Statistics Syllabus CBCS Pattern (New Course)
Master in Science (M.Sc)
Department of Statistics, Assam University, Silchar

Course No.	Title
Semester I	
101	Real Analysis
102	Linear Algebra
103	Probability Theory
104	Distribution Theory
105	Statistical Computing (Practical Paper)
Semester II	
201	Linear Models and Regression Analysis
202	Survey Sampling
203	Fundamentals of Data Collection and Analysis (CBCS paper open to PG students of other departments)
204	Statistical Inference I (CBCS paper open to all PG students)
205	Computer Programming (Practical Paper)
Semester III	
301	Design and Analysis of Experiments
302	Statistical Inference – II
303	Stochastic Process
304	Applied Statistics – I
305	Statistical Software (Practical Paper)
Semester IV	
401	Multivariate Analysis
402	Applied Statistics – II
403	(i) Industrial Statistics and Optimization Techniques I or (ii) Actuarial Statistics I
404	(i) Industrial Statistics and Optimization Techniques II or (ii) Actuarial Statistics II
405	Project Work

Note:

1. Each of the papers shall be of equal credit.
2. Students shall be exposed both to statistical theory and statistical computing.
3. Any one of the two modules in paper 403 and 404 will be offered to the students as specialization, i.e. either 403(i) and 404(i) or 403(ii) and 404(ii).
4. The Project Work shall be an application of statistical theory to practice. Students are supposed to identify a practical problem, collect necessary data, analyse them using statistical methods and report the findings.

First Semester
Paper 101
REAL ANALYSIS

Learning Outcome: Understand the basic concepts of real analysis including completeness of set, suprimum, infimum, sequence and series and their convergence, real-valued function, continuous function, uniform continuity and convergence, power series, Fourier series , unconstrained and constrained optimization problems with several variables, double and multiple integrals, uniform convergence in improper integrals and differentiation under the sign of integral. Apply these concepts of real analysis in the study of probability theory, distribution theory, statistical inference, stochastic process, Bayesian inference, linear and non-linear models, optimization techniques, multivariate statistics and other topics of statistics. On studying this paper the students are expected to develop a foundation for understanding various topics of statistics.

Unit I

Elements of set theory, Algebra of Sets, Open Sets, Closed Sets, bounded and unbounded sets, suprimum, infimum. Introduction to real numbers, Completeness in the set of Real numbers.

n-dimensional Euclidian space; open and closed intervals (rectangles), compact sets, Bolzano- Weirstrass theorem, Heine – Borel theorem. (9 lectures)

Unit II

Sequences, Cauchy's general principle of convergence, Algebra of sequence, Infinite series, different tests of convergence of series. (9 lectures)

Unit III

Real valued functions, continuous functions, uniform continuity,

Uniform convergence; Power series and Fourier series and Differentiation of functions (9 lectures)

Unit IV

Mean value theorems and applications, Taylors theorem, maxima - minima of single variable functions; maxima - minima of functions of several variables, constrained maxima - minima of functions. (9 lectures)

Unit V

Double and multiple integrals, evaluation of multiple integrals by repeated integration. Change of variables in multiple integration. Uniform convergence in improper integrals, differentiation under the sign of integral. (9 lectures)

REFERENCES

- Apostol, T. M. (1985). Mathematical Analysis, Narosa, Indian Ed.
- Royden H. L., Fitzpatrick P. M (2011). Real Analysis (4^{th} edition), PHI Learning.
- Malik, S. C. and Arora, S. (2002). Mathematical Analysis, New Age International Ltd.
- Protter, M. H. Basic Elements of Real Analysis, Springer

First Semester
Paper 102
LINEAR ALGEBRA

Learning Outcome: Understand the basic concepts of linear algebra including Fields, vector space, linear dependence, basis and dimension of vector space, orthogonal and orthonormal basis and transformation, projective transformation, algebra of matrices, partitioned matrices, rank and inverse of a matrix, Eigen values and Eigen vectors, generalized inverse, quadratic forms and solution of system of linear equations. The concepts of linear algebra shall help the student in the study of multivariate analysis, time series, linear models and regression, design of experiments, stochastic process, bivariate and multivariate distributions, statistical inference, stochastic process, Bayesian inference, linear and non-linear models, optimization techniques, and other topics of statistics.

Unit I

Fields, vector spaces, subspaces, linear dependence, basis and dimension of a vector space, completion theorem, linear equations. (9 lectures)

Unit II

Vector spaces with an inner product, Gram-Schmidt orthogonalization process, orthogonal and orthonormal basis and orthogonal projection of a vector, Ortogonal transformation, Projective transformation and their Statistical Applications (9 lectures)

Unit III

Matrices, Types of matrices, algebra of matrices, row an column vectors of a matrix, determinants, rank and inverse of a matrix, partitioned matrices, characteristic roots and vectors, Cayley – Hamilton theorem, minimal polynomial. (9 lectures)

Unit IV

Generalized inverse of a matrix, Moore and Penrose generalized inverse, Applications of generalized inverse.

Quadratic form of a matrix, Gram Matrix, Lagranges transformation of quadratic form, Cochran's Theorem. (9 lectures)

Unit V

System of linear equations, Gaussian elimination and back substitution, Row Echelon form, existence of solutions, uniqueness of solutions. (9 lectures)

REFERENCES

- Kunze Ray, Hoffman Kenneth (2008) Linear Algebra, 2nd Edition, PHI Learning Pvt. Ltd.
- Seymour Lipschutz, Marc Lipson (2005) Linear Algebra 3rd Edition, Tata McGraw Hill.
- Biswas, S. (2012). Textbook of Matrix Algebra, PHI, New Delhi
- Bhimasanaram P., A. Ramachandra Rao (2010) Linear Algebra (Texts and Readings in Mathematics) 2nd Revised edition, Hindustan Book Agency
- Dasgupta A. (2014) Abstract and Linear Algebra, Ashoke Prakashan, Kolkata

First Semester
Paper 103
Probability Theory

Learning Outcome: This paper shall give the students knowledge about the basic concepts of probability measure, measureable function, integrability of functions, probability space, theorems of probability, functions of random variables, distribution function, convergence of sequence of random variables, generating function and their convergence, law of large numbers, central limit theorems and urn models. Knowledge of probability is the basis of understanding the other domains of statistics. The knowledge of other subfields of statistics that depends on the concept of probability includes stochastic process, statistical inference, time series, regression analysis, multivariate analysis and other areas of statistical modelling. In addition to all these the students learn how to quantify the chance of an outcomes in the midst of uncertainty.

Unit I

Fields, sigma-fields, minimal sigma-field, Borel sigma-field in R_k, sequence of sets, limsup and liminf of a sequence of sets. Measure, Probability measure, properties of a measure, Lebesgue and Lebesgue-Steljes measures on R_k, (9 lectures)

Unit II

Measurable function, Simple functions, Integrability of simple functions, Probability space, Basic terminologies and theorems on probability, Independence of events, conditional probability, Bayes' Theorem and its applications (9 lectures)

Unit III

Random Variable, Functions of random variables (discrete and continuous), Distribution functions, Bi-dimensional and Multi-dimensional random variables, marginal and conditional distributions, expected values, moments, some related inequalities. (9 lectures)

Unit IV

Generating functions, characteristic function, uniqueness theorem, inversion theorem, joint characteristic function, Convergence of sequence of random variables, Urn Models (9 lectures)

Unit V

Weak law of large numbers, Chebychev's law of large numbers. Khinchin's theorem and its applications. Contilli's lemma, Borel zero-one law .
Kolmogorov's strong law of large numbers (both iid and non-iid cases).
Demoivre-Laplace central limit theorem. Lindeberg-Levy's central limit theorem.
Statement and discussion of Lindeberg- Feller's theorem. (9 lectures)

REFERENCES

- Hogg R.V., Craig, A. And McKean J. W. (2005) Introduction to Mathematical Statistics, 6th Edition, Pearson
- Feller, W. (1985). Introduction to Probability Theory and its Applications, Wiley Eastern, New Delhi
- Singh, B.M. (2002). Measure, Probability & Stochastic Processes, South Asian publishers, New Delhi.
- A. K. Md. Ehsanes Saleh and Vijay K. Rohatgi (2010) An Introduction to Probability and Statistics, Wiley India Pvt. Ltd.
- Das K. K. and Bhattacharjee D. (2008). An Introduction to Probability Theory, Asian Books, New Delhi.

First Semester
Paper 104
Distribution Theory

Learning Outcome: The paper shall expose the students to different aspects of distribution theory. On studying this paper students can get to learn the theory underlying the construction of these distributions. Thoroughly understanding the procedures of probability distributions students can apply these distributions to model

random events. On studying the theory of order statistics students can learn how to model product failure, droughts, floods and other extreme occurrences. Students are expected to have good concepts of each and every topics of distribution theory because distribution theory is the heart of statistics and almost every topic of statistics need the concepts of distribution theory.

Unit I

Univariate discrete distributions; properties and application of binomial, Poisson, hypergeometric, geometric and negative binomial distribution. (9 lectures)

Unit II

Univariate continuous distributions; statement, derivation of properties and applications of normal, exponential, beta, gamma, Cauchy, Weibull and lognormal distributions (9 lectures)

Unit III

Bivariate distributions, Bivariate Normal Distribution, Properties and applications, Derivation and properties of chi-square, t and F distributions and their inter relationship (9 lectures)

Unit IV

Derivation and properties of non-central chi-square, t and F distributions, Compound distribution, truncation of distributions. (9 lectures)

Unit V

Order Statistics, Distribution of r^{th} order statistics, Joint density of two order statistics, some special joint distributions resulting from order statistics. Mixture distribution (definition, finite mixtures and zero modified distributions, mixtures of binomial distribution), extreme value distributions. (9 lectures)

REFERENCES

- Hogg R.V., Craig, A. And McKean J. W. (2005) Introduction to Mathematical Statistics, 6^{th} Edition, Pearson
- Freund, J. E. (1998). Mathematical Statistics, PHI, New Delhi
- Biswas, S. (2002). Topics in Statistical Methodology, New Age International Publishers, New Delhi.
- Johnson, S and Kotz (1995). Distributions in Statistics, Vol – I, II and III, Houghton and Miffin.
- Wilks S.S. (2007). Mathematical Statistics, Buck Press
- Das K. K. and Bhattacharjee D. (2008). A Treatise on Statistical Inference and Distributions, Asian Books, New Delhi

First Semester

Paper 105

Statistical Computing (Practical Paper)

Learning Outcome: The paper aims at enriching the computing power of students using spreadsheets and packages like Microsoft Excel and R. The paper will help the students to understand how to go around with the computing part of some of the theoretical aspects using statistical packages. On studying this paper the students shall find themselves acquainted in the field of data science. After completing this paper students are expected to have computational expertise on topics of linear algebra, distribution theory and other basic topics of statistics. *The paper will help the students to understand how to go around with the computing part of some of the theoretical aspects electronically.*

List of Practicals to be performed using Microsoft Excel/R/Matlab

1. Computation of Determinants of matrix
2. Inverses of a matrix by partitioning
3. Rank of a matrix
4. Solutions of matrix equations
5. Characteristic roots and vectors of a matrix
6. Fitting of binomial distribution and testing the goodness of fit
7. Fitting of Poisson distribution and testing the goodness of fit
8. Fitting of negative binomial distribution and testing the goodness of fit
9. Fitting of multinomial distribution
10. Fitting of normal distribution and testing the goodness of fit
11. Fitting of lognormal distribution and testing the goodness of fit
12. Common tests of significance like t-tests, F-test and Chi-Square tests
13. Numerical Integration
14. Root extraction using different methods
15. Random number generation from different distributions
16. Simple exercise on simulation
17. Producing simple statistical graphs in R

REFERENCES

- Gardener M. (2010) Beginning R : The Statistical Programming Language, Wiley India Pvt. Ltd., New Delhi
- Bhattacharjee, D. (2010). Practical Statistics using Microsoft Excel, Asian Books, New Delhi
- Levine, D. M., Stephan, D., Krehbiel, T.C. and Berenson, M.L. (2006). Statistics for Managers Using Microsoft Excel, Prentice Hall of India Pvt. Ltd., New Delhi.
- Bruce L.L. and Hanselman D. C. (1996). Mastering Matlab 7,
- Gilat A. (2004) Matlab: An Introduction with Applications, 4th Edition, Wiley India Pvt. Ltd., New Delhi
- Albright, S.C., Winston, W. L. and Zappe C. J. (2009) Decision Making Using Microsoft Excel, Cengage Learning, New Delhi.

Second Semester

Paper 201

Linear Models and Regression Analysis

Learning Outcome: Understand the concepts of linear models and regression including simple linear regression, multiple regression, inverse regression, non-linear regression, polynomial regression, logistic regression, non-linear growth models. Study the maximum likelihood estimation for estimating parameters of these models and testing of hypothesis of parameters or functions of parameters. Finally, students are expected to choose an appropriate linear or non-linear models in a given research setting and interpret the model and report the findings scientifically. On studying this paper the students are expected to suggest appropriate regression models for given datasets to predict the behaviour of complex systems or analyze experimental, financial and biological data.

Unit I

Simple linear regression, estimation and tests of hypothesis associated with the parameters of regression, confidence interval and bands for slope and intercept, evaluating the goodness of fit, residual analysis, effect of outliers, transformation of variables. Interclass correlation, correlation ratio. (9 lectures)

Unit II

Straight line regression through origin, weighted least squares, inverse regression, comparing straight lines, two phase linear regression, multiple regression, properties of least square estimators, estimation and testing related to regression parameters, inclusion of qualitative variables as regressors, multiple and partial correlations (9 lectures)

Unit III

Problem of correlated errors, detection and removal of auto-correlation, Variance-covariance of least square estimators, estimation of error variance, case with auto-correlation, detection and correction of multicollinearity, ridge regression. (9 lectures)

Unit IV

Non-linear regression, polynomial in one variable, orthogonal polynomials, polynomial regression in several variables, Gompertz and Logistic non-linear growth models (9 lectures)

Unit V

Logistic regression, logit transformation, maximum likelihood (ML) estimation, tests of hypothesis: Wald test, likelihood ratio (LR) test, score test, test for overall regression, multiple logistic regression; forward and backward method, Interpretation of parameters. (9 lectures)

REFERENCES

- Seber, G.A.F (1977) Linear Regression Analysis, John Wiley and Sons, New York
- Joshi, D.D. (2009) Linear Estimation and Designs of Experiment, New Age International Publishers, New Delhi.
- Chatterjee, S. and Price, B. (1995) Regression Analysis by Example, John Wiley and Sons, New York.
- Rao, C. R. (1973) Linear Statistical inference and its Applications. Wiley Eastern.
- Draper, N.R. and Smith, H. (1998) Applied Regression Analysis, John Wiley, New York
- Seber, G.A.F and Wild, C.J. (1989). Nonlinear Regression, John Wiley, New York

Second Semester
Paper 202
Survey Sampling

Learning Outcome: Understand the basic concepts of various probability sampling including simple random sampling, stratified random sampling, probability proportional to size sampling, cluster sampling, multi-stage sampling, systematic sampling and non-probability sampling including distance sampling, snowball sampling, network sampling and importance sampling. Students have to know the estimation of population mean and population total using ratio and regression methods of estimation. Students have to understand sampling and non-sampling errors, modeling observational error, and randomized response technique to get information for sensitive issues. After studying this paper students can be equipped to perform different types of sampling procedure in real life situation. Students shall acquire the theoretical as well as practical knowledge of field study to analyze the data, interpret the results and draw valuable conclusions coming from various aspects.

Unit I

Review of basic finite population sampling techniques. Simple random sampling with and without replacement. Stratified sampling. Allocation problem and construction of strata.

(9 lectures)

Unit II

Unequal probability sampling: pps with replacement/without replacement methods [including Lahiri's scheme] and related estimators of a finite population mean, Hansen-Hurwitz and Desraj estimators for a general sample size and Murthy's estimator for a sample of size 2. (9 lectures)

Unit III

Ratio method of estimation (Hartley Ross and Jacknife estimators), combined ratio estimator and regression estimators based on srswor method of sampling. Combined ratio estimator

(9 lectures)

Unit IV

Cluster sampling with clusters of equal and unequal sizes. Two-stage and Multi-stage sampling, systematic sampling. (9 lectures)

Unit V

Non sampling errors, errors in survey, modeling observational errors. Randomized response technique (Wamer's model only). Basics of distance sampling, Non-probability sampling techniques, snowball network sampling and importance sampling. (9 lectures)

REFERENCES

- Cochran, W.G. (1997). Sampling Techniques, Wiley Eastern, New Delhi.
- Mukhopadhyay, P.(1998). Theory and Methods of Survey Sampling, Prentice Hall of India, New Delhi.
- Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984). Sampling Theory of Surveys with Applications, Iowa State University Press and IARS.
- Murthy, M.N. (1977). Sampling Theory and Methods, Statistical Publishing Society, Kolkata.
- Chaudhury, A. and Mukherjee, R. (1988). Randomized Response: Theory and Techniques, Marcel Decker, New York.

Second Semester
Paper 203
Fundamentals of Data Collection and Analysis
(CBCS Paper open to PG students of other departments)

Learning Outcome: This is a CBCS open paper for PG students of other departments. This paper deals with fundamentals of data collection and analysis which consists of Measures of Central Tendency, Measures of Dispersion, Primary and Secondary data, Scaling Techniques, Correlation, Measures of disease frequency, Levels of Measurement, Data Management, Data Coding, Data Cleaning, Data Processing etc. The entire concept is clearly explained about basic statistics. From this paper students shall acquire both theoretical and practical knowledge of analyzing, presenting and interpretation of real life data.

Unit I

Measures of Central Tendency (including windsorized mean and trimmed mean), Measures of Dispersion (including relative measures), Outliers, normalization and standardization of data, unweighted composite index. (9 lectures)

Unit II

Primary data, method of data collection, secondary data and its sources, random and non-random sampling techniques and their types, determination of sample size, scaling techniques (9 lectures)

Unit III

Correlation (Karl Pearson's, Spearman's, Point-biserial, Phi and Kendell's), scatter plot, lines of regression, residual analysis, r^2 for model fit, outlier detection, association of attributes, Coefficient of association, Coefficient of colligation, Goodman and Kruskal's Gamma, Kendall's tau-a, b, c, Somers' d (9 lectures)

Unit IV

Measures of disease frequency, prevalence and incidence, crude, specific and standardized rates, risk ratio, odds ratio, confounding, Mantel-Haenszel odds ratio, infant and maternal mortality rates (9 lectures)

Unit V

Levels of measurement, measurement of agreement, data management, data coding, data cleaning, data processing, rectangular data file, missing data analysis. (9 lectures)

REFERENCES

- Madsen B. (2008) Statistics for Non-statistician, Springer
- Urdan, TC. (2005). Statistics in Plain English, Lawrence Erlbaum Associates Publishers
- Gun AM., Gupta MK. And Dasgupta B. (2001) Fundamentals of Statistics, Vol. 1, World Press.
- Boslaugh S and Watters PA (2008) Statistics in a Nutshell, O'Really
- Naresh K. Malhotra and Satyabhusan Dash (2010) Marketing Research: An Applied Orientation, Fifth Edition, Pearson Education.
- D. A. deVaus (2003) Surveys in Social Research, Fifth edition, Allen and Unwin, Australia.
- Rumsey D. (2007) Intermediate Statistics for Dummies, Wiley Publishing, Inc.

Second Semester

Paper 204

Statistical Inference I

(CBCS Paper open to all PG Students)

Learning Outcome: This paper deals with point estimation, types of estimation, hypothesis testing and interval estimation. On studying this paper- the students can learn the basic concepts of statistical inference including point estimation, interval estimation and testing of hypothesis. Students have the knowledge of

properties of estimators, methods of estimation of parameters, methods of obtaining minimum variance unbiased estimators. Students can perform point estimation, hypothesis testing and interval estimation under a variety of discrete and continuous probability models. Further, students can evaluate the properties of these estimators and tests for both finite sample sizes and asymptotically as the sample size tends to infinity. From this paper the students are expected to build a foundation on inferential statistics which is the basis of higher level mathematical statistics.

Unit I

Point estimation, properties of estimators: unbiasedness, consistency, sufficiency. Neyman factorization criterion, completeness. (9 lectures)

Unit II

Minimum variance, mean square error, BLUE, minimum variance unbiased estimators, C-R inequality, Rao-Blackwell Theorem, Lehmann-Scheffe theorem (9 lectures)

Unit III

Exponential class of densities and its properties, Types of estimation- Method of Maximum Likelihood, Method of moments (9 lectures)

Unit IV

Tests of hypothesis, concepts of critical regions, test functions, two kinds of errors, size function, power function, level, MP and UMP test, Neyman-Pearson Lemma, MP test for simple null against simple alternative hypothesis. UMP tests for simple null hypothesis against one-sided alternatives and for one-sided null against one-sided alternatives in one parameter exponential family. (9 lectures)

Unit V

Interval estimation, confidence level, construction of shortest expected length confidence interval, Uniformly most accurate one-sided confidence Interval and its relation to UMP tests for one-sided null against one-sided alternative hypotheses. (9 lectures)

REFERENCES

- Hogg RV., Craig, A. & McKean JW. (2005) Introduction to Mathematical Statistics, Ed. 6, Pearson
- Kale, B.K. (1999). A First Course on Parametric Inference, Narosa Publishing House.
- Lehmann, E.L. (1986). Theory of Point Estimation, John Wiley & Sons.
- Lehmann, E.L. (1986). Testing Statistical Hypotheses, John Wiley & Sons.
- Rao, C.R. (1973). Linear Statistical Inference and its Applications, 2nd Edn., Wiley Eastern Ltd., New Delhi.
- Rohatgi, V.K. and Saleh, A.K. Md. E. (2005). An Introduction to Probability and Statistics, Second Edition, John Wiley.
- Biswas, S. (2002). Topics in Statistical Methodology, New Age International Pub., New Delhi.

- Wilks S.S. (2007). Mathematical Statistics, Buck Press
- Dudewicz, E. J. and Mishra, S.N.(1988) Modern Mathematical Statistics, John Wiley
- Das K. K. and Bhattacharjee D. (2008). A Treatise on Statistical Inference and Distributions, Asian Books, New Delhi

Second Semester
Paper 205
Computer Programming (Practical Paper)

Learning Outcome: The main purpose of this paper is to introduce the students of object oriented programming concepts in C language. C is a powerful general-purpose programming language, which can be used to develop software like operating systems, databases, compilers and so on. The learning objective of this paper is to enrich the computing power of students and provide them some exposure to the programming skills in C. Students will be able to develop their programming logic which will help them to make their own programs, applications in C language. The students can learn some basics of C language and can switch over to any other programming language in future.

Programming in C

Introduction to object-oriented programming concepts.

Programming in C: Data types, Variables, Operations and Expressions, functions and parameters, input/output, control statements such as if-else, switch, for, while and do-while, pointers, arrays (one dimensional and multi dimensional), character strings and library functions.

List of Practicals

Using the knowledge of C students are expected to program the following:

1. Factorial of a positive Integer
2. Ordering of a given set of observations
3. Finding maximum and minimum of a given set of observations.
4. Mean, variance and quantiles for ungrouped and grouped data.
5. Correlation coefficients for ungrouped data, Intra-class correlation coefficient.
6. Fitting of exponential curve and straight line to the given data.
7. Fitting of Binomial and Poisson distributions.
8. Drawing of random samples from Binomial, Poisson, Normal and Gamma distributions.
9. Fitting of standard distributions and tests for goodness of fit.
10. Method of Estimation: Moments, MLE, MLE for location parameter of Cauchy distribution.
11. Tests of significance: Drawing of power curve of a test. Test based on Chi-square, t and F statistics and related confidence intervals.
12. Large sample tests.
13. Construction of difference table, Forward, Backward and Central difference interpolation formulae. Divided difference table. Newton's divided difference and Lagrange's interpolation formula.

14. Numerical Integration: Trapezoidal Rule, Simpson's 1/3rd rule and Weddle' formula for numerical integration.
15. Operations of Matrix algebra and computation of the inverse of a matrix.

REFERENCES

- Schildt H. (1990) Teach Yourself C, Osborne/McGraw Hill.
- Kanitkar Y. (2013) Let us C, Thirteenth Edition, BPB Publications
- Srivastava S K and Srivastava D. (2009) C in Depth, BPB Publications
- Kernighan B K and Ritchie, D.M. The C Programming Language (ANSI C Version), Prentice Hall of India.
- Balagurusamy E. (2012) Programming in ANSI C, Tata McGraw Hill.
- Gottfried B., (1996) Schaum's Outline of Programming with C, McGraw Hill.

Third Semester
Paper 301
Design and Analysis of Experiments

Learning Outcome: Understand the meaning of randomization, replication, local control and contrast and make use of analysis of variance-one way, two-way with equal and unequal number of observations per cell along with analysis of covariance. Identify the common and important types of experimental designs with respective advantages and disadvantages in terms of power, cost and time. Apply the basics of statistical inference including estimation, testing of hypothesis and confidence interval in the designs. Understand and use factorial experiments, fractional factorial experiment and confounding in experiments. Differentiate between connectedness, orthogonality and balanced designs. Finally, students are expected to choose an appropriate design in a given research setting and interpret the model and report the findings scientifically. On studying this paper the students are expected to suggest appropriate experimental designs for agricultural and livestock experiments so as to minimize the experimental error.

Unit I

Review of linear estimation, Analysis of Variance: one way, two way (with m=1, m>1) observations per cell, Fixed Effect, Random Effect and Mixed Effect, Two way classified data with unequal number of observations in cells, Analysis of Co-variance (9 lectures)

Unit II

Orthogonal Contrasts, Application of ANOVA in the study of relationship: between two variables, linearity of regression, polynomial regression, homogeneity of group regression coefficients, multiple linear regression model, Non parametric ANOVA (9 lectures)

Unit III

Designs of Experiment: Basic Principles, basic designs and their analysis, relative efficiency, missing plot analysis, Graeco-Latin Square Design. (9 lectures)

Unit IV

Factorial experiments, factorial effects, study of 2 and 3 factorial experiments in randomized blocks. Complete and partial confounding. Symmetrical factorial experiments (s^m, where s is a prime or a prime power), confounding in s^m factorial experiments, s^{k-p} fractional factorial where s is a prime or a prime power (9 lectures)

Unit V

BIBD- Recovery of Interblock information, Concepts and Connectedness, Orthogonality and Balance. Intrablock analysis of General Incomplete Block design, Split-plot and Strip plot Design. (9 lectures)

REFERENCES

- Cochran, W.G. and Cox, G.M. (1959). Exponential Designs, Asia Publishing House, Singapore.
- Das, M.N. and Giri, N.C. (1986). Design and Analysis of Experiments, Wiley Eastern Limited.
- Dean, A. and Voss, D. (1999). Design and Analysis of Experiments, Springer. First Indian Reprint 2006.
- Joshi, D.D. (1987). Linear Estimation and Design of Experiments, Wiley Eastern, New Delhi.
- Montgomery, D.C. (2005). Design and Analysis of Experiments, Sixth Edition, John Wiley and Sons.
- Raghavarao, D. (1970). Construction and Combinational Problems in Design of Experiments, John Wiley and Sons.

Third Semester
Paper 302
Statistical Inference II

Learning Outcome: Understand the concepts of likelihood ratio test, monotone likelihood ratio test and similar test. Apply Bayesian Inference and Bayesian testing of hypothesis for credible intervals and Bayesian prediction. Understand the use of sequential probability ratio test and various non-parametric methods. Finally, students are expected to identify appropriate statistical inference techniques from a given research or applied problems and perform correct statistical analysis using different inferential techniques and tests. On studying this paper the students shall gather advanced knowledge in inference extending which they can learn topics like Bayesian Data Analysis, sequential techniques.

Unit I

The Likelihood Ratio Test, One-tailed and two-tailed likelihood ratio tests for mean and variance of normal populations, Asymptotic property of LRT and applications, Monotone Likelihood Ratio Test and applications, Similar tests (9 lectures)

Unit II

Overview of Bayesian inference, Concept of Prior and Posterior distributions, Types of prior and relevant computation, Bayesian estimation and Bayes rules, Loss functions. (9 lectures)

Unit III

Bayesian Testing of hypothesis, Lindley's method, Tests of point null hypothesis, Jeffreys Test for normal mean, Credible Intervals and their applications, Bayesian prediction. (9 lectures)

Unit IV

Sequential tests, Wald's Sequential Probability Ratio test, Properties of SPRT, Efficiency, Fundamental identity, Operating Characteristics and average sample number, Application of SPRT in decision making. (9 lectures)

Unit V

Non-parametric methods, Tests of goodness of fit: Chi-square, K-S Test, Sign tests, Run tests, Mann-Whitney's U Test, test of significance of rank order correlations, non-parametric estimation and confidence interval. (9 lectures)

REFERENCES

- Ferguson, T.S.(1996). Mathematical Statistics- A Decision theory Approach, Academic Press, London.
- Gibbons, J.D. and Chakraborti, S. (1992). Non-parametric Statistical Inference, Marcel Dekker, New York.
- Randles, R.H. and Wolfe, D.S. (1979). Introduction to the Theory of Non-Parametric Statistics, John Wiley and Sons.
- Rao, C.R. (1973). Linear Statistical Inference and Its Applications, Second Ed., Wiley Eastern Ltd.
- Rohatgi, V. and Saleh, A.K.Md. E (2005). An Introduction to Probability and Statistics, Second Edition, John Wiley.
- Ghosh, J.K., Delampady, M. And Samanta T. (2006) An Introduction to Bayesian Analysis Theories and Methods, Springer International Edition.
- Lee P. M. (1989) Bayesian Statistics: An Introduction, Edward Arnold.

Third Semester
Paper 303
Stochastic Process

Learning Outcome: Understand the meaning of stochastic process, Markov chain, and transition probability matrix along with classification of stochastic process. Identify the states and stationary distribution of Markov Chain along with distribution of Markov chain at a given time. Understand the concepts and applications of random walk and Gambler's ruin problem, Brownian motion, Wiener Process, Branching process and renewal process. Finally, students are expected to choose appropriate stochastic process model(s) for a given research in applied problem and apply the theory to model real phenomena and solve several problems concerning random behavior in different fields of applied science.

Unit I

Classification of Markov Chains, Higher transition probabilities in Markov Classification of States and Chains. Stability of a Markov System. Limiting behaviour: Irreducible ergodic chain. (9 lectures)

Unit II

Markov Processes with discrete state space: Poisson process and its properties, Simple Birth and Death Process, Martingales, Martingale convergence theorems. (9 lectures)

Unit III

One-dimensional, two-dimensional and three-dimensional random walks, Correlated random walk. Gambler's ruin problem. (9 lectures)

Unit IV

Introduction to Brownian Motion and Wiener process, Branching Process, Chance of Extinction. (9 lectures)

Unit V

Renewal Processes, Renewal Processes in Continuous Time, Stopping time: Wald's Equation, Elementary Renewal Theorem, Delayed and Equilibrium Renewal Processes (9 lectures)

REFERENCES

- Bailey, Norman, T.J. (1964). The Elements of Stochastic Processes, John Wiley and Sons.
- Bartlett, M.S. (1966). An Introduction to Stochastic Processes, Cambridge University Press.
- Bhat, B.R. (2000). Stochastic Models- Analysis and Applications, New Age International Publishers.
- Feller, William (1968). An Introduction to Probability Theory and its Applications, Vol. 1 (Third Ed.) John Wiley.
- Karlin, S. and Taylor, H.M. (1975). A First Course in Stochastic Processes, (Second Ed.), Academic Press.
- Medhi, J. (1994). Stochastic Processes, Second Edition, Wiley Eastern Ltd.
- Ross, S.M. (1983). Stochastic Processes. John Wiley and Sons.

Third Semester
Paper 304
Applied Statistics I

Learning Outcome: Understand the concept of national development in terms of various indices of development including human development index and national income. Determine the levels of mortality and fertility and construct life tables. Projection of population growth and measurement of income inequality using different methods are expected. Understand role, function and activities of various statistical organizations for collecting official statistics. Finally, students are expected to know the collection, analysis, forecasting and

interpretation of results of data relating to agricultural, industry, educational and other social statistics. This paper exposes the students to different fields of applied statistics and let them know how the probabilistic and computational models can be applied to some real life domains.

Unit I

Statistics for National Development- Economic development: Growth in per capita income and distributive justice. Indices of development, Human Development Index. Estimation of national income - product approach, income approach and expenditure approach.

(9 lectures)

Unit II

Measures of mortality and fertility, Life table: complete and abridged, King's method, Greville's method, Reed and Merrell method, Chiang's method, uses of life table, graduation of mortality rates. (9 lectures)

Unit III

Population growth in developing and developed countries. Population projection using Component method, Leslie marix. Labour force projection. Measuring inequality in incomes, Gini coefficient, Theil's measure. Poverty measurement - different issues, measures of incidence and intensity, combined measures e.q., indices due to Kakwani, Sen etc.

(9 lectures)

Unit IV

Official Statistics- Indian and International statistical systems: Role, function and activities of Central and State statistical organizations. Organization of large scale sample surveys. Role of National Sample Survey Organization, General and special data dissemination systems.

(9 lectures)

Unit V

System of collection of agricultural statistics, Crop forecasting and estimation, productivity, impact of irrigation projects. Statistics related to industries, foreign trade, and balance of payment, cost of living, inflation, educational and other social statistics. (9 lectures)

REFERENCES

- Basic Statistics Relating to the Indian Economy (CSO) 1990.
- Guide to Official Statistics (CSO) 1999.
- Keyfitz, N. (1977). Applied Mathematical Demography, Springer Verlag.
- Benjamin, B. (1969). Demographic Analysis, George, Allen and Unwin
- Panse, V.G., Estimation of Crop Yields (FAO).
- Principles and accommodation of National Population Censuses, UNESCO
- Statistical System in India (CSO) 1995.
- Sen, A. (1997). Poverty and Inequality.
- UNESCO. Principles for Vital Statistics Systems. Series M -12.
- Gun AM., Gupta MK. and Dasgupta B. (2001) Fundamentals of Statistics, Vol. 2, World Press.

Third Semester
Paper 305
Statistical Software (Practical Paper)

Learning Outcome

The objective of this paper is to introduce the students to at least one of the popular Statistical Software Packages that are commonly used. The paper shall provide them with an overview of the application and the different computational facilities provided in the package. Along with common tools of data analysis like regression, Descriptive Statistics, Tests of Significance both parametric and non-parametric, Graphical tools, multivariate data analysis and data manipulation tools shall also introduced. Students on studying this paper are expected to well acquaint with statistical software to apply for a given research problems using all statistical techniques learnt in the previous semester and the current semester and interpret the findings in a scientific way. This is a course after studying which students can perform different statistical computations using statistical package and can think a career on data analysis and even get self-employed as a data analyst.

REFERENCES

- Field A. (2013) Discovering Statistics Using SPSS, Sage Publications.
- Gilat. (2010) MATLAB: An Introduction with Applications, BPB Publications
- Singh YK and Chaudhuri BB (2008) MATLAB Programming, PHI, New Delhi
- Carver RH. and Nash JG. (2012) Doing Data Analysis in SPSS: Version 18.0, CENGAGE Learning.
- Hamilton LC. Statistics with STATA: Version 12, CENGAGE Learning.
- Khan RM. (2013) Problem Solving and Data Analysis using Minitab, Wiley.

Fourth Semester
Paper 401
Multivariate Analysis

Learning Outcome: In multivariate analysis students learn how to deal with the data analysis of several variables simultaneously. Necessary theoretical deductions of different multivariate techniques and deduction of multivariate probability distributions are the learning objectives of this paper. The analysis of real life data using multivariate tools like- factor analysis, discriminant analysis, cluster analysis, principal component analysis are also taught using appropriate statistical package. After studying this paper, students can be equipped to perform multivariate data analysis on real life data using statistical packages, interpret the results and in addition shall develop necessary theoretical and mathematical understanding of the multivariate processes.

Unit I

Multinomial distribution, Bivariate normal distribution, Multivariate normal distribution its properties and characterization, Random sampling from a multivariate normal distribution. Maximum likelihood estimators of parameters. Distribution of sample mean vector.

(9 lectures)

Unit II

Wishart matrix- its distribution and properties, Distribution of sample generalized variance, Null and non-null distribution of sample correlation coefficient. Null distribution of partial and multiple correlation coefficients. Distribution of sample regression coefficients. Application in testing and interval estimation. (9 lectures)

Unit III

Null distribution of Hotelling's T^2 statistic, application in tests on mean vector for one or more multivariate normal populations and also on equality of the components of a mean vector in a multivariate normal population. (9 lectures)

Unit IV

Classification and discrimination procedures for discrimination between two multivariate normal populations – sample discriminant function, tests associated with discriminant functions, Principal component, Dimension reduction, Canonical variables and canonical correlation, Factor analysis. (9 lectures)

Unit V

Multivariate linear regression model; estimation of parameters, tests of linear hypotheses. Likelihood ratio test criterion, Multivariate analysis of variance (MANOVA) of one way classified data. (9 lectures)

REFERENCES

- Anderson, T.W. (2003). An Introduction to Multivariate Statistical Analysis, Third Edition, John Wiley & Sons.
- Arnold, Steven F. (1981). The Theory of Linear Models and Multivariate Analysis, John Wiley& Sons.

- Giri, N.C. (1977). Multivariate Statistical Inference, Academic Press.
- Johnson, R.A. and Wichern, D.W. (2007). Applied Multivariate Statistical Analysis, Sixth Edition, Pearson & Prentice- Hall.
- Kshirsagar, A.M. (1972). Multivariate Analysis, Marcel Dekker.
- Lawley, D.N. and Maxwell, A.E. (1971). Factor Analysis as a Statistical Method, Second Edition, London Butterworths.
- Muirhead, R.J. (1982). Aspects of Multivariate Statistical Theory, John Wiley & Sons.

Fourth Semester
Paper 402
Applied Statistics II

Learning Outcome: The paper provides the students exposure to different models used in the field of time series analysis, survival analysis and competitive risk theory. On studying this paper students shall acquire knowledge of both theoretical and computational aspects of time series data as well as data coming from the field of medical science. While time series data is generated from various domains like population studies, business, share markets, sports, public health etc. The data concerning survival analysis are generally generated from hospital records. Thus, on studying this paper the students shall acquire the theoretical as well as practical knowledge of analyzing the data coming out from share market, Business analytics, sports, medical science, and public health and so on.

Unit I

Time-Series as discrete parameter stochastic process. Auto covariance and autocorrelation functions and their properties. Exploratory time series analysis, tests for trend and seasonality. Exponential and moving average smoothing, Holt and winters smoothing.

(9 lectures)

Unit II

Detailed study of the stationary processes: (i) moving average (MA) (ii) auto regressive (AR) (iii) ARMA and (iv) AR integrated MA (ARIMA) models. Box-Jenkin's models.

(9 lectures)

Unit III

Modelling and forecasting trend, selecting forecasting models, modelling seasonality, forecasting seasonal series, characterizing and modelling cycles, white noise, conditional forecasting models through regression (9 lectures)

Unit IV

Estimation of survival function - Acturial Estimator, Kaplan -Meier Estimator, Estimation under the assumption of IFR/DFR. Tests of exponentiality against non-parametric classes, Total time on test. (9 lectures)

Unit V

Measures of competing risks, Crude, Net and Partially crude probabilities (inter-relation and estimation), Dependent and independent risk, Analysis of censored data, Type I, Type II and Random Censoring. (9 lectures)

REFERENCES

- Box, G. E. P. and Jenkins, G. M. (1976). Time Series Analysis - Forecasting and Control, Holden-day, San Francisco.
- Anderson, T. W. (1971). The Statistical Analysis of Time Series, Wiley, N. Y.
- Montgemory, D. C. and Johnson, L. A. (1977). Forecasting and Time Series Analysis, McGraw Hill.
- Cox, D.R. and Oakes, D. (1983). Survival analysis, Chapman and Hall.
- Biswas S. (1988). Stochastic Process in Demography and Applications, Wiley Eastern Limited.

Fourth Semester
Paper 403 (i)
Industrial Statistics and Optimization Techniques I

Learning Outcome: This paper shall expose the students to different aspects of linear programming and operations research. Linear programming, inventory management, Network analysis and transportation models are commonly used to set up strategy in different real life situations including business. On studying this paper students shall learn how to convert a real life problem into mathematical model, place the constraints in the form of equations and solve the problems under a given set of constraints.

Unit I

Operations Research: Linear programming problems (LPP): Canonical and standard forms, and dual of an LPP, Graphical method to solve two variable LPP, solving LPP manually using Simplex procedure in presence of slack or/and surplus or/and artificial variables (9 lectures)

Unit II

Network analysis, Network Diagram, Time estimates, Critical Path Method, Product Evaluation and Review Technique, Time-cost optimization, Resource Allocation (9 lectures)

Unit III

Inventory Problems: Types of Inventory, Economic Order Quantity (EOQ) Model with Constant Rate of Demand, Limitations of EOQ formula, EOQ Model with Finite Replenishment Rate, Production Inventory Model, EOQ Model with Shortage. EOQ Model with Quantity Discounts. (9 lectures)

Unit IV

Lead time analysis, Reorder level, Buffer stock, Inventory control systems, Probabilistic inventory model, Probabilistic order-Level System (POLS), POLS with Instantaneous demand (9 lectures)

Unit V

Transportation models, Linear programming of transformation model, Initial feasible solution and optimum solution, Hungarian method, assignment problem, special cases in assignment problems. (9 lectures)

REFERENCES

- F.S. Hiller and G.J. Limbermann: Introduction to Operations Research, McGraw Hill, Inc. (Edition 6, 1995).
- H.A. Taha: Operations Research, Macmillan Publishing Co. Inc. (Edition 6, 1999).
- Nita H. Shah, Ravi M. Gor and Hardik Soni: Operations Research, Prentice Hall of India Private Limited.
- Kanti Swarup, Gupta,P.K. and Singh,M.M.. (1985) Operations Research; Sultan Chand & Sons.
- Churchman C.W., Ackoff R.L. and Arnoff E.L. (1957) Introduction to Operations Research; John Wiley.

Fourth Semester
Paper 404 (i)
Industrial Statistics and Optimization Techniques II

Learning Outcome: The paper deals with reliability, queuing theory, simulation and statistical quality control. On studying this paper the students shall get the theoretical understanding of how to compute probability of survival of machines, models related to production system in industries, reaching conclusions through models for which live data is not available through simulation and so on. The study of queuing theory shall provide the students with the understanding of the theoretical basis of the mathematical models governing queues, waiting time for getting a service, average number of customers in a queue and so on in both real and virtual queues.

Unit I

Reliability: Definitions and Relationships between Survival Function, Failure Distribution, Hazard Function, Mean Time To Failure (MTTF), Reliability of Systems, Parametric Distributions - Weibull, Gamma, Lognormal and Exponential as life time Distributions. Derivation of reliabilities for these distributions (9 lectures)

Unit II

Reliability: Concept of Aging, IFR, IFRA classes of Distributions and their Dual, Coherent System as Binary Function: Minimal Cut and Path Sets (vectors), Representation of Structure

Function of Series, Parallel and k out of n: G Systems of Independent Components. Redundancy: Parallel Redundancy, Standby Redundancy. (9 lectures)

Unit III

Queuing Theory, single-channel queuing model, queuing cost behaviour, multiple channel queuing model, Steady-state solutions of M/M/1 and M/M/c models with associated distributions of queue length and waiting time. (9 lectures)

Unit IV

Simulation, its applications, Monte Carlo method, generation of random numbers from probability distributions, simulation in spreadsheets, variance reduction techniques, regenerative method. (9 lectures)

Unit V

Statistical quality control, process control, control charts for variables and attributes, modified control charts, CUSUM charts, product control, sampling inspection plans (one, two, multiple and sequential), sampling inspection by variables. (9 lectures)

REFERENCES

- Kapur and Lamberson (1977) Reliability in Engineering Design, John Wiley & Sons. New York.
- L.J. Bain and M. Englhardt (1991) Statistical analysis of reliability and life testing models, Marcel Dekker
- Zacks, S (1992) Introduction to reliability analysis probability models and statistical methods, Springer Verleg.
- Kleinrock L. (1975) Queueing Systems, vol. 1, Theory; John Wiley
- Saaty T.L. (1961) Elements of Queueing Theory with Applications; McGraw Hill
- Grant E.L (1964). Statistical Quality Control, McGraw Hill.
- Duncan A.J (1974). Quality Control and Industrial Statistics, Taraporewala and Sons.

Fourth Semester
Paper 403 (ii)
Actuarial Statistics I

Learning Outcome: This paper exposes the students to different aspects of the basics of actuarial science. The paper explains the concept of insurance and its different terminologies like loss function, premium etc. along with some advanced models of demography concerning insurance industry. The entire concept is explained using probability models that can be designed for aggregate values of population survival. On studying this paper students can get the basic knowledge how the insurance industry works, how the policies are designed and the way in which premiums are fixed.

Unit I

Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, force of mortality, common loss distributions, collective risk models for a single period and for an extended period, ruin theory, applications. (9 lectures)

Unit II

Survival models, Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables. (9 lectures)

Unit III

Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws. Multiple decrement models, deterministic and random survivorship groups. (9 lectures)

Unit IV

Central rates of multiple decrements, net single premiums. Stationary Population. Mortality estimation: exposure to risk, approximation for incomplete data. Parametric, tabular and graphical methods, tests of graduation (9 lectures)

Unit V

Population Projections, distribution of aggregate claims, compound Poisson distribution and its applications. (9 lectures)

REFERENCES

- Bowers et al. (1997). *Actuarial Mathematics*, Second Edition. Society of Actuaries.
- N.L. Bowers, H.U. Gerber, J.C. Hickman, D.A. Jones and C.J. Nesbitt, (1986). 'Actuarial Mathematics', Society of Actuarias, Ithaca, Illiois, U.S.A. Second Edition (1997).
- Slud, E.V. (2001). Actuarial Mathematics and Life-Table Statistics, University of Maryland, USA.
- Trowbridge, C. L. (1989). Fundamental Concepts of Actuarial Science, Actuarial Education and Research Fund, USA.

Fourth Semester
Paper 404 (ii)
Actuarial Statistics II

Learning Outcome: With paper number 403 (ii) introducing the concept of insurance and the mathematical models that are used in designing the insurance policies, this paper extends the different concepts of insurance such as the Life insurance, Life annuities, Net premiums and Net premium reserves along with their derivatives. All the concepts of death-level benefit insurance, endowment insurance, differed insurance, varying benefit insurance, varying annuities, recursions, claim amount distributions, stop-loss insurance etc. taught

through empirical and probabilistic models shall provide the students with knowledge about the basic models related to Actuarial Statistics.

Unit I

Principles of compound interest. Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding. (9 lectures)

Unit II

Life insurance: Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, differed insurance and varying benefit insurance, recursions, commutation functions. (9 lectures)

Unit III

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. (9 lectures)

Unit IV

Net premiums: Continuous and discrete premiums, true monthly payment premiums, apporionable premiums, commutation functions, accumulation type benefits. Payment premiums, apportionable premiums, commutation functions, accumulation type benefits. (9 lectures)

Unit V

Net premium reserves: Continuous and discrete net premium reserve, allocations of loss to policy years, commutation functions. Claim amount distributions, stop-loss insurance. Credibility Theory: credibility premium, credibility factor, Bayesian and empirical approaches, applications to credibility premiums for standard models. (9 lectures)

REFERENCES

- Atkinson, M.E. and Dickson, D.C.M. (2000). An Introduction to Actuarial Studies, Elgar Publishing.
- Bedford, T. and Cooke, R. (2001). Probabilistic risk analysis, Cambridge.
- Bowers et al. (1997). Actuarial Mathematics, Second Edition. Society of Actuaries.
- Philip, M. et. al (1999). Modern Actuarial Theory and Practice, Chapman and Hall.
- N.L. Bowers, H.U. Gerber, J.C. Hickman, D.A. Jones and C.J. Nesbitt, (1986). Actuarial Mathematics, Society of Actuarias, Ithaca, Illiois, U.S.A. Second Edition (1997)
- Trowbridge, C. L. (1989). Fundamental Concepts of Actuarial Science, Actuarial Education and Research Fund, USA.

Fourth Semester
Paper 405
Project Work

Objective

The objective of this paper is to train the students to undertake projects individually. The projects shall enable the students to take up their own statistical study and to understand the application of statistical methods that they learned during the course. The project requires the students to synthesize the topics from the course into some theme of practical use. They are expected to design computer programs or use statistical software for computational purpose. Students shall conduct their own independent statistical research, from start to finish. For the project each student shall work under the supervision of a faculty member of the department.

In consultation of the supervisor, students shall decide on a researchable topic for their project. The topic shall be presented before all faculty members for approval with details objective and methodology. Once approved the student shall work on the project. There shall be two mid term evaluation of the project to appraise the continuous progress. Before the start of the end-semester examination students are required to summit the project report/dissertation in hard copy in duplicate. During the end semester examination students shall present the same, whereby they shall be evaluated by an external examiner.

Learning Outcome: The main purpose of this paper is to allow the students to apply the different statistical procedure learned by them during the PG Program to solve real life problems. The students pick up a research problem, set the objectives, collect necessary data, clean the data, analyze it using appropriate statistical tool, reach to conclusion and prepare a report on it. The learning objective of this work is thus two-fold:

(a) In one-way it shall teach the students how to collect data, how to arrange them for analysis and then to determine the type of analysis necessary to reach the objective of the study.
(b) The learning of how to identify a research problem, how to set the objectives, how to model it out and how to report the results as well as the entire process.

Following (a) and (b) students can learn to start research independently, provides the basis of higher studies (research in the subject) and start a career as data analyst.

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