relation between hazard ratio, relative risk and odds ratio, relative survival estimation. (14 hrs.)

Module III

Nonparametric methods for comparing survival distributions- log rank test, confidence interval for hazard ratio, stratified log- rank, Peto's test, Gehan test, Mantel- Haenzel test.

(14 hrs.)

Module IV

Life time distributions- parametric (Exponential, gamma, weibull, logistic), linear failure rate, parametric inference (point estimation, confidence intervals, scores, likelihood ratio test), accelerated failure time model, Cox-Snell residuals. (16 hrs.)

Module V

Identification of prognostic factors related to survival time, Cox's proportional hazards regression model with one and several covariates, rank test for the regression coefficients, adequacy assessment of the proportional hazards model, time dependent extension of the Cox model, test with non-proportional hazards, parametric and nonparametric inference for this model. (16 hrs.)

Suggested Readings:

1. Klein, J. P. and Moeschberger, M.L. (2003). Survival Analysis, Springer.
2. Elandt, Johnson and Johnson (1998). Survival Models and Data Analysis, John Wiley & Sons.
3. Miller, R. G. (2000). Survival Analysis, 2nd Ed. John Wiley & Sons.
4. Machin D. , Cheung Y. B. & Parmer M. KB. (2006). Survival Analysis – A Practical Approach, John wiley& Sons.
5. Fisher L.D. & Belle G. V. (1993). Biostatistics- A Methodology for the Health sciences, John Wiley & Sons.
6. Pressat R. & Atherton A. (1972). Demographic Analysis.
7. Preston S. H., Heuveline P. &Guillot M. Demography – Measuring and Modeling Population Processes.

8 .Lawless,J.F. (2002) .Statistical Models and Methods for Life Time Data, 2 nd ed., John Wiley.
9. Kalbfleisch,J.D. and Prentice,R.L. (2002). Statistical analysis of Failure Time Data, 2 nd ed., John Wiley.

MSTE 107 STOCHASTIC FINANCE (3 credits)

Module I

Basic concepts of financial markets, forward contracts, future contracts, options – call and put options, European option and American options, hedgers, speculators, arbitrageurs, interest rates, compounding, present value analysis, risk free interest rates. (12 hrs.)

Module II

Returns, gross returns and log returns. Porfolio theory – trading off expected return and risk, one risky asset and one risk free asset. Two risky assets, estimated expected return, optimal mix of portfolio CAPM, capital market line, betas and security market line. (14 hrs)

Module III

Options, pricing via arbitrage, law of one price, risk neutral valuation. Binomial model- single and multi period binomial model, martingale measure. Modeling returns, lognormal model, random walk model, geometric Brownian motion process. Ito lemma (without proof). Arbitrage theorem. The Black-Scholes formula. Properties of the Black-scholes option cost, the delta hedging arbitrage strategy, some derivatives, their interpretations and applications. (18 hrs.)

Module IV

Volatility and estimating the volatility parameter, implied volatility, pricing American options, pricing of European option using Monte-Carlo and pricing an American option using finite difference methods. Call options on dividend-paying securities. Pricing American put options, modeling the prices by adding jumps to geometric Brownian motion. Valuing investments by expected utility. Modeling security market: Self-financing portfolio and no arbitrage, price process models, division rule, product rule. (14 hrs.)

Model V

Financial Time series – special features of financial series, linear time series models : AR (1),AR (p),ARMA(p,q) processes, the first and second order moments, estimation and forecasting methods, models for conditional heteroscedasticity: ARCH (1),ARCH (p),GARCH(p,q) models and their estimation.Comparison of ARMA and GARCH processes.

(14 hrs.)

Suggested Readings :

1. David Ruppert(2004). Statistics and Finance – an Introduction, Springer International Edition
2. Sheldon M Ross (2003). An elementary introduction to Mathematical Finance, Cambridge University Press.
3. Christian Gourieroux and Joann Jasiak(2005). Financial Econometrics, New Age International(P) Ltd.
4. John C.Hull(2008). Options,Futures and other derivatives, Pearson Education India
5. Masaaki Kijima (2003).Stochastic Process with applications to Finance, Chapman &

Hall.
6. Ruey S. Tsay (2005). Analysis of Time Series, 3 rd ed. John Wiley & Sons.
7. Cuthbertson, K and Nitzsche,D.(2001).Financial Engineering – Derivatives and Risk Management, John Wiley & Sons

MSTE 108 STATISTICAL GENETICS (3)

Module I

Mendelian ratios and their testing, linkage, detection and estimation, equilibrium population and Hardy Weinberg law, inbreeding, inbreeding co-efficient and coefficient of parentage, inbreeding, estimation and testing of Heterosis, effect of migration, mutation and selection, sex - linked genes. (14 hrs.)

Module II

Average effect of a gene, breeding value, estimation of genetic components of variation, heritability and repeatability, estimation of phenotypic, genotypic and environmental correlations. selection, individual and pedigree selection. (14 hrs.)

Module III

Designs of plant breeding trials- compact family block designs, square and rectangular lattice designs, multivariate analysis of variance, cluster analysis, similarity algorithms and clustering methods for quantitative data. (16 hrs.)

Module IV

Path analysis, discriminent analysis for selection indices, analysis of designs for diallel, partial diallel and line x tester crosses. (12 hrs.)

Module V

Analysis of genotype - environment interactions, measurement of stability and adaptability- liner and non-linear approaches, combining ability and specific combining ability in diallel crosses, analysis of microarray data. (16 hrs.)

Suggested Readings:

1. Dabholkar, A. R. (1992) *'Elements of Biometrical Genetics*' . Concept Publishing Company , New Delhi.
2. Falconer, D. S. (1985). *'Introduction to QuantitaiveGenetics'* , English Language Book Society , Longman.
3. Jain, J.P. (1991). '*Statistical Techniques in Quantitative Genetics'*, Hindustan Publishing company, New Delhi.
4. Kempthorne, O. (1957). '*An Introduction to Genetic Statistic* ', TheLowa State University Press, London.
5. Li, C. C. (1982). 'Population Genetics'. The University of Chicago Press.
6. Mather, K. and Jinks J. l. (1977), '*Introduction to Biometrical Genetics*', Chapman and Hall.
7. Narain, P. (1990). '*Statistical Genitics*', Wiley Eastern, New Delhi, Hyderabad.

8. Percus, J.K. (2001). '*Mathematics of Genome analysis*', Cambridge University Press.
9. Sing, R. K. & Chaudhary, B. D. 1985. '*Biometrical Methods in quantitative Genetic analysis*' Kalyani Publishers, Ludhiana.
10. Stansfield W. D. (1991). '*Theory and Problems of Genetics*', Schum's Outline Series.
11. Mather , K.(1938). *The measurement of Linkage in Heredity*,Chemical Publishing Co.,New York.

MSTE 109 OPERATIONS RESEARCH (3 credits)

Module I: Linear Programming: objectives and assumptions, formulation of linear programming problem, graphic method, simplex method, duality problems (10 hrs.)
Module II: Transportation problems, assignment problems, Sequencing problem, traveling salesmen problems, network analysis, GANTT, CPM, PERT. (14 hrs.)
Module III
Inventory control models, cost involved in inventory management. types of inventory – deterministic and stochastic, Economic order quantity (EOQ) model, continuous review (Q) system, periodic review (P) system, hybrid system, simulation. (16 hrs.)
Module IV
Queuing Systems : Elements of queuing model, roles of exponential distribution, birth and death models, Little's formula, specialized poisson queues – M/M/1, M/M/C and their stationary distributions. (16 hrs.)
Module V
Decision making under risk and uncertainties. Decision problem, Maximal criterion. Minimum criterion Minimax regret criterion. Laplace criterion, Pay off tables, Decision trees, Expected value of prefect information . (16 hrs.)

Suggested Readings:

1. Ravindran A, Philips D.T and Soleberg, Operations Research – Principles and Practice, John Wiley and Sons.
2. J K Sharma Operations research – Theory and Applications Macmillan.
3. Frederick S Hiller and GeralaJlieberman, Introduction to Operations Research Tata Mcgraw Hill.
4. KantiSwarup, Gupta, Manmohan (2004) 10^{th} edition, Operations Research – Principles and Practice.
5. Thaha H A, Operations Research – An Introduction, Prentice Hall.
6. Mittal K.V (1983) Optimization methods in OR system analysis, Wiley Eastern
7. Cook, T.M. & Russell R.A. 1989 Introduction to Management science Prentice Hall
8. Vohra, N.D. 2006, Quantitaive Techniques in Management McGraw Hill.
9. Wagner, H.M.2005, Principles of Operations Research.