Appendix C

# चौधरी चरण सिंह विश्वविद्यालय, मेरठ

# Chaudhary Charan Singh University, Meerut

CHAUDHARY CHARAN SINGH UNIVERSITY, MEERUT

चौधरी चरण सिंह विश्वविद्यालय मेरठ

19 65

यत्र सत्यस्य परमं निधानम्

**NAAC A++**

## Syllabus of:

## M.Sc. (Statistics)

**One Year Programme**

**(As per guidelines of U.P. Government according to National Education Policy-2020 w.e.f. the session 2026-2027)**

25/7/26 25/7/26 25/7/26

## Members of the Board of Studies

| S. No. | Name | Designation | College/ University | Signature |
|---|---|---|---|---|
| 1. | Prof. Hare Krishna | Dean, Faculty of Science | C.C.S. University, Meerut | |
| 2. | Prof. Bhupendra Singh | Convener-I | Department of Statistics, C.C.S. University, Meerut | |
| 3. | Prof. Seema Raj | Convener-II | M.M. College, Modinagar | |
| 4. | Dr. Shiv Kumar | Member | Janta Vedic College, Baraut | |
| 5. | Sh. Rajeev Kumar | Member | Janta Vedic College, Baraut | |
| 6. | Prof. Sanjeev Kumar Tomar | External Subject Expert | Department of Statistics, B.H.U., Varanasi | |
| 7. | Prof. Athar Ali Khan | External Subject Expert | Department of Statistics and Operations Research, A.M.U., Aligarh | |
| 8. | Prof. D.K. Garg | External Subject Expert | Department of Statistics, Punjabi University, Patiala | |
| 9. | Prof. Pawan Kumar | External Subject Expert | Department of Statistics, University of Jammu | |
| 10. | Dr. Abha Chandra | Retd. Principal | Meerut College, Meerut | |
| 11. | Dr. Anil Kumar | ADG (Coordination) | ICAR, Krishi Bhawan, New Delhi | |

## SUBJECT: STATISTICS

### Semester-wise Titles of the Papers in M.Sc. (Statistics) One Year Programme

| Year | Sem. | Course Code | Paper Title | Core Compulsory/ Elective/ Value added | Theory/Practical | Credits | Teaching Hours |
|---|---|---|---|---|---|---|---|
| First | First | | Quality Control & Reliability Engineering | Core Compulsory | Theory | 04 | 60 |
| | | | Advanced Statistical Inference | Core Compulsory | Theory | 04 | 60 |
| | | | Operations Research | Core Compulsory | Theory | 04 | 60 |
| | | | Any one of the following<br>(a) Advanced Bayesian Statistics<br>(b) Actuarial Science & Official Statistics<br>(c) Advanced Designs of Experiments | Core Elective | Theory | 04 | 60 |
| | | | Practical Lab | Core Compulsory | Practical | 04 | 120 |
| | | | Industrial Training/Research Project/Survey | Core Compulsory | Project | 04 | 60 |
| | Second | | Multivariate Analysis | Core Compulsory | Theory | 04 | 60 |
| | | | Time Series & Vital Statistics | Core Compulsory | Theory | 04 | 60 |
| | | | Any one of the following<br>(a) Data Analytics & Python<br>(b) Advanced Operations Research<br>(c) Bio-Statistics | Core Elective | Theory | 04 | 60 |
| | | | Any one of the following<br>(a) Stochastic Process & Survival Analysis<br>(b) Econometrics<br>(c) Research Methodology & Computer Application | Core Elective | Theory | 04 | 60 |
| | | | Practical Lab | Core Compulsory | Practical | 04 | 120 |
| | | | Industrial Training/Research Project/Survey | Core Compulsory | Project | 04 | 60 |

## Subject Prerequisites

To study this subject, a student must have completed a four-year B.Sc. (Honours) degree with Statistics as the major subject.

## 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 Statistics in both semesters. In each semester, there will be one research project of 04 credits.

## Programme Outcomes (POs)

Students having Degree in M.Sc. (with Statistics) should have the knowledge of different concepts and techniques of Statistics and data analytics and ability to apply this knowledge in various fields of government and private sectors such as banking, medical, defense, agriculture etc. Students may pursue their future career in the field of data analysis and Research.

## Programme Specific Outcomes (PSOs)

After completing M.Sc. (Statistics) One Year Program, the student should have

PSO-1: Knowledge and expertise of different applied univariate and multivariate concepts, methodologies and tools of Statistics.

PSO-2: Ability to collect, validate and analyze data by using appropriate statistical techniques.

PSO-3: Ability to provide information in different forms including graphical representation, numerical and theoretical description etc. in an efficient manner.

PSO-4: Ability to understand the nature of the data and identify and solve a wide range of real life problems related to Statistics.

PSO-5: Knowledge of applied statistical techniques and statistical software including programming language (e.g. C , R, Python and SPSS).

PSO-6: Capability to use appropriate statistical skills for solving problems of interdisciplinary areas including finance, health, agriculture, government, business, industry, medical.

PSO-7: Ability to understand and compete with the challenges to fulfill the demand of the government and non-government sectors in terms of conducting survey and data analysis in a professional manner. These techniques will be helpful to generate the employability skills in the students.

## DETAILED COURSES OF STUDY FOR M.Sc. (STATISTICS) One Year Programme

### FIRST SEMESTER

| Programme/Class: **M.Sc.** | Year: **First** | Semester: **First** |
|---|---|---|
| Subject: **STATISTICS** | | |
| Course Code: - | Course Title: **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.

**Course Outcomes:**

CO1- It provides the knowledge of the quality control techniques.

CO2- It is helpful for the quality controller to understand and use the concept of statistical quality control in industries.

CO3- Students will be able to apply the knowledge of reliability engineering in designing of the product.

CO4- It is completely the job-oriented course.

| Credits: **04** | Core: **Compulsory** |
|---|---|
| Max. Marks: **100** | Min. Passing Marks: ..... |

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

| Unit | Topic | No. of Lectures |
|---|---|---|
| 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. | **12** |
| 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. | **12** |
| 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. | **12** |
| 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. | **12** |

| | | |
|---|---|---|
| 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 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. | **12** |

**Suggested Readings:**


1. Montgomery, D.C. (2019). Introduction to Statistical Quality Control, 8th edition. Wiley.
2. Duncan, A.J. (1986). Quality Control and Industrial Statistics, 5th edition. Richard D. Irwin.
3. Goon, A.M., Gupta, M.K. & Dasgupta, B. (2002). Fundamentals of Statistics, Vol. II, 8th edition. The World Press, Kolkata.
4. Srinath, L.S. (2005). Reliability Engineering, 4th edition. Affiliated East-West Press.
5. Balagurusamy, E. (1984, latest reprint 2017). Reliability Engineering. McGraw-Hill Education (India).
6. Barlow, R.E. & Proschan, F. (1996). Mathematical Theory of Reliability, Classics in Applied Mathematics reprint. SIAM.
7. Frankel, E.G. (1988). Systems Reliability and Risk Analysis, 2nd edition. Kluwer Academic.
8. Ebeling, C.E. (2010). An Introduction to Reliability and Maintainability Engineering, 2nd edition. Waveland Press.

| Programme/Class: **M.Sc.** | Year: **First** | Semester: **First** |
|---|---|---|
| Subject: **STATISTICS** | | |
| Course Code: | Course Title: **Advanced Statistical 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-square 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.

**Course Outcomes:**

CO1- The Student will learn to analyze and solve the fundamental problems of statistical inference.

CO2- The knowledge of sequential analysis will be helpful in decision making while testing of sophisticated items.

CO3- Non-parametric tests are widely used for analysing survival data, hence, students have better opportunity to get job in medical fields.

CO4- This course is mainly designed to provide employability skills to students.

| Credits: **04** | Core: **Compulsory** |
|---|---|
| Max. Marks: **100** | Min. Passing Marks: ..... |

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

| Unit | Topic | No. of Lectures |
|---|---|---|
| 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. | **20** |
| 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** |
| 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-Smirnov test for one and two samples. | **20** |

**Suggested Readings:**


1. Wald, A. (1947). Sequential Analysis. John Wiley & Sons (Dover reprint, 2004).
2. Ferguson, T.S. (1967). Mathematical Statistics: A Decision Theoretic Approach. Academic Press.
3. Gibbons, J.D. & Chakraborti, S. (2021). Nonparametric Statistical Inference, 6th edition. CRC Press.
4. Siegel, S. & Castellan, N.J. (1988). Nonparametric Statistics for the Behavioral Sciences, 2nd edition. McGraw-Hill.
5. Mood, A.M., Graybill, F.A. & Boes, D.C. (1974). Introduction to the Theory of Statistics, 3rd edition. McGraw-Hill.
6. Goon, A.M., Gupta, M.K. & Dasgupta, B. (2005). An Outline of Statistical Theory, Vol. II (Statistical Inference), 3rd edition. The World Press, Kolkata.
7. Rohatgi, V.K. & Saleh, A.K.Md.E. (2015). An Introduction to Probability and Statistics, 3rd edition. Wiley.
8. Gupta, S.C. & Kapoor, V.K. (2020). Fundamentals of Mathematical Statistics, 12th edition. Sultan Chand & Sons.

| Programme/Class: **M.Sc.** | Year: **First** | Semester: **First** |
|---|---|---|
| Subject: **STATISTICS** | | |
| Course Code: | Course 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 modelling and their optimum solution in the context of practical problems belonging to Govt./Pvt. Sectors.

**Course Outcomes:**

CO1- The Student will learn to understand the concepts of allocation and transportation problems.

CO2- The knowledge of LPP will help the students to formulate the real life problems in mathematical forms.

CO3- The knowledge of various queuing models has wide applications in service sector.

CO4- This course is mainly designed to provide the skills of solving assignment, transportation and maintenance problems.

| Credits: **04** | Core: **Compulsory** |
|---|---|
| Max. Marks: **100** | Min. Passing Marks: ..... |

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

| Unit | Topic | No. of Lectures |
|---|---|---|
| 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. | **12** |
| 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. | **12** |
| 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, Degeneracy in transportation problems. **Assignment Problems:** Assignment problems, formulation of these problems and their solutions, Unbalanced Assignment problems. | **12** |
| 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×n, m×2, m×n by minimax and maximin technique, arithmetic method, algebraic method, dominance principle, graphical method matrix method, sub-game method and linear programming techniques. | **12** |

| | | |
|---|---|---|
| V | **Queueing Theory:** Introduction of the queuing system, Various components of a 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. | **12** |

**Suggested Readings:**


1. Swarup, K., Gupta, P. K., and Man Mohan (2019). Operations Research, 20th Ed., Sultan Chand & Sons, New Delhi.
2. Taha, H. A. (2022). Operations Research: An Introduction, 11th Ed., Pearson Education, Hoboken, NJ.
3. Sharma, J. K. (2024). Operations Research: Theory and Applications, 7th Ed., Trinity Press, New Delhi.
4. Sharma, S. D. (2017). Operations Research: Theory, Methods and Applications, 15th Ed., Kedar Nath Ram Nath & Co., Meerut.
5. Hillier, F. S., and Lieberman, G. J. (2021). Introduction to Operations Research, 11th Ed., McGraw-Hill Education, New York.
6. Gass, S. I. (2003). Linear Programming: Methods and Applications, 5th Ed., Dover Publications, Mineola, NY.
7. Saaty, T. L. (2004). Mathematical Methods of Operations Research, Dover Publications, Mineola, NY.
8. Jones, A. J. (2000). Game Theory: Mathematical Models of Conflict, Horwood Publishing, Chichester, UK.

| Programme/Class: **M.Sc.** | Year: **First** | Semester: **First** |
|---|---|---|
| Subject: **STATISTICS** | | |
| Course Code: - | Course Title: **Advanced Bayesian Statistics** | |

**Need of the Course:** To understand statistical inference from the Bayesian perspective, one should have the knowledge of prior and posterior distributions, Bayesian estimation, credible intervals, hypothesis testing, and decision theory.

**Objective of the Course-** The course objectives are:

- To formulate Bayesian methods for parameter estimation and hypothesis testing.
- To understand and apply Bayesian inference, decision theory, and computational techniques in statistical analysis.

**Course Outcomes:**

CO1- Understand the fundamentals of Bayesian inference.
CO2- Apply Bayesian methods for parameter estimation.
CO3- Construct Bayesian credible intervals and posterior distributions.
CO4- Perform Bayesian hypothesis testing using computational techniques.
CO5- Apply Bayesian methods in insurance, finance and risk analysis.

| Credits: **04** | Core: **Elective** |
|---|---|
| Max. Marks: **100** | Min. Passing Marks: ..... |

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

| Unit | Topic | No. of Lectures |
|---|---|---|
| I | **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. | **12** |
| II | 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, | **12** |
| III | Computation of posterior distribution, Bayesian calculations, Monte Carlo Technique, Approximation methods, Empirical method, Gibbs sampler. | **12** |
| 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. | **12** |
| 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). | **12** |

**Suggested Readings:**


1. Bansal, A.K. (2007). Bayesian Parametric Inference. Alpha Science / Narosa.
2. Berger, J.O. (1985). Statistical Decision Theory and Bayesian Analysis, 2nd edition. Springer.
3. Robert, C.P. & Casella, G. (2004). Monte Carlo Statistical Methods, 2nd edition. Springer.
4. Gelman, A., Carlin, J.B., Stern, H.S., Dunson, D.B., Vehtari, A. & Rubin, D.B. (2013). Bayesian Data Analysis, 3rd edition. CRC Press.
5. Robert, C.P. (2007). The Bayesian Choice, 2nd edition. Springer.
6. Rohatgi, V.K. & Saleh, A.K.Md.E. (2015). An Introduction to Probability and Statistics, 3rd edition. Wiley.
7. Hogg, R.V., McKean, J.W. & Craig, A.T. (2019). Introduction to Mathematical Statistics, 8th edition. Pearson.
8. Goon, A.M., Gupta, M.K. & Dasgupta, B. (2005). An Outline of Statistical Theory, Vol. II (Statistical Inference), 3rd edition. The World Press, Kolkata.

| Programme/Class: **M.Sc.** | Year: **First** | Semester: **First** |
|---|---|---|
| Subject: **STATISTICS** | | |
| Course Code: - | 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 their functioning with optimization.

**Course Outcomes:**

CO1- An Actuarial Science course is designed to teach the students about risk assessment, financial Modelling and future risk predictions.

CO2- It deals with financial modelling, pricing and risk management, among others.

CO3- Students get the job opportunities in insurance industry.

CO4- The official statistics course teaches students about institutional, legal and organizational aspects of official statistic in India.

| Credits: **04** | Core: **Elective** |
|---|---|
| Max. Marks: **100** | Min. Passing Marks: ..... |

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

| Unit | Topic | No. of Lectures |
|---|---|---|
| I | Utility theory, insurance and utility theory, models 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, some analytical laws of mortality, select and ultimate tables. | **12** |
| II | Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws | **12** |
| 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. | **12** |
| 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. | **12** |
| 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. | **12** |

| | | |
|---|---|---|
| | 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. | |

**Suggested Readings:**


1. Dickson, D.C.M., Hardy, M.R. & Waters, H.R. (2020). Actuarial Mathematics for Life Contingent Risks, 3rd edition. Cambridge University Press.
2. Bowers, N.L., Gerber, H.U., Hickman, J.C., Jones, D.A. & Nesbitt, C.J. (1997). Actuarial Mathematics, 2nd edition. Society of Actuaries, Schaumburg, Illinois.
3. Deshmukh, S.R. (2022). Actuarial Statistics: An Introduction Using R, 2nd edition. Universities Press.
4. Deshmukh, S. (2012). Multiple Decrement Models in Insurance. Springer (India).
5. Saluja, M.R. (1972). Indian Official Statistical Systems. Statistical Publishing Society, Calcutta.
6. United Nations (2017). Principles and Recommendations for Population and Housing Censuses, Revision 3. UN Statistics Division.
7. Panse, V.G. (1954). Estimation of Crop Yields. FAO, Rome.
8. Ministry of Statistics & Programme Implementation (NSO), current editions. Guide to Official Statistics / Statistical System in India / National Accounts Statistics. Government of India.

| Programme/Class: **M.Sc.** | Year: **First** | Semester: **First** |
|---|---|---|
| Subject: **STATISTICS** | | |
| Course Code: - | Course Title: **Advanced Designs of Experiments** | |

**Need of the Course:** Experimental designs are those by which the knowledge of various statistical topics can be applied in agriculture field for improving the crop-plants through genetic-techniques.

**Objective of the Course-** The objective of the course is to provide the knowledge of the construction and analysis of various applied designs such as BIBD, Factorial, Different types of L.S.D. etc.

**Course Outcomes:**

Keeping the knowledge of the course, one can

**CO1-** apply the techniques of advanced designs in Biological and Agriculture research in order to see the significant effect of different new drugs/treatments.

CO2- Describe how to design experiments, carry them out, and analyse the data they yield.

CO3- Understand the process of designing an experiment including factorial and fractional factorial designs.

CO4- Examine how a factorial design allows cost reduction, increases efficiency of experimentation.

| Credits: **04** | Core: **Elective** |
|---|---|
| Max. Marks: **100** | Min. Passing Marks: ..... |

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

| Unit | Topic | No. of Lectures |
|---|---|---|
| I | **Constructions:** Elementary Theory of groups, Elements of projective and Euclidean Geometries, Galois field. | **14** |
| II | **Construction of -**<br>(i) Mutually orthogonal Latin squares.<br>(ii) Hyper Graeco Latin Squares<br>(iii) Incomplete Block Designs (Balanced and Partially Balanced), and<br>(iv) Totally and partially Confounded symmetric factorial designs. | **14** |
| III & IV | **Analysis:** Analysis of factorial design ($2^4, 3^3, 3^2$) Square and rectangular lattice designs, partially balanced incomplete block designs with recovery of interblock information. | **18** |
| V | Fractional Factorial Experiments: Fractional replication in case of $2^n$ and $3^{TM}$ types, Analysis of group experiments. | **14** |

**Suggested Readings:**


1. Das, M.N. & Giri, N.C. Design and Analysis of Experiments, 2nd edition. New Age International.
2. Raghavarao, D. (1988). Constructions and Combinatorial Problems in Design of Experiments. Dover.
3. Montgomery, D.C. (2020). Design and Analysis of Experiments, 10th edition. Wiley.
4. Kempthorne, O. (1952). The Design and Analysis of Experiments. John Wiley & Sons.
5. Cochran, W.G. & Cox, G.M. (1957). Experimental Designs, 2nd edition. John Wiley & Sons.
6. Mann, H.B. (1949). Analysis and Design of Experiments. Dover.
7. Dey, A. (2010). Incomplete Block Designs. Hindustan Book Agency / World Scientific.
8. Chakrabarti, M.C. (1962). Mathematics of Design and Analysis of Experiments. Asia Publishing House.

| Programme/Class: **M.Sc.** | Year: **First** | Semester: **First** |
|---|---|---|
| Subject: **STATISTICS** | | |
| Course Code: | Course Title: **Practical Lab based on the courses taught in the First Semester.** | |

**Course Outcomes:**

CO1- It provides the practical knowledge of quality control techniques.

CO2-Students will learn how to implement sampling inspection plans.

CO3- Students will learn how to perform non-parametric tests on real datasets.

CO4- The knowledge of advanced designs of experiments will help students to analyze field data.

| Credits: **04** | Core: **Compulsory** |
|---|---|
| Max. Marks: **100** | Min. Passing Marks: ..... |

Total No. of Lectures-Tutorials-Practical (in hours per week): **0-0-4.**

| Topic | No. of Hours in Lab |
|---|---|
| 1. Problems based on mean and range charts.<br>2. Problems based on charts for qualitative data.<br>3. Problems based on single and double sampling inspection plans.<br>4. Problems based on non-parametric tests.<br>5. Problems based on advanced designs of experiments. | **120** |

**Suggested Continuous Evaluation Methods:**

Continuous Internal Evaluation shall be based on Practical File/Record, ClassActivities and Overall performance. The marks shall be as follows:

| | |
|---|---|
| **Practical File/Record** | **(10 marks)** |
| **Class Interaction** | **(05 marks)** |
| **Report Preparation/ Presentation** | **(10 marks)** |

**Suggested Practical Examination Evaluation Methods: (75 Marks)**

Practical Examination Evaluation shall be based on Viva-voce and Practical Exercises.The marks shall be as follows:

| | |
|---|---|
| **Practical Exercise (Major) 01 x 25 Marks** | **25 Marks** |
| **Practical Exercise (Minor) 02 x 15 Marks** | **30 Marks** |
| **Viva-voce** | **20 Marks** |

## SECOND SEMESTER

| Programme/Class: **M.Sc.** | Year: **First** | Semester: **Second** |
|---|---|---|
| Subject: **STATISTICS** | | |
| Course Code: - | Course Title: **Multivariate 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 correlation analysis, regression analysis, discriminant analysis, factor analysis, etc. which are used in reduction, factorization, 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 modelling of data from real applications, including model identification, estimation and interpretation.

**Course Outcomes:**

CO1-This course is designed to teach students the applications of multivariate statistical techniques.

CO2- Students will learn the use of multiple correlation and regression tools to observe the effect of one variable to the others.

CO3- It helps to handle and analyse big data.

CO4- It helps students to get employability skills.

| Credits: **04** | Core: **Compulsory** |
|---|---|
| Max. Marks: **100** | Min. Passing Marks: ..... |

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

| Unit | Topic | No. of Lectures |
|---|---|---|
| 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. | **12** |
| II | Maximum Likelihood Estimators of Mean Vector and Co-Variance Matrix, 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 $\mu$ when $\Lambda$ is known, Sufficient statistics for $\mu$ and $\Lambda$ . | **12** |
| 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. | **12** |
| 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 | **12** |

| | | |
|---|---|---|
| | Normal Populations, Fisher's Discriminant Functions. | |
| 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. | 12 |

**Suggested Readings:**


1. Anderson, T.W. (2003). An Introduction to Multivariate Statistical Analysis, 3rd edition. Wiley.
2. Johnson, R.A. & Wichern, D.W. (2007). Applied Multivariate Statistical Analysis, 6th edition. Pearson.
3. Giri, N.C. (2004). Multivariate Statistical Analysis, 2nd edition. Marcel Dekker.
4. Kshirsagar, A.M. (1972). Multivariate Analysis. Marcel Dekker.
5. Rao, C.R. (1973). Linear Statistical Inference and its Applications, 2nd edition. Wiley.
6. Morrison, D.F. (2005). Multivariate Statistical Methods, 4th edition. Brooks/Cole–Thomson.
7. Roy, S.N. (1957). Some Aspects of Multivariate Analysis. Wiley / Asia Publishing House.
8. Srivastava, M.S. & Khatri, C.G. (1979). An Introduction to Multivariate Statistics. North-Holland.

| Programme/Class: **M.Sc.** | Year: **First** | Semester: **Second** |
|---|---|---|
| Course Code: - | Subject: **STATISTICS** | |
| | Course Title: **Time Series & Vital Statistics** | |

**Need of the Course:** Time series is a sequence of data points indexed in time order. 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.

**Course Outcomes:**

CO1-This course is very helpful to get the depth knowledge of time series analysis.

CO2-It also covers the study of the vital. Statistics including construction of life table, source of demographic data etc.

CO3- Students will learn the effect of seasonal and cyclic variation on the time series data like sales, production, interest rates etc.

CO4- After completing this course, students are expected to apply various techniques of time series models, including the seasonal autoregressive moving average (SARIMA) models, regression with ARMA models

| Credits: **04** | Core: **Compulsory** |
|---|---|
| Max. Marks: **100** | Min. Passing Marks: ..... |

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

| Unit | Topic | No. of Lectures |
|---|---|---|
| I | **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. | **15** |
| II | Measurement of Seasonal and Cyclical functions, Periodogram and Harmonic Analysis. | **10** |
| III | **Stationary and Non stationary Time Series:** Concepts, Auto regression, Autocorrelation, Partial Autocorrelation and Correlogram analysis. | **10** |
| IV & 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 Intercensal and Postcensal estimation. | **25** |

**Suggested Readings:**


1. Box, G.E.P., Jenkins, G.M., Reinsel, G.C. & Ljung, G.M. (2015). Time Series Analysis: Forecasting and Control, 5th edition. Wiley.
2. Chatfield, C. (2003). The Analysis of Time Series: An Introduction, 6th edition. Chapman & Hall/CRC.
3. Kendall, M.G. & Ord, J.K. (1990). Time Series, 3rd edition. Edward Arnold.
4. Goon, A.M., Gupta, M.K. & Dasgupta, B. (2002). Fundamentals of Statistics, Vol. II, 8th edition. The World Press, Kolkata.
5. Srinivasan, K. (1998). Basic Demographic Techniques and Applications. Sage Publications.
6. Cox, P.R. (1976). Demography, 5th edition. Cambridge University Press.
7. Biswas, S. (1988). Stochastic Processes in Demography and Applications. New Age International (Wiley Eastern).
8. Keyfitz, N. & Caswell, H. (2005). Applied Mathematical Demography, 3rd edition. Springer.

| Programme/Class: **M.Sc.** | Year: **First** | Semester: **Second** |
|---|---|---|
| Subject: **STATISTICS** | | |
| Course Code: - | Course Title: **Data Analytics & Python** | |

**Need of the Course:** The data analytics course is needed to train students for handling, analyzing and interpretation of different types of datasets such as marketing, medical, agricultural, banking, insurance etc.

**Objective of the Course:** The aims is to build a strong foundation of data science concepts that help students to learn practical implementation of machine learning through real-world datasets.

**Course Outcomes:**

After studying this course, students will be able to

CO1- Understand and use python data science libraries as a tool for data science.

CO2- Describe common Python functionality and features used for data analytics.

CO3- Clean and identify the data from dataset by performing analysis and pre-processing on dataset.

CO4- Understand and apply statistical methods for classifications and predictions.

| Credits: **04** | Core: **Elective** |
|---|---|
| Max. Marks: **100** | Min. Passing Marks: ..... |

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

| Unit | Topic | No. of Lectures |
|---|---|---|
| I | **Python:** Introduction to programming using Python, Syntax and Data Types, Variables, Operators, Input/output, Flow of Control (Modules, Branching), If, If- else, Nested if-else, Looping, For, While, Nested loops, Control Structure Iterators, User-defined functions, Strings and Tuples, Accessing Strings, Basic Operations, String slices, Working with Lists, Introduction, Accessing list, Operations, Function and Methods, Files, Modules, Dictionaries, Functions and Functional Programming, Declaring and calling Functions, Declare, assign and retrieve values from Lists, Introducing Tuples, Accessing tuples, NumPy, Pandas, Exploratory Data Analysis, Summary statistics (mean, median, mode, variance, standard deviation), Seaborn, matplotlib. | **16** |
| II | **Data Analytics:** **Machine Learning Techniques:** Linear and Logistic Regression, Multiple linear regression, Fitted regression lines, AIC, BIC, Model Fitting (Over-fitting, Balanced fitting, Under-fitting), Multicollinearity, Heteroscedasticity, Outliers, Training and Test Data, Introduction to Logistic regression, interpretation, odds ratio, Misclassification, Probability, AUC, R-Square. | **12** |
| III | **Supervised Learning Classification:** CART, KNN (classifier, distance metrics, KNN regression), Decision Trees (hyper parameter, depth, number of leaves), Naive Bayes, Support vector Machines. | **12** |

| | | |
|---|---|---|
| IV | **Unsupervised Learning:** Clustering - K-Means & Hierarchical, Distance methods - Euclidean, Manhattan, Cosine, Mahalanobis, Features of a Cluster - Labels, Centroids, Inertia, Eigen vectors and Eigen values, Principal component analysis. | **10** |
| V | **Ensemble Techniques:** Bagging & Boosting, Random Forest. | **10** |

**Suggested Readings:**


1. Matthes, E. (2023). Python Crash Course: A Hands-On, Project-Based Introduction to Programming, 3rd edition. No Starch Press.
2. Thareja, R. (2019). Python Programming: Using Problem Solving Approach, 2nd edition. Oxford University Press, New Delhi.
3. McKinney, W. (2022). Python for Data Analysis: Data Wrangling with pandas, NumPy, and Jupyter, 3rd edition. O'Reilly.
4. Géron, A. (2022). Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow, 3rd edition. O'Reilly.
5. Dutt, S., Chandramouli, S. & Das, A.K. (2024). Machine Learning, 2nd edition. Pearson.
6. Raschka, S., Liu, Y. & Mirjalili, V. (2022). Machine Learning with PyTorch and Scikit-Learn. Packt.
7. Ramalho, L. (2022). Fluent Python, 2nd edition. O'Reilly.
8. Ozdemir, S. (2025). Principles of Data Science, 3rd edition. Packt Publishing.

| Programme/Class: **M.Sc.** | Year: **First** | Semester: **Second** |
|---|---|---|
| Subject: **STATISTICS** | | |
| Course Code: - | Course 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.

**Course Outcomes:**

CO1-This course helps students to get the knowledge of mathematical and computational modelling of real decision-making problems, including the use of modelling tools and computational tools, as well as analytic skills to evaluate the problems.

CO2- It deals with the design, implementation, and analysis of computational experiments.

CO3- Students will get proficiency with tools from optimization and simulation including the fundamental applications of those tools in industry and the public sector in contexts involving uncertainty and scarce or expensive resources.

| Credits: **04** | Core: **Elective** |
|---|---|
| Max. Marks: **100** | Min. Passing Marks: ..... |

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

| Unit | Topic | No. of Lectures |
|---|---|---|
| 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. | **12** |
| II | **Quadratic Programming**: Structure of quadratic programming, Kuhn-Tucker conditions, Wolfe's modified simplex and Beale's methods for solving a Q.P. | **12** |
| III | **Revised Simplex Method:** Standard forms for revised simplex method, computational procedure for standard form-1 and standard form-2. | **12** |
| 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.<br>**Replacement Problem:** Replacement policy of items whose maintenance cost increases with time constant and varying scrap value. | **12** |
| 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. | **12** |

**Suggested Readings:**


1. Sharma, J.K. (2016). Operations Research: Theory and Applications, 6th edition. Trinity Press.
2. Taha, H.A. (2017). Operations Research: An Introduction, 10th edition. Pearson. (11th ed., 2022, also available)
3. Sharma, S.D. (2017). Operations Research: Theory, Methods and Applications, 15th edition. Kedar Nath Ram Nath & Co., Meerut.
4. Hillier, F.S. & Lieberman, G.J. (2021). Introduction to Operations Research, 11th edition. McGraw-Hill.
5. Hadley, G. (1987 reprint). Linear Programming. Addison-Wesley / Narosa, New Delhi.
6. Hadley, G. (1964). Nonlinear and Dynamic Programming. Addison-Wesley.
7. Gass, S.I. (2003). Linear Programming: Methods and Applications, 5th edition. Dover.
8. Gupta, R.K. (2014). Linear Programming, 15th edition. Krishna Prakashan Media (P) Ltd., Meerut.

| Programme/Class: **M.Sc.** | Year: **First** | Semester: **Second** |
|---|---|---|
| Subject: **STATISTICS** | | |
| Course Code: - | Course Title: **Bio-Statistics** | |

**Need of the Course:** To know the genetic structure of populations and the forces that alter that structure, one should have the knowledge of deterministic and probabilistic models of random mating, generalized treatment of mutation, migration and selection, and plant genetics.

**Objective of the Course-** The course objectives are:

- To formulate probability models for the laws of genetic transmission.
- To identify and assess the impact of basic forces that changes the genetics of a population.

**Course Outcomes:**

After studying this course, Students will be able

CO1- To formulate probability models for the laws of genetic transmission.

CO2- To identify and assess the impact of basic forces that changes the genetics of a population

CO3- To analyse genetic data to estimate the forces of genetic change.

| | |
|---|---|
| Credits: **04** | Core: **Elective** |
| Max. Marks: **100** | Min. Passing Marks: ..... |

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

| Unit | Topic | No. of Lectures |
|---|---|---|
| I & II | Structure of a Breeding Population, Genetic Correlation under dominance, deterministic models of random mating under chromosomes and chromatid segregation, Generalized treatment of Mutation, Migration and Selection. | **22** |
| III & IV | Applications of Fisher's fundamental theorem of Natural Selection, Theory of Inbreeding, sex linked genes, Path Coefficients, Homozygosity in Finite Populations, Stationary distributions of genes, Haploid and Diploid Models. | **22** |
| V | Diffusion models in Genetics, Estimation of Components Of variation, Detection and estimation of Epistatic interaction and linkage in heredity, Chromosome mapping, Plant Genetics, Estimation of Gene frequencies in different blood group systems. | **16** |

**Suggested Readings:**


1. Narain, P. (1990). Statistical Genetics. Wiley Eastern / New Age International.
2. Crow, J.F. & Kimura, M. (1970). An Introduction to Population Genetics Theory. Harper & Row (Blackburn Press reprint, 2009).
3. Ewens, W.J. (2004). Mathematical Population Genetics I: Theoretical Introduction, 2nd edition. Springer.
4. Kempthorne, O. (1957). An Introduction to Genetic Statistics. John Wiley & Sons.
5. Moran, P.A.P. (1962). The Statistical Processes of Evolutionary Theory. Clarendon Press, Oxford.
6. Li, C.C. (1955). Population Genetics. University of Chicago Press.
7. Bailey, N.T.J. (1961). Introduction to the Mathematical Theory of Genetic Linkage. Clarendon Press, Oxford.
8. Falconer, D.S. & Mackay, T.F.C. (1996). Introduction to Quantitative Genetics, 4th edition. Longman/Pearson.

| Programme/Class: **M.Sc.** | Year: **First** | Semester: **Second** |
|---|---|---|
| Subject: **STATISTICS** | | |
| Course Code: - | Course Title: **Stochastic Process & Survival Analysis** | |

**Need of the Course:** To understand stochastic models for random phenomena and statistical methods for analyzing lifetime and reliability data, one should have the knowledge of stochastic processes, survival analysis, lifetime distributions, and reliability estimation techniques.

**Objective of the Course-** The course objectives are:

- To understand the fundamental concepts of stochastic processes and survival analysis.
- To develop statistical methods for analyzing lifetime data and estimating reliability using classical and Bayesian approaches.

**Course Outcomes:**

CO1- The knowledge of the survival analysis will help students to get job in Bio-Statistics fields.

CO2- Students gets basic knowledge about stochastic processes in the time domain.

CO3-The student is able to formulate simple stochastic process models in the time domain and provide qualitative and quantitative analyses of such models.

CO4- The skills of stochastic analysis will provide job opportunity in share market.

CO5- The knowledge of this course can be applied in various diverse fields such as operations research, finance and insurance sectors, banking, planning & forecasting.

| Credits: **04** | Core: **Elective** |
|---|---|
| Max. Marks: **100** | Min. Passing Marks: ..... |

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

| Unit | Topic | No. of Lectures |
|---|---|---|
| I | **Stochastic Process:** Markov Chain, Chapman–Kolmogorov equation, classification of states, criteria for ergodic, persistent null and transient states, stationary distributions, limit theorems on transient and persistent null states. | **12** |
| II | **Survival Analysis:** **Basic concepts:** Definition of survival function, Failure rate or hazard function, Mean residual life and their relationship, Life testing plans or censoring methods, Right and left censoring, Type I and II censoring with and without replacement, Random Censoring. | **12** |
| III | **Some failure time distributions:** One and two parameter exponential, Gamma, Weibull, the extreme value and normal probability models as used in the analysis of life time data and in problems related to the modeling of aging or failure processes, some mixture models in a lifetime distribution. | **12** |
| IV | **Estimation Procedures:** Estimation of Parameters and survival function associated with various life time distributions and life testing plans, Various properties of these estimators, confidence intervals for parameters and survival function. | **12** |

| | | |
|---|---|---|
| V | **Bayesian Techniques in Reliability Estimation:** Bayes Estimator of parameters and reliability function associated with life time distributions. Their properties and comparison with classical estimators. | 12 |

**Suggested Readings:**


1. Medhi, J. (2009). Stochastic Processes, 3rd edition. New Age International.
2. Cox, D.R. & Miller, H.D. (1965). The Theory of Stochastic Processes. Chapman & Hall.
3. Srinivasan, S.K. & Mehata, K.M. (1976). Stochastic Processes. Tata McGraw-Hill.
4. Lawless, J.F. (2003). Statistical Models and Methods for Lifetime Data, 2nd edition. John Wiley & Sons.
5. Deshpande, J.V. & Purohit, S.G. (2005). Lifetime Data: Statistical Models and Methods. World Scientific.
6. Sinha, S.K. (1986). Reliability and Life Testing. Wiley Eastern.
7. Mann, N.R., Schafer, R.E. & Singpurwalla, N.D. (1974). Methods for Statistical Analysis of Reliability and Life Data. John Wiley & Sons.
8. Martz, H.F. & Waller, R.A. (1982). Bayesian Reliability Analysis. John Wiley & Sons.

| Programme/Class: **M.Sc.** | Year: **First** | Semester: **Second** |
|---|---|---|
| Subject: **STATISTICS** | | |
| Course Code: - | 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.

**Course Outcomes:**

After studying this course, students will be able to

CO1- Recognize simple and multiple linear regression as a tool for analysing economic data (cross-section and time series).

CO2- perform basic model validation procedures.

CO3- Develop models for economic forecasting both from micro as well as macroeconomics points of views.

CO4- rigorously understand issues in connecting data, statistics and economic theory.

| Credits: **04** | Core: **Elective** |
|---|---|
| Max. Marks: **100** | Min. Passing Marks: ..... |

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

| Unit | Topic | No. of Lectures |
|---|---|---|
| I | 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. | **14** |
| II | 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. | **12** |
| III | Heteroscedasticity, consequences and tests for it, estimation procedures under hetroscedastic disturbances. Auto correlated disturbances, Effects on estimation of parameters, Cochrane-Orcutt and Prais–Winsten transformation, Durbin-Watson test. Error-in-variables model, Inconsistency of least squares procedures, Consistent estimation of Parameters by instrumental variables. | **14** |
| 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 identification, A necessary and sufficient condition for the | **20** |

| | | |
|---|---|---|
| | 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. | |

**Suggested Readings:**


1. Greene, W.H. (2018). Econometric Analysis, 8th edition. Pearson.
2. Rao, C.R., Toutenburg, H., Shalabh & Heumann, C. (2008). Linear Models and Generalizations: Least Squares and Alternatives, 3rd edition. Springer.
3. Maddala, G.S. & Lahiri, K. (2009). Introduction to Econometrics, 4th edition. Wiley.
4. Gujarati, D.N. & Porter, D.C. (2009). Basic Econometrics, 5th edition. McGraw-Hill.
5. Johnston, J. & DiNardo, J. (1997). Econometric Methods, 4th edition. McGraw-Hill.
6. Theil, H. (1971). Principles of Econometrics. John Wiley & Sons.

| Programme/Class: **M.Sc.** | Year: **First** | Semester: **Second** |
|---|---|---|
| Subject: **STATISTICS** | | |
| Course Code: | Course Title: **Research Methodology & Computer Application** | |

**Need of the Course:** The researcher has to learn how to do research and what tools he should use.

**Objective of the Course:** The Objectives of the course is to make research students learn the scientific research methods and approaches.

**Course Outcomes:**

After studying this course, students will earn

CO1- The knowledge basic principles of research, objectives of research, importance, types of research. The basics of computer application in our research work.

CO2- The skills of research paper writing.

CO3- The knowledge of citation, bibliography, h-index, plagiarism etc.

CO4- The knowledge of INFLIBNET, e-journals, e-library, Scopus, database etc.

| Credits: **04** | Core: **Elective** |
|---|---|
| Max. Marks: **100** | Min. Passing Marks: ..... |

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

| Unit | Topic | No. of Lectures |
|---|---|---|
| I | **Introduction to Research Methods**: Definition of research, role and objectives of research, applications and types of research, research process and steps in it. Collecting and reviewing the literature, conceptualization and Formulation of a research problem, Identifying variables, constructing hypothesis, Synopsis. | **12** |
| II | **Research Design**: Selecting and defining a research problem, need for research design, features of a good research design, different research designs (exploratory, descriptive experimental and diagnostic research).<br>**Design of Sample Survey**: Census V/s Sample enumerations, objectives and principles of sampling, Types of sampling, Sampling and Non-sampling errors. Designing Questionnaires and interview. Determination of the sample size. | **12** |
| III | **Measurement of Scaling Concepts**: Scales of measurements, nominal, ordinal, interval and ratio scales, Errors in measurements. Validity and Reliability in measurement, Scale Construction Techniques. | **12** |
| IV | **Data Collection & Analysis**: Primary & secondary data, Validity and Reliability of data collection procedures, data preparation, exploratory data analysis, parametric and non-parametric tests, correlation and regression analysis, ANOVA, Multivariate Techniques.<br>**Report Writing**: Discussions, Conclusion, referencing and | **12** |

| | | |
|---|---|---|
| | various formats for reference writing, Bibliography, Thesis Writing, Formats of publications in research journals including subject classification, Impact factor, Citation index. | |
| V | **Computer Applications**: Data Communication and networks, LAN, WAN,GAN, Internet, Website, Webpage, E-mail, Search Engines, Scientific search engines. PDF and Latex files.<br>**MS WORD :** Test formatting, Math Type, MS Equation editor, INFLIBNET, e-journals, e-library, Scopus, Central blatt Math, Mathematical reviews. | 12 |

**Suggested Readings:**


1. Kothari, C.R. & Garg, G. (2019). Research Methodology: Methods and Techniques, 4th edition. New Age International.
2. Kumar, R. (2019). Research Methodology: A Step-by-Step Guide for Beginners, 5th edition. Sage.
3. Creswell, J.W. & Creswell, J.D. (2018). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 5th edition. Sage.
4. Panneerselvam, R. (2014). Research Methodology, 2nd edition. PHI Learning.
5. Gupta, S.P. (2021). Statistical Methods, 46th revised edition. Sultan Chand & Sons, New Delhi.
6. Gupta, S. (2008). Research Methodology and Statistical Techniques. Deep & Deep Publications, New Delhi.
7. Lamport, L. (1994). LaTeX: A Document Preparation System, 2nd edition. Addison-Wesley.

| Programme/Class: **M.Sc.** | Year: **First** | Semester: **Second** |
|---|---|---|
| Subject: **STATISTICS** | | |
| Course Code: | Course Title: **Practical Lab based on the courses taught in Second Semester.** | |

**Course Outcomes:**

After completing this course, students will have:

1. Ability to deal with the problems based on estimation of the mean vector and variance- covariance matrix using multivariate data.
2. Ability to deal with problems based on multiple correlation and regression analysis.
3. Ability to deal with the problems based on time series analysis..
4. Ability to fit models using supervised and unsupervised learning.
5. Knowledge of statistical programming in Python software.

| Credits: **04** | Core: **Compulsory** |
|---|---|
| Max. Marks: **100** | Min. Passing Marks: ..... |

Total No. of Lectures-Tutorials-Practical (in hours per week): **0-0-4.**

| Topic | No. of Hours in Lab |
|---|---|
| 1. Problems based on multivariate data analysis.<br>2. Problems based on time series data analysis.<br>3. Problems based on fitting trend.<br>4. Construction of life table.<br>5. Data analysis using Python. | **120** |

**Suggested Continuous Evaluation Methods:**

Continuous Internal Evaluation shall be based on Practical File/Record, ClassActivities and Overall performance. The marks shall be as follows:

| | |
|---|---|
| **Practical File/Record** | **(10 marks)** |
| **Class Interaction** | **(05 marks)** |
| **Report Preparation/ Presentation** | **(10 marks)** |

**Suggested Practical Examination Evaluation Methods: (75 Marks)**

Practical Examination Evaluation shall be based on Viva-voce and Practical Exercises.The marks shall be as follows:

| | |
|---|---|
| **Practical Exercise (Major) 01 x 25 Marks** | **25 Marks** |
| **Practical Exercise (Minor) 02 x 15 Marks** | **30 Marks** |
| **Viva-voce** | **20 Marks** |

There shall be 04-05 Practical Exercises in Examination comprising 01 as Major(Compulsory) and 03-04 as Minor (Students have to attend any 02).

***Each course will follow the following:***

**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.