M.Sc. STATISTICS

SEMESTER – III								
S.no	**Course**	**Code**	**Tittle of the course**	**H / W**	**C**	**SEE**	**IA**	**TOTAL Marks**
01	CC	ST 301	Econometric Methods	4	4	70	30	100
02		ST 302	A: Bio Statistics B: Parametric Estimation	4	3	50	25	75
03		ST 303	A:Operations Research B: Statistical Testing in Data Analysis	4	3	50	25	75
04	P	ST 304	Practical – V (ST - 302 & ST - 303)	6	2	35	15	50
05	SOC	ST 305	A: Time Series Analysis B: Discrete Mathematics	4	3	50	25	75
06		ST 306	A: Demography and Official Statistics B:Reliability Theory	4	3	50	25	75
07	P	ST307	Practical – VI(ST - 305 & ST - 306)	6	2	35	15	50
08		ST 308	OOTC/open elective A: Statistics For Biological and Earth Sciences B: BUSINESS ANALYTICS	4	2	70	30	100
*	Seminar/tutorials /remedial classes and quiz as part of internal assessment			4	0	0	0	0
			Total	36	22	340	160	500

ST-301: Econometric Methods

Unit-I: Introduction to Econometrics. Nature of econometric study. Simple linear regression, multiple linear regression, basic assumptions. Ordinary Least Squares (OLS) estimation and their properties. Use of prior information. Restricted least squares estimators Tests of hypothesis about regression coefficients and ANOVA. Mixed regression estimator.
Unit-II: Prediction – best linear unbiased predictor. Regression diagnostics and specification tests: Residual analysis for identifying influential observations, recursive residuals and their applications. Subset selection of explanatory variables, Mallows C_p-statistic. Introduction to Logistic regression model. Estimation and testing the significance of the coefficients.
Unit-III: Violation of basic ideal conditions: Disturbance with non-zero mean; asymptotically unco-operative regressors. Multicollinearity – its consequences and testing. Ridge estimator and its properties. Ridge regression. Stochastic regressors, autoregressive models, Instrumental variables, Errors in variables.
Unit-IV: Heteroscedasticity, tests for heteroscedasticity. Generalised Least Squares (GLS) estimators and its properties. Feasible generalized least squares estimators. Grouping of observations. Sets of Regression Equations. Auto correlation, its consequences and testing for autocorrelation. Estimation.

Course Outcomes:

CO1: A broad knowledge of regression analysis relevant for analysing economic data.
CO2: Learn estimation of model parameters ,inference problems in case of simple and multiple linear regression model
CO3: estimate the model parameters of regression model when some of the basic ideal conditions are violated
CO4: regression model adapted to cross section and time-series data
CO5: Learn to select the best subsets of regressors for the model.
CO6: Learn how to use estimated regression models for prediction.
CO7: Understand the estimation techniques and inference procedure in case of simultaneous equations model

References:

1. Badi H. Battagi (2002): Econometrics, 3rd Ed., Springer.
2. B.Abraham and Ledotter, J. (1983) Statistical Methods for Forecasting, John Wiley & Sons
3. Draper N.R. and Smith H. (1998): Applied Regression Analysis, 3rd Ed., John Wiley and Sons, Inc.
4. Dilip M. Nachane(2006): Econometrics-Theoretical Foundations and Empirical Perspective, Oxford University Press, New Delhi.
5. Fombay T.B., Hill R.C. and Johnson S.R. (1988) *Advanced Econometric Methods*, Springer- Verlag.
6. Greene W.H. (1993): Econometric Analysis, Macmillan, New York.
7. Johnston J. (1984): Econometric Methods, 3rd Ed., McGraw Hill.
8. Johnston J. and Dinardo J. (1997): Econometric Methods, 4th Ed., McGraw-Hill Companies.
9. G.S. Maddala (1977): Econometrics, McGraw-Hill Inc.

ST-302(A): Bio Statistics

Unit-I: Structure of Biological assay , Types of Biological assays: Direct assays, Potency ratio, Fieller's theorem, Behren's distribution, Two generalizations of Fieller's theorem.

Unit-II: Quantitative dose-response relationships, Linear dose-response regression, Parallel line bioassay, Slope Ratio Bioassay, Quantal responses, Estimation of median effective dose, Transformations: Probit and Logit transformations.

Unit-III:: Basic Biological concepts: Gene, Chromosomes, Alleles, Concepts of Geno types and Phenotypes, Family studies, Basic mating from single gene cross, Matrix approach to basic matings of single gene cross, Checker board method, Mendal's law of heredity: Geneotypes and Pheno type ratios, Branching system method.

Unit-IV: Types of matings, Random Mating, Concept of Gene pool, Gene frequency, Hardy–Weinberg law of equilibrium, Calculation of Gene frequencies, Genotypic frequency, Generation matrix approach to inbreeding, Estimation of Gene frequencies in ABO blood group system, Maximum Likelihood Method, Minimum Chi-Square method, Genetic parameters; Heritability Coefficients, Genetic Correlations, Repeatability, selection index; Inbreeding coefficient.

References

1. D.J. Finney (1971): Statistical Methods in Biological Assay, Charles Griffen and Company, London.
2. D.J. Finney (1971): Probit Analysis, 3rd Edition, S.Chand and Company Ltd, New Delhi.
3. William D. Stansfield. (1969): Theory and Problems of Genetics, Schaum's Outline Series, MC Graw Hill, New York.
4. Oscar Kempthorne (1973): An Introduction to Genetic Statistics, Jagmohan Book agency, New Delhi.
5. J.P. Jain (1992): Statistical Techniques in Quantitative Genetics, 2nd Edition, Hindustan Publishing House, New Delhi.
6. Basu, S. B. (1996), Quantitative Genetics Research Technique, Kalyani Publishers, New Delhi.

<table>
<tr><td>Subject Code</td><td>Subject Name</td><td colspan="2">Credits Allotted</td><td>Total</td></tr>
<tr><td rowspan="2">ST 302 (a)</td><td rowspan="2">Bio-Statistics</td><td>Theory</td><td>Practical</td><td rowspan="2">4</td></tr>
<tr><td>4</td><td>----</td></tr>
<tr><td>Course Objective</td><td colspan="4">To understand about Biological assay and their types, distribution and some of theorems.
To learn dose response relationships, their estimation, transformations.
To discuss Geno types and phenol types, Matrix operations to base mattings of single gen cross etc.
To estimate Gene frequency using different methods.</td></tr>
<tr><td>Course
Out comes</td><td colspan="4">Students learnt about Biological assay, their distribution and theorems, dose response relationships, basic concepts of biological assay, estimation methods of gene frequencies, etc.</td></tr>
</table>

ST-302(B): Parametric Estimation

Unit-I: Sufficiency: Sufficient statistics, Fisher's information, Factorization theorem, minimal sufficiency, Lehaman-Scheffe theorem, complete sufficient statistic, Sufficiency in Exponential family of distributions and Pitman family of distributions. Ancillary statistics. Basu's theorem & its applications.

Unit-II: Uniformly minimum variance unbiased estimators, Minimum Variance unbiased estimators , uniformly minimum variance unbiased estimators(UMVUE),Rao-Blackwell theorem, Lehmann-Scheffe theorem on UMVUE, Bhattacharya bounds, Minimum variance bound unbiased estimators.

Unit-III: Methods of Estimation: Method of maximum likelihood; minimum chi-square and modified minimum chi-square, Asymptotic properties of maximum likelihood estimator (MLE). Confidence interval estimation: Pivotal method of construction of confidence interval, confidence interval based on MLE.

Unit-IV: Bayes Estimation: Difference between classical method and Bayes method of estimation. Concept of prior and posterior distributions, squared error and weighted squared error loss functions to estimate parameters of binominal, Poisson, geometric, uniform, exponential and normal distributions.

Objectives: To provide an introduction to the fundamental theory of parametric estimation. Use classical and Bayesian approaches to formulate and solve problems for parametric estimation.

Outcomes: Upon satisfactory completion of the course, students become able to apply the different methods of parametric estimation to solve the problems in statistical inference. Students also become able to determine the distribution and statistical properties of estimator.

Books:

1. Mukhopadhyay, N. (2000): Probability and Statistical inference, Marcel Dekker.
2. Lehmann, E.L. (1983): Theory of Point estimation, Wiley Eastern.
3. Kale, B. K. (1999): A first course on parametric inference. Narosa publishing, New Delhi.
4. Rohatgi, V.K. & A.K. Md.E. Saleh (2001): An Introduction to Probability & Statistics, 2nd ed., John Wiley.
5. Zacks, S. (1971): Theory of Statistical Inference, John Wiley.
6. Dudewicz, E. J. and Mishra, S.N. (1988): Modern Mathematical Statistics, Wiley Eastern.
7. Goon, Gupta and Dasgupta. (1970): An outline of Statistical Theory, Vol. II, World Press, Calcutta.
8. Casella, G and Berger, R.L.(2002):Statistical Inference, Brooks/ Cole Publishing Co., Pacific Grove.
9. Box, G.E.P. and G.C. (1973): Bayesian inference in Statistical Analysis. Adison Wesley.
10. Rao, C.R.(1973): Linear Statistical Inference and its Applications, John Wiley.
11. Mood, A. M. Graybill, F. and Boes, D. C. (1974): Introduction to the Theory of Statistics, McGraw Hill.

ST-303(A): Operations Research

Unit-I: Definition and scope of Operations research; phases in Operations Research; models and their solutions (Review of Linear Programming). Definition of Dual-Primal, Relationships- Dual Simplex Sensitivity or Post Optimal Analysis, Revised Simplex method.

Unit-II: Non-linear programming - Kuhn Tucker conditions. Wolfe's algorithm for solving quadratic programming problems. Integer programming – Branch and bound algorithm and cutting plane algorithm.

Unit-III: Flows in networks max-flow-min-cut theorem. Project Management; PERT and CPM probability of project completion, PERT – crashing.

Unit-IV: Decision making in the face of competition, two-person games, pure and mixed strategies, existence of solution and uniqueness of value in zero- sum games, finding solution in 2x2, and 2xm, and mxn games. Non – zero sum games, co-operative and competitive games, equilibrium solutions and their existence in bi- matrix games. Nash equilibrium solution.

References

1. Taha H.A (1982) Operational Research: An Introduction; Macmillan.
2. Hiller F. Sand Leiberman G.J. (1962) Introduction to Operations Research; Holden Day
3. Kanti Swarup; Gupta P.K and Singh M.M (1985) Operations Research; Sultan Chand.
4. Philips D.T, Ravindran A and Solberg J Operations Research, Principles and Practice.
5. Curchman C.W; Ackoff R.L and Arnoff E.L(1957) introduction to Operations Research; John Wiley
6. Hadley G (1964) Non-Linear and Dynamic programming Addison Weslay.
7. Mckinsey J.C.C(1952) Introduction to the theory of games Mc Graw Hill.P.K.Gupta; D.S.Hira Operations Research S.CHand.

<table>
<tr><td>Subject Code</td><td>Subject Name</td><td colspan="2">Credits Allotted</td><td>Total</td></tr>
<tr><td rowspan="2">ST-303(A)</td><td rowspan="2">Operations Research</td><td>Theory</td><td>Practical</td><td rowspan="2">4</td></tr>
<tr><td>4</td><td>----</td></tr>
<tr><td>Course Objective</td><td colspan="4">To introduce operations research, Dual-primal, Revised simplex methods.
To discuss Non-linear programming and integer programming and their related problems.
To explain Network flow charts, CPM and PERT, project management models.
To discuss Game theory of 2×2, 2×m, m×n and non-zero sum games with their illustrations.</td></tr>
<tr><td>Course Out comes</td><td colspan="4">Students understood about Dual primal, Revised simplex methods.
Students learnt non-linear programming, integer programming, CPM, PERT, different models of games.</td></tr>
</table>

ST-303(B): Statistical Testing in Data Analysis

Unit- I: Population and sample, parameter, statistic, estimator, statistical properties of estimators. Basic concepts concerning testing of hypotheses, procedure for hypothesis testing. Null hypothesis, alternate hypothesis, statistical test procedures, test statistic, two types of errors, level of significance, p-value, size and power of the test. One sided and two sided test procedures. Parametric and nonparametric tests.

Unit-II: Assumptions, test procedures and examples - One sample Z test, hypothesis testing of means, hypothesis testing for differences between means under equal variance and unequal variances, paired t-test, tests for proportions. Sample size and its determination.

Unit -III: Hypothesis testing for comparing a variance to some hypothesized population variance, testing the equality of variances of two normal populations, hypothesis testing of correlation coefficients, confidence intervals.

Unit-IV: Non-parametric tests, sign test, Wilcoxon signed rank test, Wilcoxon rank sum test-Mann- Whitney test, Contingency tables - Chi-square test for independence of attributes, Principles of design of experiments, basic principle of ANOVA, ANOVA – CRD, RBD, LSD.

Course Outcomes:

CO1: Demonstrate their knowledge of the basics of inferential statistics by making valid generalizations from sample data

CO2: Perform Test of Hypothesis as well as calculate confidence interval for a population parameter for single sample and two sample cases. Understand the concept of p-values.

CO3: Learn non-parametric test such as the Chi-Square test for Independence as well as Goodness of Fit.

CO4: Compute and interpret the results of Bivariate and Multivariate Regression and Correlation Analysis, for forecasting and also perform ANOVA and F-test.

References:

1. J.Medhi (1992): Statistical Methods : An Introductory Text, Wiley Eastern Limited.

2. Douglas A. Lind, William C. Marchal, Samuel A. Wathen (2012), “Basic Statistics for Business & Economics” McGraw-Hill Education

ST-304: Practicals – V (ST - 302 & ST - 303)

ST-305(A): Time Series Analysis

Unit-I: Review of Time Series Analysis. Growth models: Modified Exponential Curve, Gompertz curve, Logistic curve and their Fitting; Measurement of cyclical component: Harmonic analysis, auto regression series: Markoff and Yule's series, Periodogram and correlogram analysis, measurement of irregular component: variate difference method.

Unit-II: Need and uses of forecasting, classification and characteristics of forecasts, forecasting based on regression techniques: simple and multiple linear regression and non-linear regression techniques, moving averages smoothing methods: simple and double, multi average methods; explanatory version time series forecasting, test for trend seasonality.

Unit-III: Exponential smoothing methods: trend adjusted exponential smoothing, double and triple exponential smoothing, win ten's method, chow's adaptive control methods, brown's one parameter adaptive method: Box-Jenkins three parameter smoothing, Harrison's Harmonic smoothing methods, tracking signal.

Unit-IV: Box-Jenkin's time series methods: 1. Moving average 2. Autoregressive (AR) 3. ARMA and 4. AR integrated MA (ARIMA) models, estimation of ARIMA model parameters, forecasting with ARIMA models, Diagnostic checking of the model: Analysis of residuals, forecasting using transfer function model, concept of Kalmon's Filters.

References

1. Thomopouls, N.T (1980): Applied Forecasting Methods. Engle Wood Cliffs, N.J, Prentice Hall.
2. Wheel Wishart, S.C; and S. Makridaks (1980): Forecasting Methods for Management III edition, New York. John Wiley.
3. Sullivan, William G. and Wayne Claycambe. W (1977): Fundamentals of Forecasting. Prentice Hall. Virginia.
4. Gupta. S.C and V.K. Kapoor (1995): Fundamentals of Applied Statistics, Sulthan & Chand Sons. New Delhi.
5. Bovas, Abraham and Johannes Ledolter (1983): Statistical Methods for Forecasting, John Wiley & Sons. New York.
6. Box, G.E.P and Jenkkins, G.M (1976): Time Series Analysis Forecasting and Control, Holden Day, San Francisco.
7. Anderson, T.W (1971): The Statistical Analysis of Time Series, John Wiley, New York.
8. Markidakis, S Steven C. Wheel Wright and Victor E. Mcgee (1983): Forecasting: Methods and Applications, 2nd Edition, New York, John Wiley & Sons.

Subject Code	Subject Name	Credits Allotted		Total
ST305(A)	**Time series Analysis**	Theory	Practical	4
		4	----	
Course Objective	To fit growth curves, measurement of cyclical and irregular component with simple examples. To discuss Forecasting and their techniques like regression, non-linear regression, exponential smoothing, etc. To explain Box Jenkins time series models and their estimation of parameters, fitting and diagnostic checking.			
Course Out comes	Students understood about Time series analysis with some important growth models and their fitting. Students learnt Forecasting using regression, non-linear regression techniques, single, double, triple and adoptive exponential smoothing models. Students have experience in AR, MA, ARMA, ARIMA models fitting, diagnostic checking etc.			

ST-305(B): Discrete Mathematics

Unit- I: Logic: Propositional equivalence, predicates and quantifiers, Methods of proofs, proff strategy, sequences and summation, mathematical induction, recursive definitions and structural induction, program correctness.
Counting: The basics of counting, the pigeonhole principle, permutations and combinations, recurrence relations, solving recurrence relations, generating functions including-exclusion principle, application of inclusion-exclusion.
Unit-II: Relations: Relations and their properties, n-array relations and their applications, representing relations, closure of relations, equivalence of relations, partial orderings.
Graph theory: Introduction to graph, graph terminology, representing graphs and graphs isomorphism, connectivity, Euler and Hamilton paths, planar graphs, graphs coloring introduction to trees, application of trees.
Unit-III: Group theory: Groups, subgroups, generators and evaluation of power, cossets and Lagrange's theorem, permutation groups and Burnside's theorem, isomorphism, automorphisms, homomorphism and normal subgroups, rings, integral domains and fields.
Unit-IV: Lattice theory: Lattices and algebras systems, principles of duality, basic properties of algebraic systems define by lattices, distributive and complimented lattices, Boolean lattices and Boolean algebras, uniqueness of finite Boolean expression, prepositional calculus theory: Coding of binary information and error detection, decoding and error correction.

References:
1) K.H. Rosen: Discrete Mathematics and its application, 5th edition, Tata McGraw Hill . Chapter 1(1.1-1.5), Chapter 3 (3.1-3.4,3.6), Chapter 4(4.1-4.3,4.5),Chapter6(6.1.2,4.4-6.6)Chapter7(7.1-7.6),Chapter8(8.1-8.5,8.7,8.8)
2) C.L.Liu: Elements of Discrete Mathematics,2nd edition, TMH 2000. Chapter 11(11.1-11.10 except 11.7), Chapter 12(12.1 -12.8)
3) B.Kalman: Discrete Mathematical Structure, 3rd edition, Chapter 11(11.1,11.2)

ST-306(A): Demography and Official Statistics

Unit-I: Nature, Scope and limitations of demography; Sources of Demographic data in India; Measures of Mortality; life-tables; construction of abridged life table; Measures of fertility Stochastic models for reproduction, Reproduction rates: GRR and NRR; Concepts of Migration and Urbanization.

Unit-II: Population Projections: Stable and Stationary populations, Lotka's model; Use of Leslie matrix. Population estimates; Chandrasekhar and Deming's method, component method, Stochastic models of population growth, Exponential and logistic population growth models: Birth and death model, Birth-death and migration model.

Unit-III: Population Genetics: Concepts of Genotypes and Phenotypes; Basic Mating from Single gene cross, Punnet Square method, Mendal's laws of heredity; Random mating; Hardy-Weinberg Equilibrium law; Calculation of Gene frequencies, Estimation of Gene frequencies in ABO blood group system.

Unit-IV: Statistical systems in India; CSO, NSSO and their functions; scope and content of population Census in India; Methods of conducting population census, Economic census and Agricultural census in India and defects; Sources of forest statistics.

References
1. Suddender Biswas (1988), Stochastic Process in Demography and Applications, Wiley Eastern Ltd, New Delhi.
2. K.B. Pathak and F. Ram (1992), Techniques of Demographic Analysis, Himalayan Publishing House, Bombay.
3. Osacr Kempthorne (1973), An Introduction to Genetic Statistics, Jagmohan Book Agency, New Delhi.
4. William D. Stansfield (1969), Theory and Problems of Genetics, Schaum's Outline Series, MC Graw Hill, New York.
5. B.N. Gupta (1994), Statistics, Sahitya Bhavan, Agra.
6. B.L. Agrawal (1994), Basic Statistics, 2nd Edition, Wiley Eastren, New Delhi.
7. Asthana (1970), Indian Official Statistics.

Subject Code	Subject Name	Credits Allotted		Total
		Theory	Practical	
ST - 306(A)	**Demography and official statistics**	4	----	4
Course Objective	To study about demography and their importance, different reproduction. To explain population Genetics, CSO, NSSO and their scope and contents in population census in India.			
Course Out comes	Students know the growth rates, life tables, GRR, NRR and growth models. Students understood about gene frequencies, genotypes, phenotypes etc. Students learnt about population census methods, organizations in India and their functions.			

ST-306(B): Reliability Theory

Unit –I: Basic concepts in reliability: Failure rate, mean, variance and percentile residual life,
identities connecting them; Notions of ageing - IFR, IFRA, NBU, NBUE, DMRL, HNBUE,
NBUC etc and their mutual implications; TTT transforms and characterization of ageing
classes.

Unit –II: Non-monotonic failure rates and mean residual life functions, Study of life time models viz. exponential, Weibull, lognormal, generalized Pareto, gamma, Makeham, Rayleigh with reference to basic concepts and ageing characteristics; Bathtub and upside down bathtub failure rate distributions.

Unit –III: Discrete time failure models: - Definition of basic functions and their properties; Ageing classes and their mutual implications (IFR and DFR, IFRA and DFRA, NBU (NWU), NBUE, DMRL and IMRL, Discrete Time Failure Models- geometric distribution, negative binomial distribution, discrete Weibull distributions,

Unit IV: Bivariate ageing classes - bivariate failure rate, bivariate IFR, bivariate IFRA, bivariate NBU, bivariate exponential distributions and their properties. concepts and measures of dependence in reliability - RCSI, LCSD, PF2, WPQD. Reliability estimation using MLE - exponential, Weibull and gamma distributions based on censored and non-censored samples; UMVUE estimation of reliability function; Bayesian
reliability estimation of exponential and Weibull models.

Text Books:

1. Lai, C.D and Xie, M. (2006) Stochastic ageing and dependence in reliability (Relevant topics) Springer.

2. Sinha S K (1986) Reliability and Life Testing, Wiley Eastern.
31
References:
1. Barlow R.E. and Proschan F. (1965). Mathematical Theory of Reliability, Wiley, New
York.
2. Barlow, R.E. and Proschan, F. (1975). Statisical Theory of Reliability and Life Testing, Holt, Reinhart and Winston.

3. Marshall, A.W. and Olkin, I. (2007). Life Distributions, Springer.

ST-307: Practical – VI(ST - 305 & ST - 306)

ST-308: OOTC/Open Elective

ST 308 (A): STATISTICS FOR BIOLOGICAL AND EARTH SCIENCES

Unit - I: Statistical measures: Statistical diagrams and graphs; Frequency distributions; Measures of central tendency: Arithmetic mean, Median and Mode; Measures of variation: Range, Quartile Deviation, Mean Deviation, Standard deviation, Coefficient of variation; Karl Pearson's coefficient of Skewness.
Unit- II : Random Variable and Probability Distributions: Definition of Probability, Additive and Multiplicative laws of probability (statements only), Random variable, Binomial, Poisson, Normal and Exponential distributions (properties and applications), CurveFitting: Principle of least squares; Fitting of a straight line, Exponential curve and Power curve; Correlation and Regression Analysis: Karl Pearson's coefficient of correlation, Spearman's Rank correlation coefficient; Simple linear regression; Multiple and Partial correlation coefficients; Multiple linear regression; Yules coefficient of Association.

Unit –III: Tests of Significance: Basic concepts; Z- test for proportions and means; Applications of t, χ^2 and F tests; Paired t-test; Analysis of Variance (ANOVA) and Analysis of Covariance (ANCOVA) techniques for one way and two way classifications (single observation per cell), Confidence limits.

Unit- IV: Special Statistical Tools: Experimental designs CRD, RBD and LSD and their analysis; concept of critical difference; Duncan's Multiple range test; Elements of Principal components Analysis, Factor Analysis; Cluster Analysis and Discriminant analysis; Hotelling's T^2 and Mahalanobis D^2 statistics; Multivariate Analysis of Variance (MANOVA); Canonical correlations; Concept of Probit analysis.

References

1. Bailey, N.T.J.(1959), Statistical Methods in Biology, The English Universities Press Ltd.,
2. Pillai, S.K., and Sinha, H.C.(1968), Statistical Methods for Biological workers, Ram Prasad and sons, Agra.

3. Basu, S.P.(1996), Quantitative Genetics Research techniques, Kalyani publishers, New Delhi.
4. Misra, B.N., and Misra, M.K.(1998), Introductory Practical Biostatistics, Naya Prakash, Kolkata.
5. Johnson, R.A., and Wichern, D.W.(2001), Applied Multivariate Statistical Analysis, Third edition, Prentice Hall of India, New Delhi.
6. Federer, W.T.(1963), Experimental Designs and its applications, Macmillon.

<table>
<tr><td>Subject Code</td><td>Subject Name</td><td colspan="2">Credits Allotted</td><td>Total</td></tr>
<tr><td rowspan="2">ST 308 (a)</td><td rowspan="2">Statistics for Biological and Earth sciences</td><td>Theory</td><td>Practical</td><td rowspan="2">4</td></tr>
<tr><td>4</td><td>----</td></tr>
<tr><td>Course Objective</td><td colspan="4">To learn basic statistics and their worked out examples.
To discuss about different tests like t, F, χ^2 and Z fro means, proportions, variances, standard deviation etc. with illustrations.
To explain ANOVA and ANCOVA for one way and two way classification and their importance in analysis.
To discuss Special statistical tools and multivariate analysis.</td></tr>
<tr><td>Course
Out comes</td><td colspan="4">Students learnt about Graphs, measures of averages, measures of dispersion etc.
Students understood about Basic probability and important distributions with workout examples.
Students used t, F, χ^2 , ANOVA and ANCOVA and non-parametric tests with examples.
Students used Advanced statistics tools with working illustrations.</td></tr>
</table>

ST 308(B): BUSINESS ANALYTICS

UNIT-I: BUSINESS MATHEMATICS: Matrix Algebra: Addition, Multiplication, Transpose and Inverse of Matrices; Determinants, Solution of Linear Equations; Limits of Algebraic functions; Rules for Differentiation; Linear programming problem-Graphical Method; Applications.

UNIT-II: BUSINESS ANALYSIS**:** Statistical Measures: Mean, Median and Mode; Standard Deviation and Coefficient of Variation; Correlation and Regression analysis; Linear and Compound growth rates; Measures of Association; concepts of R^2 and $\overline{R}^2$.

UNIT-III: BUSINESS STATISTICAL INFERENCE**:** Elements of Probability; Concepts of Binomial, Poisson and Normal Distributions; Sampling Techniques: Simple Random Sampling and Stratified Random Sampling; Determination of sample size; Tests of Significance: z, t, χ^2 and F tests, ANOVA Technique.

UNIT-IV: BUSINESS INFORMATICS**:** Time series Analysis; Determination of Trend and seasonal components, Basic Forecasting Methods; computer Applications to Business Analysis; Statistical Quality Control: control charts $\overline{X}$,R, p, npand c-charts.

References:

1. Azel and Sounderpandian, Complete Business Statistics, TMH.
2. JK Sharma, Business Statistics, Pearson.
3. RS Bhardwaj, Mathematics for Economics and Business, EB.
4. RP Hooda, Statistics for Business and Economics, McMillan.
5. GC Beri, Business Statistics, TMH.
6. Glynn Davis and BrankoPecar, Business Statistics using Excel, Oxford University press, 2010.
7. J.K. Sharma, Fundamentals of Business Statistics, 2nd Edition, Vikas Publication, 2014.
8. SC Gupta, Fundamentals of Statistics, Himalaya Publications, 2013.
9. N.D. Vohra, Business Statistics, Tata McGraw Hill, 2013.
10. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons Publishers, New Delhi.
11. S.C. Gupta and V.K. Kapoor, Fundamentals of Applied Statistics, Sultan Chand & Sons Publishers, New Delhi.
12. R. Pannerselvam, Research Methodology, Published by PHI Learning Private Limited, New Delhi.
13. Donald R Cooper and Pamela S Schnidler, Business Research Methods, Nineth Edition, Tata Mc Graw Hill Publishing Company Limited, New Delhi.

<table>
<tr><td>Subject Code</td><td>Subject Name</td><td colspan="2">Credits Allotted</td><td>Total</td></tr>
<tr><td rowspan="2">ST 308-(b)</td><td rowspan="2">Business Analytics</td><td>Theory</td><td>Practical</td><td rowspan="2">4</td></tr>
<tr><td>4</td><td>----</td></tr>
</table>

Course Objective	To learn basic statistics and their worked out examples. To discuss different tests like t, F, χ^2 and Z fro means, proportions, variances, standard deviation etc. with an illustrations. To study ANOVA and ANCOVA for one way and two way classification and their importance in analysis. To use special statistical tools and multivariate analysis.
Course Out comes	Students learnt Graphs, measures of averages, measures of dispersion etc. Students studied basic probability and important distributions with workout examples. Students used t, F, χ^2 , ANOVA and ANCOVA and non-parametric tests and discussed with examples. Students performed advanced statistics tools for solving the problems.

SEMESTER- IV								
S.no	**Course**	**Code**	**Tittle of the course**	**H/W**	**C**	**SEE**	**IA**	**TOTAL Marks**
01	OOSTCs/ Papers in Department	ST 401	A: Advanced Econometric Methods B. Python	4	3	50	25	75
02		ST 402	A: R Programming B: Statistics For Research, Industry And Community development	4	3	50	25	75
03	Practicle	403	Practical – VII (ST - 401 and ST - 402)	6	2	35	15	50
04	Project	404	Project Work – Orientation classes	14	12	65	35	100
		Conducting Classes for Competitive, Communications Skill UGC/CSIR and NET/SLET examinations		12	--	--	--	--
			Total	36	20	200	100	300
			Total Semester	144	84	1220	580	1800

ST-401 (A): Advanced Econometric Methods

Unit-I: Generalized linear Model; Aitken's theorem; GLS estimator, Asymptotic distribution of GLS estimator; Analysis of residuals, OLS, BLUEs and Recursive residuals; Sudentized and predicted residuals; Granger's test of causality; nested and non nested statistical models; Cox and J tests.

Unit-II: Specificiation error; Consequences; specification bias; Ramsey's RESET test; Lagrange Multiplier test for adding variables; comparing two linear regression models; Dummy variable approach; Stepwise and Piecewise linear regression; Switching Regression Model.

Unit-III: Qualitative and limited dependent variable models; the linear probability model; probit model; Logit model and their estimation; concept of limited dependent variables; specification of Tobit model; concepts of censored and Truncated samples; estimation in censored and Truncated Samples.

Unit-IV: Sets of linear regression models; specification of the Seemingly Unrelated Regression Equations (SURE) model; OLS and GLS estimation of SURE model; Zellner's Feasible GLS estimator; Seemingly Unrelated Unrestricted Residuals (SUUR) estimator; Seemingly Unrelated Restricted Residuals (SURR) estimator; Reduction of the Zeller's Feasible GLS estimator to the OLS estimator.

References

1. Johnston, J (1984): Econometric Methods, III rd edition , MC Graw Hill.
2. Judge, C.G., Griffths, and Hill, R.C. et al (1985): Theory and Practice of Econometrics, John Wiley.
3. Gujarathi, D (1979): Basic Econometrics, Mc Graw hill.
4. Srivastava, V.K and Giles, D.E.A (1987), Seemingly Unrelated Regression Equations Models: Estimation and Inference, Marcel Dekker, Inc
5. Cook. D and Weisberg. S (1982), Residuals and Inference in Regression, Chapman and Hall.

Subject Code	Subject Name	Credits Allotted		Total
		Theory	Practical	
ST401(A)	**Advanced Econometric Methods**	4	----	4
Course Objective	To explain OLS, GLS, BLUE and Recursive residuals with their properties. To discuss different regression models and their importance. To perform estimation in censored and Truncated Samples. To fit sets of linear regression models and their related estimators.			
Course Out comes	Students understood GLM, SURE, nested and non nested statistical models. Students learnt about specification error, adding, switching models. Students performed Probit, logit models and their estimation.			

ST-401 (B): Python

UNIT – I:Introduction to Python Programming Language: Introduction to Python Language,Strengths and Weaknesses, IDLE, Dynamic Types, Naming Conventions, String Values, String Operations, String Slices, String Operators, Numeric Data Types, Conversions, Control Flow and Syntax, Indenting, The if Statement, Relational Operators, Logical Operators, True or False, Bit Wise Operators, The while Loop, break and continue, The for Loop, Lists, Tuples, Sets, Dictionaries, Sorting Dictionaries, Copying Collections, In Functions.

UNIT –II :Object and Classes : Classes in Python, Principles of Object Orientation, Creating Classes, Instance Methods, File Organization, Special Methods, Class Variables, Inheritance, Polymorphism, Type Identification, Custom Exception Classes.

UNIT –III : Functions and Modules : Introduction, Defining Your Own Functions, Parameters, Function Documentation, Keyword and Optional Parameters, Passing Collections to a Function, Variable Number of Arguments, Scope, Functions - "First Class Citizens", Passing Functions to a Function, Mapping Functions in a Dictionary, Lambda, Modules, Standard Modules – sys,□Standard Modules – math,Standard Modules – time,The dir Function**.**

UNIT –IV : I/O and Error Handling In Python : Introduction, Data Streams,□Creating Your Own Data Streams, Access Modes, Writing Data to a File, Reading Data From a File, Additional File Methods, Using Pipes as Data Streams, Handling IO Exceptions, Working with Directories, Metadata, Errors, Run Time Errors, The Exception Model, Exception Hierarchy, Handling Multiple Exceptions.

Books for Study:

1. Dive into Python, Mike
2. Learning Python, 4th Edition by Mark Lutz
3. Programming Python, 4th Edition by Mark Lutz

Course Outcomes:

1: Able to understand the concept of Python Programming.
2: Expertise in Object and Classes.
3: To be able to explore Functions and Modules learning.
4: Able to understand the concept of I/O and Error Handling In Python.

Course Out comes:

1. Students have done Python Programming and their Object and Classes.
2. Students have understandI/O and Error Handling In Python

ST-402 (A): R Programming

UNIT-I: Familiarizing with R environment, Using R console as a calculator, R atomic types, methods of creating vectors, combining vectors and repeating vectors, different ways of subsetting vectors using indexing, names and logicals. Arithmetic and logical operations. Using character vectors for text data, manipulating text using strsplit(), paste(), cat(), grep(), gsub() functions; handling factor data. Working with dates.

UNIT – II: Creating Matrices, getting values in and out of matrices, performing matrix calculations; Working with multidimensional Arrays; creating data frames, getting values in and out of data frames, adding rows to data frame, adding variables to data frame; creating lists, extracting components from a list, changing values of components of lists. Getting data into and out of R - reading data in CSV files, EXCEL files, SPSS files and working with other data types. Getting data out of R – working with write.csv() and write.table() functions.

UNIT – III: Writing Scripts and functions in R. writing functions with named, default and optional arguments. functions using as arguments. Debugging your code. Control statements in R – conditional control using if, if-else, ifelse; looping control using for, while, repeat; transfer of control using break and next. Manipulating and processing data - creating subsets of data, use of merge() function, sorting and ordering of data. Group manipulation using apply family of functions - apply, sapply, lapply, tapply. Base graphics. Use of high-level plotting functions for creating histograms, scatter plots, box-whiskers plot, bar plot, dot plot, Q-Q plot and curves. Controlling plot options using low-level plotting functions - Adding lines, segments, points, polygon, grid to the plotting region; Add text using legend, text, mtext; and Modify/add axes, Putting multiple plots on a single page

UNIT – IV: Working with probability distributions - normal, binomial, Poisson and other distributions. Summary statistics, hypothesis testing - one and two-sample Student's t-tests, Wilcoxon U-test, paired t-test, paired U-test, correlation and covariance, correlation tests, tests for association- Chi-squared test and goodness-of- fit tests. Formula notation, one-way and two-way ANOVA and post-hoc testing, graphical summary of ANOVA and post-hoc testing, extracting means and summary statistics; linear regression.

References:

1. Mark Gardener(2012), Beginning R - The Statistical Programming Language, Wiley India Pvt Ltd.
2. Andrie de Vries and JorisMeys(2015), R Programming for Dummies, Wiley India Pvt Ltd.
3. Jared P. Lander(2014), R For Everyone - Advanced Analytics and Graphics, Pearson Education Inc.

Course Outcomes:

1: Understand the atomic types of R, different methos of creating and filtering of vectors,manipulationoftextdata,factor data and dates.

2: Understandhowtocreate,subsetandmodifydatastructureslikematrices, arrays,dataframesandlists.UnderstandhowtoreaddataintoandoutofR.

3: Understand the control statements of R, writing functions and scripts in R and debuggingfeatures ofR.Understandtheuseofapply familyoffunctions.

4: Understandtheusethehigh-levelplottingfunctionsinRtocreategraphsin baseRandthe low-levelplottingfunctionstocustomizethe graphs.

5: Understandtheuseofbuilt-infunctionstoperformhypothesestesting, correlationandregressionanalysis,andANOVA.

Course objectives:

1: Able to create and manipulate vectors,matrices,arrays,data frames and lists. Should beabletoworkwithcharacterdata,factordataanddates.

2: AbletowritescriptsandfunctioninRandreaddatafrom.csvfiles,EXCELfiles andSPSSfiles.

3: Abletodistinguishbetweenhigh-levelandlow-levelplottingfunctionsavailable inbaseR.

4: Abletousebuilt-infunctionstoanswerquestionsrelatingtoprobability

distributions,parametricandnonparametrichypothesistesting,correlationand
regressionanalysis,andone-wayandtwo-wayANOVA.

ST-402 (B): STATISTICS FOR RESEARCH, INDUSTRY AND COMMUNITYDEVELOPMENT

UNIT- I: Response Surface Designs: First and Second order Response Surface models; Rotatable designs; concept of connected design; outliers and Winsorized t - statistic; Stepwise regression; Specification of Random coefficients Regression model; Specification of variance components model; MINQUE Theory; Non parametric regression, the partially linear regression model.

UNIT-II: Simulation: Scope and limitations; Simulation models; Generation of RandomNumbers; Monte-Carlo simulation; Simulation of Queueing, Inventory Systems; Networks and Job sequencing.Data Envelopment Analysis (DEA): Non parametric approach to productive efficiency; Input, output correspondences for Frontier production function; Mathematical Programming for productive efficiency: Farrell and Timmer approaches with reference to Cobb-Douglas production function.

UNIT-III: Demand Analysis: Laws of Demand and Supply; price and partial elasticities of demand; Pigous method for Time Series and Family Budget data; Engel's curve; Pareto law of Income distribution;Production Functions: Basic concepts; Isoquants; Cobb-Douglas, CES and Translog Production functions and their properties and estimation; Tools for Data Mining.

UNIT-IV: Social Surveys for Community Development: Objects, Types of Social Survey; Steps in social survey; Gallop polls; Prephology, Data collection; Kinds of measurement; Scaling methods: Thurstone, Likert and Guttman methods; Concepts of Validity and Reliability; Methods of calculating reliability coefficients; Test Reliability; ANOVA for Ranked data: Kruskal-Wallis and Friedman tests; Elements of cluster analysis, Factor analysis., path coefficient analysis and Discriminant analysis.

References

1. Das, M.N. and Giri, N.C. (1979), Design and Analysis for Experiments, Wiley Eastern (P) Ltd., New Delhi.
2. Montgomery, C.D. (1976), Design and Analysis of Experiments, Wiley & Sons, New York.
3. Johnston, J., and Dinardo, J. (1997), Econometric Methods, Fourth Edition, Mc Graw-Hill International Editions, New York.
4. Judge., C.G., et.al (1985), Theory and Practice of Econometrics, John Wiley.
   Taha, H.A. (1992), Operations Research, An Introduction, Fourth Edition

ST-403: Practical – VII (ST - 401 and ST - 402)

ST-404 Student Project

65 Marks for project thesis, 25 for project Viva Voce and 10 marks for Project presentation.