M.Sc., STATISTICS

SEMESTER-I

ST 101: LINEAR ALGEBRA

Unit-I: Algebra of matrices; Elementary transformations; Rank and Inverse of a matrix; Nullity; Partitioned matrices; Kronecker product; Generalized inverse of matrix; Moore-Penrose generalized inverse; Solutions of simultaneous equations.

Unit-II: Finite dimensional Vector Spaces; Vector Spaces and Subspaces; Linear dependence and independence; Basis and dimension of a vector space; Completion theorem; Inner product Spaces; Orthonormal basis and Gram-Schmidt orthogonalization process; Orthogonal projection of a vector.

Unit-III: Linear transformations and properties; Orthogonal and unitary transformations; Real quadratic forms; Reduction and classification of quadratic forms; Hermitian forms; Sylvesters law of inertia; Canonical reduction of quadratic form.

Unit-IV: Characteristic roots and vectors; Cayley – Hamilton theorem; Minimal polynomial; Similar matrices; Spectral decomposition of a real symmetric matrix; Reduction of a pair of real symmetric matrices; Hermitian matrices.

References

1. Graybill, F.A. (1983). Matrices with applications in statistics, 2nd ed. Wadsworth, Belmont (California).
2. Rao, C. R. (1985). Linear statistical inference and its applications, Wiley Eastern Ltd., New Delhi.
3. Searle, S. R. (1982). Matrix Algebra useful for Statistics, John Wiley and Sons. Inc.
4. Bellman, R. (1970), Introduction to Matrix Analysis, 2nd ed. McGraw Hill, New York.
5. Campbell, H.G. (1980), Linear Algebra with Applications, 2nd Edition, Prentice-Hall, Englewood Cliffs (new Jersey), 1980.
6. Biswas, S. (1984), Topics in Algebra of Matrices, Academic Publications.
7. Hadley, G. (1987), Linear Algebra, Narosa Publishing House.
8. Halmos, P.R. (1958), Finite-dimensional Vector Spaces 2nd ed. D.Van Nostrand Company, Inc.
9. Hoffman, K. and Kunze, R, (1971). Linear Algebra, 2nd ed., Prentice Hall
10. Rao, A.R. and Bhimasankaram, P. (1992), Linear Algebra, Tata McGraw Hill Publishing Company Ltd.
11. Rao, C.R. and Mitra, S.K. (1971), Generalized Inverse of Matrices and its Applications, John Wiley and Sons, Inc.
12. Narayan, S. (1970), Theory of Matrices, S. Chand &Company, New Delhi.

Subject Code	Subject Name	Credits Allotted		Total
ST-101	**Linear Algebra**	Theory	Practical	4
		4	---	
Course Objective	1. To Prepare Students about algebra of matrices and vector spaces. 2. To explain about roots vectors and linear transformations with an examples			
Course Out comes	Students understood for estimation of elementary transformations in matrix and their solutions. Students learnt about characteristic roots and vectors with numerical examples. They also know theoretical proofs of theorems.			

ST 102: PROBABILITY AND DISTRIBUTIONS

Unit-I: Classes of sets, fields, σ -fields, minimal σ -field, Borel σ – 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-Stieltjes measures, Measurable functions, Random variables, sequence of random variables, almost sure convergence, convergence in probability (and in measure). Monotone convergence theorem, Fatou's lemma, Dominated convergence theorem.

Unit-II: Expectation of a random variable, inequalities on expectations, Markov, Holder, Jensen and Liapiunov inequalities. Borel- Cantelli - Lemma, Independence, Weak law and strong law of large numbers for iid sequences, Chebyshev's theorem, khinchine's theorem, Kolmogorov theorems (statements only), convergence in distribution.

Unit-III: Laplace and Weibull distributions.Functions of random variables and their distributions, sampling distributions: central Chi Square, t and F distributions and its properties, applications, relation between t and F, F and χ^2; Fisher's Z-distribution, fisher's Z-transformation. Non-central chi-square, t and F distributions and their properties.

Unit-IV: Multiple and partial correlation coefficients, multiple linear regression, inter relationship among partial and multiple correlation and regression coefficients. Null distributions of simple, partial and multiple correlation coefficients. Order statistics and their distributions, joint and marginal distributions of order statistics, distribution of range. Extreme values and their asymptotic distributions.

References

1. Ash, Robert. (1972). Real Analysis and Probability. Academic Press.
2. Billingsley, P. (P. (1986) Probability and Measure. Wiley.
3. Kingman, J F C and Taylor, S. J. (1966). Introduction to Measure and Probability. Cambridge University Press.
4. Loeve, M (1963), Probability theory
5. Bhatt B.R (1998), Modern Probability theory, Wiley Eastern
6. Rohatgi V.K. (1984): An Introduction to probability theory and mathematical statistics.
7. Rao C.R (1973): Linear Statistical Inference and its Applications, 2/e, Wiley Eastern.
8. Pitman J. (1993): Probability, Narosa Publishing House.
9. Johnson, N.L and Kotz, S.M. (1972): Distributions in Statistics, Vol. I , II & III. Houghton and Miffin.
10. David H.A (1981): Order Statistics, II Edition, and John Wiley.
11. Feller W (1966): Introduction to probability theory and its applications, Vol. III, second edition. Wiley Eastern.

<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-102</td><td rowspan="2">Probability and Distributions</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">1. To Explain about classes of sets and Probability measures
2. To discuss on random variables and convergence in probability and the important theorems with proofs.
3. To discuss about inequalities on expectations with their derivations and laws of numbers.
4. To explain about different discrete and continuous distributions and their Properties.
5. To learn about derivations and properties of various sampling distributions.
6. To explain order Statistics and their properties</td></tr>
<tr><td>Course Out comes</td><td colspan="4">1. Students must have knowledge about random variables, expectations, sets and their properties and inequalities where ever necessary.
2. Students also know the weak law, strong law and central limit theorem and their importance
3. Students know about different continuous and discrete distributions and their properties.
4. They have awareness about central and non central sampling distributions and order Statistics. Idea about simple, partial and multiple correlation coefficients.</td></tr>
</table>

ST 103 (a) : SAMPLING TECHNIQUES

Unit-I: Review of basic concepts of sampling theory such as sampling design, sampling scheme, sampling strategy etc., Sampling with varying probability with and without replacement, PPS WR/WOR methods – Lahiri's sample scheme, Hansen – Hurwitz, Des Raj estimators for a general sample size and Murthy estimator for a sample of size 2, Symmentrized Des Raj estimator.

Unit-II: Hurwitz – Thompson estimator (HTE) of a finite population total / mean, expression for V(HTE) and its unbiased estimator. IPPS scheme of a sampling due to Midzuno – Sen and JNK Rao (sample size 2 only). Rao – Hartley-Cochran sampling scheme for a sample of size n with random grouping.

Unit-III: Ratio and Regression methods of estimation, Two stage sampling, Multi stage sampling, Cluster sampling. Resampling methods and its applications.

Unit-IV: Double sampling for difference, ratio, regression and PPS estimators; Large scale sample surveys, Errors in surveys, A mathematical model for errors of measurement, Sampling and Non-sampling errors, Sources and types of non-sampling errors, Remedies for non-sampling errors.

References

1. Chaudhuri. A and Mukerji. R (1988): Randomized Response Theory and Techniques, New Yory, Marcel Dekker Inc.
2. Cochran W.G (1988): Sampling Techniques III Edition (1977) Wiley.
3. Des Raj and Chandak (1988): Sampling Theory. Narosa.
4. Murthy M.N (1977): Sampling Theory and Methods. Statistical Publishing Society.
5. Sukhatme et al (1984): Sampling Theory of Surveys with Applications. Iowa State University Press & IARS
6. Sing D and Chudary F.S (1986): Theory and Analysis of Sample Survey Designs. New Age International Publishers.
7. Hedayat A.S and Sinha B.K. (1991): Design and Inference in Finite Population Sampling. Wiley.
8. Mukhopadhyay P(1996): Inferential problems in Survey Sampling. New Age International.
9. Wolter K.M (1985): Introduction to Variance Estimator. Springer. Verlag.
10. Hansen M.M and Hurwitz W.M and Mandow W.G (1954): Sample Survey Methods and Theory, Vol. I and Methods and Applications Vol. II, John Wiley and Sons.
11. Philli. I. Good (2013):Introduction to statistics through resampling methods and R, 2nd edition.

Subject Code	Subject Name	Credits Allotted		Total
ST-103 (a)	**Sampling Techniques**	Theory	Practical	4
		4	----	
Course Objective	1. Discuss about basic concepts of sampling techniques PPS WR/WOR models. 2. To study about Hurwitz Thompson estimator, PPS scheme. 3. To learn about Ratio and Regression methods and their properties. 4. To explain Double sampling for difference estimators using ratio regression and PPS's, Non sampling error and their remedies.			
Course Out comes	1. Students learnt different sampling techniques of with replacement/ without replacement and Different sampling models. 2. Students studied Non-Sampling errors and different remedies.			

ST 103 (b) : STOCHASTIC PROCESSES

Unit-I: Introduction to stochastic processes (sp's): classification of sp's according to state apace and time domain. Countable state Markov chains (MC's), Chapman – Kolmogorov equations, calculation of n – step transition probability and its limit. Stationary distribution, classification of states,, transient MC, random walk and gambler's ruin problem.

Unit-II: Discrete state space continuous time MC: Kolmogorov – Feller differential equations, Poisson process, birth and death process; Applications to queues and storage problems. Wiener process as a limit of random walk, first – passage time and other problems.

Unit-III: Renewal theory: Elementary renewal theorem and applications. Statement and uses of key renewal theorem, study of residual life time process: weakly stationary and strongly stationary process; Moving averages and auto regressive process.

Unit-IV: Branching process: Galton – Watson branching process, probability of ultimate extinction, distribution of population size. Martingale in discrete time, inequality, convergence and smoothing properties. Statistical inference in MC and Markov process.

References

1. Adke, S.R and Manjunath, S.M (1984): An Introduction to Finite Markov Processes, Wiley Eastern.
2. Bhat, B.R (2000): stochastic Models: Analysis and Applications, New Age International, India.
3. Cinlar, E (1975): Introduction to Stochastic Processes, Prentice Hall.
4. Feller, W (1968): Introduction to Probability and its Applications, Vol. 1, Wiley Eastern.
5. Harris, T.E (1963): The Theory of Branching Processes, Springer – Verlag.
6. Hoel, P.G., Port, S.C and Stone, J.C (1972): Introduction to Stochastic Processes, Houghton Miffin & Co.
7. Jagers, P (1974): Branching Process with Biological Applications, Wiley.
8. Karlin, S and Taylor, H.M (1975): A First Course in Stochastic Processes, Vol. 1, and Academic Press.
9. Medhi, J (1982): Stochastic Processes, Wiley Eastern.
10. Parzen, E (1962): Stochastic Processes, Holden – Day.

Subject Code	Subject Name	Credits Allotted		Total
ST-103 (b)	**Stochastic Process**	Theory	Practical	4
		4	----	
Course Objective	1. To explain stochastic process and their classification according to space and domain. 2. To discuss about Birth and death process, Renewal theory and its applications, stochastic process and their importance, Markov chains, Poisson process, Renewal theory, Branching process etc.			
Course Out comes	1. Students understood stochastic processes, Markov chains, Poisson process, Renewal theory, Branching process, etc.			

ST 104 : PRACTICAL-I

At least 20 practicals covering papers relating to the subjects Linear Algebra, Probability and Distributions in this semester must be carried out. (75 marks for practical examination + 25 marks for record in the semester)

<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-104</td><td rowspan="2"><u>PRACTICALS</u></td><td>Theory</td><td>Practical</td><td rowspan="2">4</td></tr>
<tr><td>----</td><td>4</td></tr>
<tr><td>Course Objective</td><td colspan="4">1. To write different problems manually solving through calculators.
2. To write problems and solving them on computers using Statistical software like Excel and other relevant softwares like easy fit etc.,</td></tr>
<tr><td>Course Out comes</td><td colspan="4">Numerical problems related to Probability and Distribution Theory, Linear Algebra etc., are solved by executing programs on computers.</td></tr>
</table>

ST 105: STATISTICAL COMPUTING

Unit-I: Programming in C: Identifiers and Key words, data types and their declaration. Data input and output, operators and expressions. Control statements, if, if-else, case, go to statements. Loops, while, do-while and for statements. One and two-dimensional arrays. Concept of structures, Unions and pointers. Simple programs.

Unit-II: Structure of C++ program, Concept of OOP, tokens, key words, data types, dynamic initialization, manipulators, operator overloading. Function prototyping, inline functions, friend function and virtual functions with examples. Data binding using class, creating objects, defining member functions with simple examples. The concept of inheritance and polymorphism. Dynamic memory allocation and processing of linked lists.

Unit-III: Review of Excel, sorting, filtering and construction of charts. Curve fitting and interpretation of the output. Statistical functions in Excel - Calculating theoretical probability using Binomial, Poisson and Normal distributions. Matrix operations- Transpose, Product and Inverse operations using Excel. Pivot tables and look up functions.

Unit-IV: Data bases using MS-Access – working with tables and forms. Various types of queries – make table, update, crosstab and delete quires and their SQL code. Creating reports using Access. Crystal reports tool - standard and cross tab reports using Access and Excel data. Group expert, sort expert, select expert and section expert. Running totals and formulas. Simple statistical charts like Bar graph and Pie Diagrams.

References

1. Balaguruswamy, E (2007), Programming in ANSI C, 4E, Tata Publishing McGraw-Hill Publishing Ltd.
2. Balaguruswamy, E (1998), Object Oriented Programming with C++, Tata Publishing McGraw-Hill Publishing Ltd.
3. Ravi Chandran. D (2002), Programminig with C++, Tata Publishing McGraw-Hill Publishing Ltd.
4. Sarma K.V.S. (2010), Statistics Made Simple Do it Yourself on PC, Prentice Hall.

Subject Code	Subject Name	Credits Allotted		Total
ST-105	**STATISTICAL COMPUTING**	Theory	Practical	4
		4	----	
Course Objective	1. To learn about C and C++ and writing programs. 2. To study Excel operations to statistical charts, distributions both discrete and continuous, matrix operations like transpose, product and inverse. 3. To learn MS-access working with tables and forms entry of queries and their operations, SQL code for queries			
Course Out comes	1. Students wrote programs in C and C++. 2. They understood about MS-Excel for statistical distributions, charts and matrix operations. 3. They know MS-Access for tables and forms and their SQL codes.			

ST 106 : PRACTICAL-II

At least 20 practicals covering papers relating to the subjects Sampling Techniques and Statistical Computing in this semester must be carried out. (75 marks for practical examination + 25 marks for record in the semester)

Subject Code	Subject Name	Credits Allotted		Total
ST-106	**PRACTICALS**	Theory	Practical	4
		----	4	
Course Objective	1. To write different problems manually solving through calculators. 2. To write problems and solving them on computers using Statistical software like Excel, C, C++ etc.,			
Course Out comes	Numerical problems related to, Sampling Techniques and Statistical Computing are solved by executing programs on computers.			

SEMESTER – II

ST 201: STATISTICAL INFERENCE

Unit-I: Point estimation - Unbiasedness, Consistency, Efficiency and Sufficiency; Fisher-Neyman factorization theorem, complete sufficient statistics, minimum variance unbiased estimator (MVUE), Cramer - Rao inequality, Battacharayas inequality, Rao – Blackwell theorem. Exponential family, Maximum Likelihood estimation method, method of moments, method of minimum chi-squares and interval estimation.

Unit-II: Tests of hypothesis: Basic concepts, Most Powerful (MP) test, Neyman – Pearson Lemma, Consistency and Unbiased tests, Uniformly Most Powerful (UMP) test, UMP Unbiased tests, similar critical regions, Lehmann – Scheffe theorem, Likelihood Ratio Tests, Asymptotic Distribution of LR test, Bartlett's test for homogeneity of variances and Wald Test.

Unit-III: Non – Parametric tests of significance; Sign Test, Wilcoxon-Mann-Whitney U-test, Run test, Kolmogorov - Simrnov one and two sample tests, Median test, Kendall's τ test. Concept of asymptotic relative efficiency, CAN, BAN, CAUN and BEST CAUN estimators, MLE in Pitman family and Double Exponential distribution, MLE in Censored Truncated distribution.

Unit-IV: Statistical decision theory – decision problems and two person games, problems of inference viewed as decision problems, non-randomized and randomized decision rules, Loss and Risk functions, admissibility, complete and essentially complete class, complete class theorem. Bayes principle, determination of Bayes rule Minimax principle, determination of minimax rule, minimax theorem. Minimax estimates of parameters of Binomial, Poisson and Normal distributions.

References:

1. Rohtagi, V.K (1988): An Introduction to Probability and Mathematical Statistics, Wiley Eastern
2. Rao C.R (1973), Linear Statistical Inference and its applications, (Revised Edition), Wiley Eastern
3. Lehmann, E.L (1986), Theory of point estimation, (Student Edition)
4. Lehmann, E.L (1986), Testing Statistical Hypothesis (Student Edition)
5. Gibbons, J.D (1985), Non-parametric statistical inference, 2nd Edition, Mercel Dacker Inc
6. Siegal Sidney (1987), Non-parametric Statistics for behavioral sciences, 3rd Edition, Springer Verlog
7. Kendal, M.G and Stuart, A (1968), The advanced theory of statistics, Vol-II, Chales Griffin and Co., London
8. Ferguson, T.S (1967), Mathematical Statistics – a decision theoretic approach, Academic Press
9. Goon, A.M, Gupta, M and Das Gupta, B (1980), An outline of statistical theory, Vol-II, World Press, Calcutta.

Subject Code	Subject Name	Credits Allotted		Total
ST 201	**STATISTICAL INFERENCE**	Theory	Practical	4
		4	----	
Course Objective	1. To study the Estimation methods of point and their different measures and theorems, inequality. 2. To discuss about Testing of hypothesis that contains NP Lemma, UHP test, Bartlett's, Wald test, LR test and some theorems relates to hypothesis testing. 3. To discuss different Non-parametric tests with examples. Asymptotic relative efficiency and truncated distributions. 4. To study the Game theory and their problems, minimax rule, minimax theorem and minimum estimates of parameters using different distributions.			
Course Out comes	Students know about point estimation, testing of hypothesis, Non parametric models, Game theory, theorems and Proofs where ever necessary.			

ST 202: MULTIVARIATE ANALYSIS

Unit-I: Multivariate normal distribution, marginal and conditional distributions, characteristics functions, Maximum likelihood estimators of parameters, distribution of sample mean vector and dispersion matrix, distribution of quadratic form in the exponent of the multivariate normal density.

Unit-II: Hotelling's T^2 and its applications – T^2 distribution, application of T^2 to single sample, two sample and multiple sample problems, optimum properties of T^2 test. Mahalobis D^2 statistic and its distribution, Multivariate Analysis of Variance (MANOVA) of one and two-way classified data.

Unit-III: Classification and discrimination: procedures for classification into two multivariate normal populations, Fisher's Discriminant function, classification into more than two multivariate normal populations, Wishart distribution and its properties, concept of sample generalized variance and its distribution.

Unit-IV: Principal Component Analysis – properties, method of extraction of principal components; Canonical variables and canonical correlations; Factor Analysis – mathematical model, estimation of factor loading, concept of factor rotation; Cluster Analysis – similarities and dissimilarities, Hierarchical clustering: single and complete linkage method.

References

1. Anderson, T.W (1983), An introduction to Multivariate Statistical Analysis, Wiley, 2nd Edition.
2. Rao, C.R (1973), Linear Statistical Inference and its applications, 2nd edition, Wiley
3. Srivastava. M.S and Khatri, C.G (1979), An introduction to Multivariate Statistics, North Holland
4. Morrison,F(1985): Multivariate Statistical Methods, Mc Graw Hill Book Company.
5. Johnson A.R and Wishern, D.W (1996), Applied Multivariate Statistical Analysis, Prentice Hall of India
6. Sharma, S (1996), Applied Multivariate Techniques, Wiley
7. Krishisagar, A.M (1972), Multivariate Analysis, Marcel Dekker
8. K.C. Bhuyan(2005): Multivariate Analysis and its Applications, Central

Subject Code	Subject Name	Credits Allotted		Total
ST 202	**Multivariate analysis**	Theory	Practical	4
		4	----	
Course Objective	1. To study about Multivariate normal distributions and their properties, it's importance. 2. To discuss Hotelling's T^2, Mahalanobis D^2 statistic and its applications and properties. 3. To explain MANOVA with one and two way classified data. 4. To discuss about Principal Component Analysis, Factor Analysis and Cluster Analysis with appropriate methods.			
Course Out comes	1. Students learnt about importance of multivariate variables and their distributions 2. T^2, D^2, MANOVA models are understood and know it's importance. 3. Classification analysis methods explained according to their classification algorithm.			

ST 203(a): LINEAR MODELS AND APPLIED REGRESSION ANALYSIS

Unit-I: Two and Three variable Linear Regression models; General linear model: Assumptions; OLS estimation; BLUE; Tests of significance of individual regression coefficients; Testing the equality between two regressions coefficients; Test of significance of complete regression.

Unit-II: Criteria for model selection; Goodness of fit measures; R^2 and adjusted R^2 Criteria; C_p criterion; testing the general linear hypothesis; Chow test for Equality between sets of regression coefficients in two linear models; test for structural change; restricted least squares estimation; Generalized Mean Squared error criterion.

Unit-III: Non-normal disturbances and their consequences; test for normality; Jarque-Bera test; Shapiro-Wilk test, Minimum Absolute Deviation (MAD) estimation; Box-Cox transformations.
Statistical analysis of residuals, OLS residuals, BLUS residual, Studentised residual, Predicted residual, tests against heteroscadasticity.

Unit-IV: Non-Linear regression; Non linear least squares estimation; Maximum Likehoodestimation; Idea of computational methods; Gradient methods, Steepest descent method and Newton-raphson method; testing general Nonlinear hypothesis; Wald test, Lagrange multiplier test and likelihood ratio Test. Robust , probit, binomial logistic ,multiple logistic regression.

References

1. Johnston, J (1984): Econometric Methods, III rd edition. MC Graw Hill.
2. Gujarathi, D (1979): Basic Econometrics, MC Graw Hill.
3. Judge, C.G., Griffiths, R.C.Hill, W.E ., Lutkephol, H and Lee, T.C (1985): The Theory and Practice of Econometrics, John Wiley and Sons.
4. Draper, N and Smith, B (1981): Applied Regression Analysis, Second Edition

Subject Code	Subject Name	Credits Allotted		Total
ST 203(a)	**Linear models and Applied Regression Analysis**	Theory	Practical	4
		4	----	
Course Objective	1. To discuss about linear regression models and their assumptions. 2. To study about different criteria for model selection and their Goodness of fit measures. 3. To explain Non normal disturbances and their consequences and statistical analysis of residuals. 4. To discuss about Non-linear regression estimation methods.			
Course Out comes	1. Students learnt about different linear and non-linear regression models and their appropriate computational procedures. 2. They know R^2, adjusted R^2 and C_p criteria for model selection.			

ST 203(b): 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
ST 203(b)	**Demography and official statistics**	Theory	Practical	4
		4	----	
Course Objective	1. To study about demography and their importance, different reproduction. 2. To explain population Genetics, CSO, NSSO and their scope and contents in population census in India.			
Course Out comes	1. Students know the growth rates, life tables, GRR, NRR and growth models. 2. Students understood about gene frequencies, genotypes, phenotypes etc. 3. Students learnt about population census methods, organizations in India and their functions.			

ST 204 : PRACTICAL-III

At least 20 practicals covering all papers relating to the subject in this semester must be carried out. (75 marks for practical examination + 15 marks for viva-voce + 10 marks for record in the semester)

Subject Code	Subject Name	Credits Allotted		Total
ST-204	**PRACTICALS**	Theory	Practical	4
		----	4	
Course Objective	1. To exercise different practical problems manually through calculators. 2. To discuss problems relates to semester - II papers.			
Course Out comes	Students know about the solving of Numerical problems related to semester –II. . .			

ST 205 : DESIGN AND ANALYSIS OF EXPERIMENTS

Unit-I: Linear Model; Estimability of linear parametric functions; BLUE, Gauss-Markoff theorem; Generalized Gauss-Markoff theorem, ANOVA model, ANOVA for Two way and three way classifications, ANCOVA technique for one way and two-way classifications. Multiple comparisons tests using Tukey's, Duncans, Sheffe's and Dunnet's tests.

Unit-II: Latin squares and their construction, Mutually orthogonal Latin squares; Missing plot technique in Latin square Design, Graeco-Latin square Design; Analysis of Factorial Experiments involving factors with two and three levels in randomized blocks.

Unit-III: Necessity of confounding, Types of confounding, complete and partial confounding in 2^n, 3^2 and 3^3 factorial designs, Analysis of confounded factorial designs; Fractional Replication, Split Plot design.

Unit-IV: Incomplete Block Designs; B I B D, Inter and Intra Block analysis of a BIBD, Types of BIBD, construction of BIBD's using Mutually orthogonal Latin squares; Concepts of Youden square and lattice Design, Two-Associate PBIB design, Analysis of P B I B design.

References

1. M.N. Das and N.C.Giri (1979), Design and Analysis of Experiments, Wiley, Eastern, Pvt. Ltd., New Delhi.
2. C.D. Montgomery (1976), Design and Analysis of Experiments, Wiley & Sons, New York
3. M.C.Chakbravarthy, (1962), Mathematics of Design of Experiments, Asia Publishing House, Calcutta.
4. Oscar Kempthrone (1974), The Design and Analysis of Experiments, Wiley Eastern, Pvt. Ltd., New Delhi.
5. W.T. Federer (1972), Experimental Designs Theory and Application, Mac Millan Company, New York.
6. Angela Dean and Daniel Ross (1999), Design and Analysis of Experiments, Springer-Verlag.
7. D.D.Joshi (1987), Linear Estimation and Design of Experiments, Wiley Eastern, Pvt. Ltd., New Delhi.
8. P.W.M.John (1971), Statistical Design and Analysis of Experiments, Macmillan
9. F.Pukelshiem (1993), Optimal Design of Experiments, Wiley & Sons
10. D.Raghava Rao (1971), Construction and combinatorial problems in Design of Experiments, Wiley & Sons
11. Aloke Day (1986), Theory of Block Designs, Wiley Eastern, Pvt. Ltd., 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 205</td><td rowspan="2">Design and Analysis of Experiments</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">1. To learn ANOVA and ANCOVA for one and two way classifications analysis and their multiple comparison tests.
2. To explain Latin squares, different types of Latin squares and their missing plots.
3. To discuss on Confounding, their types, confounding 2^n, 3^2 and 3^3 factorial designs etc.
4. To discuss about BIBD, PBIBD construction analysis.</td></tr>
<tr><td>Course Out comes</td><td colspan="4">1. Students learnt ANOVA, ANCOVA technique for one way and two-way classifications. Multiple comparisons tests using Tukey’s, Duncans, Sheffe’s and Dunnet’s tests.
2. Students understood about Latin squares and their construction, missing plot technique etc.
3. Students explained about Incomplete Block Designs and their analysis, etc.</td></tr>
</table>

ST 206 : PRACTICAL-IV

At least 20 practicals covering all papers relating to the subject in this semester must be carried out. (75 marks for practical examination + 15 marks for viva-voce + 10 marks for record in the semester)

<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-206</td><td rowspan="2"><u>PRACTICALS</u></td><td>Theory</td><td>Practical</td><td rowspan="2">4</td></tr>
<tr><td>----</td><td>4</td></tr>
<tr><td>Course Objective</td><td colspan="4">1. To exercise different practical problems manually through calculators.
2. To discuss problems relates to semester - II papers.</td></tr>
<tr><td>Course Out comes</td><td colspan="4">Students know about the solving of Numerical problems related to semester –II. .
.</td></tr>
</table>

SEMESTER – III

ST 301: ECONOMETRIC METHODS

Unit-I: Quick review of Inference in general linear model; multi collinearity; Sources and consequences; detection, Farrar-Glauber Test; remedies, Ridge family of estimators and its properties; Heteroscedasticity; sources and consequences; Tests for Heteroscedasticity; Glejser's test Goldfeld-Quandt test; remedies, estimation under Heteroscedasticity.

Unit-II: Autocorrelation; sources and consequences; first order auto regressive Scheme; Durbin-Watson test; Remedies; Estimation under autocorrelation; Stochastic Regressors; Errors-in-Variables linear model; IV and ML estimation methods.

Unit-III: Finite Distributed lag models; Arithmetic lag; Inverted V-lag; Almon's Polynomial lag and Shiller's lag models; Infinite distributed lag models; Geometric lag model; OLS and IV methods of estimation; Koyek's two step and Wallis three step procedures; Pascal lag model.

Unit-IV: Simultanious linear equations models; identification; rank and order conditions; indirect least squares, IV and LIML methods; two stage least squares; k-class estimators; three stage least squares and FIML methods of estimation.

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. Intrilligator, M.D (1980): Econometric Models, Techniques and Applications, Prentice Hall.

Subject Code	Subject Name	Credits Allotted		Total
ST-301	**ECONOMETRIC METHODS**	Theory	Practical	4
		4	----	
Course Objective	1. To explain about heteroscedasticity, multicollinearity and their sources, consequences and tests. 2. To discuss about Autocorrelation, different orders of Autocorrelation and their estimation procedures. 3. To explain different lag models and their estimate procedures. 4. To discuss about simultaneous linear equations model and their different methods and estimation.			
Course Out comes	1. Students learnt heteroscedasticity, multicollinearity and autocorrelation and their estimation procedures. 2. Students understood about different lag models and simultaneous linear equations model with their estimation methods.			

ST 302: OPERATIONS RESEARCH – I

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.

Subject Code	Subject Name	Credits Allotted		Total
		Theory	Practical	
ST-302	**Operations Research-I**	4	----	4
Course Objective	1. To introduce operations research, Dual-primal, Revised simplex methods. 2. To discuss Non-linear programming and integer programming and their related problems. 3. To explain Network flow charts, CPM and PERT, project management models. 4. To discuss Game theory of 2×2, 2×m, m×n and non-zero sum games with their illustrations.			
Course Out comes	1. Students understood about Dual primal, Revised simplex methods. 2. Students learnt non-linear programming, integer programming, CPM, PERT, different models of games.			

ST 303 : PRACTICAL-V

At least 20 practicals covering all papers relating to the subject in this semester must be carried out. (75 marks for practical examination + 25 marks for record in the semester)

<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</td><td rowspan="2">PRACTICAL-III</td><td>Theory</td><td>Practical</td><td rowspan="2">4</td></tr>
<tr><td>----</td><td>4</td></tr>
<tr><td>Course Objective</td><td colspan="4">1. To solve the different practical problems manually through calculators and computers.

2. To do the Practical problems related to semester - III papers.</td></tr>
<tr><td>Course Out comes</td><td colspan="4">Students solved the Numerical problems related to semester -III theory papers .
.</td></tr>
</table>

ST 304 (a) : COMPUTER PROGRAMMING AND DATA ANALYSIS

Unit-I: Essentials of R-language – Expressions and objects, assignments, creating vectors, vectorized arithmetic, creating matrices, operations on matrices, lists, data frame creation, indexing, sorting and conditional selection with examples. Programming using conditional statements and loops, data editor, reading data from text files.

Unit-II: Obtaining summary statistics, generating tables, bar plots, pie charts, box plots, histograms. Random sampling from discrete and continuous distributions, plotting density and cumulative density curves, Q-Q plots with suitable examples.

Unit-III: Data Analysis Pak in Excel, descriptive statistics, tests of hypothesis, ANOVA, Correlation and Regression, Random Number Generation from different distributions, Binomial, Poisson, Uniform, Normal and from discrete distributions with given mean and variance. Forecasting Using Excel – Moving Averages and Exponential Smoothing, Use of functions, Linest, Logest, Forecast , Growth, Trend for trend analysis. The use of solver for optimization – Application to LPP.

Unit-IV:: Data handling using SPSS: Opening Excel files in SPSS. Merging of files, selection of records, recoding. Analysis tools, descriptive statistics, cross tabs (with stress on procedures and syntax). Post-hoc analysis for multiple comparisons using Tukey's test, Duncan's Multiple Range Test, Dunnet's test and Scheffe's test with interpretation. Selection of variables in Multiple Linear Regression – stepwise procedures and analysis of residuals. Procedure for Binary Logistic regression, Factor analysis, Linear Discriminant analysis and Cluster analysis.

References

1. Introductory Statistics with R by Peter Dalgaard, Springer, 2nd editions, 2008
2. The R book by Micheal J. Crawley, John Wiley and Sons, Ltd, 2007
3. Sarma, K.V.S (2010), Statistics Made Simple, Do it Yourself on PC, Prentice Hall of India.
4. Johnson and Wichern, Multivariate Analysis, Prentice Hall

<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-304 (a)</td><td rowspan="2">COMPUTER PROGRAMMING AND DATA ANALYSIS</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">1. To learn R language, simple programming relating to statistics using R.
2. To use R for different discrete and continuous distributions.
3. To discuss Excel analysis pak for t, F, ANOVA etc. with examples.
4. To explain SPSS for ANOVA with post hoc analysis, correlation, regression etc. with illustrations.</td></tr>
<tr><td>Course Out comes</td><td colspan="4">1. Students learnt software like R, SPSS and Excel pak for statistical tools.
2. Students wrote programmes in R and enter the data and analyze using Excel and SPSS.</td></tr>
</table>

ST 304 (b) : BIOSTATISTICS

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.

Subject Code	Subject Name	Credits Allotted		Total
		Theory	Practical	
ST 304 (b)	**Bio-Statistics**	4	----	4
Course Objective	1. To understand about Biological assay and their types, distribution and some of theorems. 2. To learn dose response relationships, their estimation, transformations. 3. To discuss Geno types and phenol types, Matrix operations to base mattings of single gen cross etc. 4. To estimate Gene frequency using different methods.			
Course Out comes	Students learnt about Biological assay, their distribution and theorems, dose response relationships, basic concepts of biological assay, estimation methods of gene frequencies, etc.			

ST304 (c) : TOTAL QUALITY MANAGEMENT AND SIX SIGMA

Unit I: Need for TQM, evolution of quality, Definition of quality, TQM philosophy – Contributions of Deming, Juran, Crosby, Taguchi and Ishikawa.

Unit II: Vision, Mission, Quality policy and objective, Planning and Organization for quality, Quality policy Deployment, Quality function deployment, Analysis of Quality Costs.

Unit III: Customer focus, Leadership and Top management commitment, Employee involvement – Empowerment and Team work, Supplier Quality Management, Continuous process improvement, Training, performance Measurement and customer satisfaction.

Unit IV : SIX SIGMA AND PDSA: An overview of six sigma methodology, DMAIC,DFSS and lean six sigma; product / process understanding : SIPOC, VSM, FMEA ; The Seven QC Tools of Quality, New Seven management tools, Bench Marking, JIT, POKA YOKE, 5S, KAIZEN, Quality circles.

Reference

1. Narayana V. and Sreenivasan, N.S.(1996): "Quality Management – Concepts and Tasks", New Age International.
2. Zeiri(1991): "Total Quality Management for Engineers", Wood Head Publishers.
3. Juran J.M and Frank M. Gryna Jr.(1982): "Quality Planning and Analysis", TMH, India.
4. Brain Rethery(1993): ISO 9000, Productivity and Quality Publishing Pvt.Ltd.
5. D.Mills(1993): Quality Auditing, Chapman and Hall.

Subject Code	Subject Name	Credits Allotted		Total
		Theory	Practical	
ST304 (c)	**TOTAL QUALITY MANAGEMENT AND SIX SIGMA**	4	----	4
Course Objective	1. To learn about TQM, Definition, importance and philosophy. 2. To discuss about quality and their planning and organization, Analysis of Quality costs. 3. To explain Six sigma and seven QC management tools.			
Course Out comes	1. Students learnt about TQM and different philosophy given by authors. 2. Students understood about Quality, planning, importance of leadership and top management, empowerment and team work etc. 3. Students used Advanced tools like six sigma and seven QC management.			

ST 305 : PRACTICAL-VI

At least 20 practicals covering all papers relating to the subject in this semester must be carried out. (75 marks for practical examination + 25 marks for record in the semester)

Subject Code	Subject Name	Credits Allotted		Total
ST-305	**PRACTICAL-III**	Theory	Practical	4
		----	4	
Course Objective	1. To solve the different practical problems manually through calculators and computers. 2. To do the Practical problems related to semester - III papers.			
Course Out comes	Students solved the Numerical problems related to semester -III theory papers . .			

ST 306 (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 Analysia, 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 306 (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">1. To learn basic statistics and their worked out examples.
2. To discuss about different tests like t, F, χ^2 and Z fro means, proportions, variances, standard deviation etc. with illustrations.
3. To explain ANOVA and ANCOVA for one way and two way classification and their importance in analysis.
4. To discuss Special statistical tools and multivariate analysis.</td></tr>
<tr><td>Course Out comes</td><td colspan="4">1. Students learnt about Graphs, measures of averages, measures of dispersion etc.
2. Students understood about Basic probability and important distributions with workout examples.
3. Students used t, F, χ^2 , ANOVA and ANCOVA and non-parametric tests with examples.
4. Students used Advanced statistics tools with working illustrations.</td></tr>
</table>

ST 306 (b): STATISTICS FOR SOCIAL AND BEHAVIOURAL SCIENCES

Unit- I: Statistical Measures: Measures of central tendency: Arithmetic Mean, Median and Mode; Measures of Variation: Range, Quartile Deviation, Standard Deviation, Coefficient of Variation, Measures of Skewness.

Unit- II: Probability and Distributions: Concept of Probability, Laws of Probability (statements only); Random Variable; Probability Distributions: Binomial, Poisson and Normal distributions (properties and applications).

Unit- III: Tests of Significance: Basic concepts; Random sampling techniques; Standard error of statistic; Large sample tests for proportions and means; Small sample tests: Applications of t, χ^2 and F tests; Analysis of Variance (ANOVA) and Analysis of Covariance (ANCOVA) techniques for one way and two way classifications (single observation per cell); Nonparametric tests: Wilcoxon Signed Rank test, Median test and Mann-Whitney U-test.

Unit- IV: Special statistical tools: Computation of Linear and Compound Growth rates and their tests of significance; Chow test for Structural change; Granger Causality test; Stepwise regression; R^2 and $\overline{R}^2$statistics; Multiple Range tests: l.s.d. test and Duncan's test: ANOVA for Ranked data; Krushkal-wallis test, Friedman test; Elements of Factor analysis and Discriminant analysis.

References

1. Gupta, S.C.(1997), Fundamentals of Statistics, Himalayan Publishers, Mumbai.
2. Kshirasagar, A.M. (1972), Multivariate Analysis, Marcel Decker, New York.
3. Gujarati, D.(1995), Basic Econometrics, Mc Graw Hill.
4. Ferguson, C.A.(1971), Statistical Analysis in Psychology and Education, McGraw Hill.
5. Johnson, R.A., and Wichern, D.W. (2001), Applied Multivariate Statistical Analysis, Third Edition, Prentice-Hall of India (p) Ltd.,. New Delhi.

Subject Code	Subject Name	Credits Allotted		Total
		Theory	Practical	
ST 306 (b)	**Statistics for social and behavioural sciences**	4	----	4
Course Objective	1. To learn about Basic statistics measures with examples. 2. To discuss important concepts, probability distributions like Binomial, Poisson and Normal properties and applications. 3. To explain Parametric and non-parametric test and discussed with illustrations. 4. To discuss advanced statistical tools with examples.			
Course Out comes	1. Students learnt about Graphs, measures of averages, measures of dispersion etc. 2. 3. Students understood about basic probability and important distributions with workout examples. 4. Students applied t, F, χ^2, ANOVA and ANCOVA and non-parametric tests and discussed with examples. 5. Students used Advanced statistics tools with illustrations.			

SEMESTER – IV

ST 401: TIME SERIES ANALYSIS AND FORECASTING METHODS

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.

<table>
<tr><td>Subject Code</td><td>Subject Name</td><td colspan="2">Credits Allotted</td><td>Total</td></tr>
<tr><td rowspan="2">ST401</td><td rowspan="2">Time series Analysis and forecasting methods</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">1. To fit growth curves, measurement of cyclical and irregular component with simple examples.
2. To discuss Forecasting and their techniques like regression, non-linear regression, exponential smoothing, etc.
3. To explain Box Jenkins time series models and their estimation of parameters, fitting and diagnostic checking.</td></tr>
<tr><td>Course Out comes</td><td colspan="4">1. Students understood about Time series analysis with some important growth models and their fitting.
2. Students learnt Forecasting using regression, non-linear regression techniques, single, double, triple and adoptive exponential smoothing models.
3. Students have experience in AR, MA, ARMA, ARIMA models fitting, diagnostic checking etc.</td></tr>
</table>

ST 402: OPERATIONS RESEARCH – II

Unit-I: Bellman's principle of optimality, general formulation, computational methods and application of Dynamic programming. Multi-stage decision processes and Dynamic programming. Goal Programming and stochastic programming.

Unit-I1: Queuing models-specifications and effectiveness measures.Steady state solutions of M/M/1 and M/M/c models with associated distributions of queue length and waiting time. M/G/1 Queue and Pollazcek Khinchine result. Steady-state solutions of M/Ek/1 and Ek/M/1 queues. Bulk queues.

Unit-I1I: Analytical structure of inventory problems; EOQ formula of Harris, its sensitivity analysis and extensions allowing quantity discounts and shortages. Multi-item inventory, subject to constraints.Models with random demand, the static risk model.(s-S) policy for inventory and its derivation in the case of exponential demand; multi-echelon inventory models.Models witlh variable supply and models for perishable items; estimation of EOQ in some simple cases.

Unit-IV: Replacement problems; block and age replacement polices; dynamic programming approach for maintenance problems; replacement of items with long life. Group and individual replacement policies.

References

1. Hadley G (1964) Non-Linear and Dynamic programming Addison Weslay.
2. Kleinrock L.(1975) Queueing systems vol.1, Theory; John Wiley.
3. Saaty T.L(1961) : Elements of Queueing Theory with Applications.
4. Gross D and Harris. C.M(1974) Fundamentals of queueing theory ; John Wiley.
5. Philips D.T, Ravindran A and Solberg J Operations Research, Principles and Practice.
6. Curchman C.W; Ackoff R.L and Arnoff E.L(1957) introduction to Operations Research; John Wiley
7. Mckinsey J.C.C(1952) Introduction to the theory of games Mc Graw Hill. P.K. Gupta; D.S. Hira Operations Research S.C Hand.

Subject Code	Subject Name	Credits Allotted		Total
ST- 402	**Operations Research-II**	Theory	Practical	4
		4	----	
Course Objective	1. To perform Dynamic programming and their applications and computation procedure with illustration. 2. To discuss different Queuing models steady state solutions with examples. 3. To explain Inventory models with and without shortages, S-splicy, EOQ estimation with simple examples. 4. To understand Replacement problems such as block and age replacement problems, individual and group replacement policies with examples.			
Course Out comes	Students learnt about Queuing models, Dynamic programming, Goal programming, Stochastic programming, inventory control models, replacement problems with some simple examples.			

ST 403 : PRACTICAL –VII

At least 20 practicals covering all papers relating to the subject in this semester must be carried out. (75 marks for practical examination + 15 marks for viva-voce + 10 marks for record in the semester)

<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- 403</td><td rowspan="2">PRACTICAL VII</td><td>Theory</td><td>Practical</td><td rowspan="2">4</td></tr>
<tr><td>-----</td><td>4</td></tr>
<tr><td>Course Objective</td><td colspan="4">1. To perform different practical problems manually through calculators and computers.

2. To solve Practical problems related to semester - IV papers.</td></tr>
<tr><td>Course Out comes</td><td colspan="4">Students have awareness on Numerical problems relating to semester 4 theory papers .
.</td></tr>
</table>

ST 404 (a): STATISTICAL PROCESS AND QUALITY CONTROL

Unit-I: Basic concepts of quality, causes of variation, principle of Shewart's control chart, control charts for attributes and variables. Control limits and probability limits. Process monitoring and control, process capability, modified control chart. Capability indices C_p, C_{pk}, and C_{pm}. Concept of Six sigma and its relationship with process capability.

Unit-II: The OC and ARL of Shewart's control charts. Control by gauging, Moving Average and Exponentially Weighted Moving Average charts. CUSUM charts using V-mask and decision interval methods. Multivariate control charts – Control Ellipsoid, Hotelling's T^2 chart.

Unit-III: Acceptance sampling plans for attribute inspection – Type-A and Type-B OC curves. Single, double and sequential sampling plans and their properties. Sampling plans with rectifying inspection-concept of AOQ, AOQL. Design of Single sampling plan with given ATI. Plans for inspection by variables with one-sided and two-sided specifications.

Unit-IV: Sampling plans for continuous inspection-construction of Dodge CSP-1, CSP-2 and Multi level plans and their properties. Chain sampling and its applications. Design of Skip lot sampling plan and its ASN. Sampling plans with inspection error- derivation of AOQ and ATI in presence of errors.

References

1. Montgomery D.C (2009), Introduction to Statistical Quality Control, 6/e, John Wiley and Sons, New York.
2. Edward G. Schilling, Dean V. Neubauer, (2009), Acceptance sampling in quality control Second Edition, Taylor & Francis.
3. Mittage, H.J and Rinne, H (1993): Statistical Methods of Quality Assurance, Chapmann Hall, London, UK.
4. Ott. E.R (1975), Process Quality Control, Mc Graw Hill
5. Phadke, M.S (1989), Quality Engineering through Robust Design, Prentice Hall
6. Duncan, A.J (1974), Quality Control and Industrial Statistics, 3rd Ed., New York, Irwin.
7. Philip J. Ross (1989), Taguchi techniques for quality engineering, McGraw Hill

<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 - 404(a)</td><td rowspan="2">STATISTICAL PROCESS AND QUALITY CONTROL</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">1. To understand the basic concepts of control charts for variables and their indices.
2. To discuss different control charts like Shewart’s moving average, multivariate etc. with their applications.
3. To explain different sequential sampling plans and six sigma tool etc. with their properties and applications..</td></tr>
<tr><td>Course Out comes</td><td colspan="4">1. Students understood the basic concepts of control charts for variables and their indices.
2. Students performed different control charts like Shewart’s moving average, multivariate etc. with their applications.
3. Students used different sequential sampling plans and six sigma tool etc. in solving the problems.</td></tr>
</table>

ST 404(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

<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- 404(b)</td><td rowspan="2">STATISTICS FOR RESEARCH, INDUSTRY AND COMMUNITYDEVELOPMENT</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">1. To explain Response surface models, stepwise, partially linear and non-parametric regression models with their applications.
2. To perform Simulation models, demand analysis and their related tools.
3. To discuss on Social server, steps in social server measurements for social server with examples.</td></tr>
<tr><td>Course Out comes</td><td colspan="4">Students performed Simulation models, response surface models, demand analysis, social survey and their related measures.</td></tr>
</table>

ST 404 (c): ADVANCED ECONOMETRIC MODELS

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.

<table>
<tr><td>Subject Code</td><td>Subject Name</td><td colspan="2">Credits Allotted</td><td>Total</td></tr>
<tr><td rowspan="2">ST405(c)</td><td rowspan="2">Advanced Econometric Models</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">1. To explain OLS, GLS, BLUE and Recursive residuals with their properties.
2. To discuss different regression models and their importance.
3. To perform estimation in censored and Truncated Samples.
4. To fit sets of linear regression models and their related estimators.</td></tr>
<tr><td>Course Out comes</td><td colspan="4">1. Students understood GLM, SURE, nested and non nested statistical models.
2. Students learnt about specification error, adding, switching models.
3. Students performed Probit, logit models and their estimation.</td></tr>
</table>

ST 405 : STUDENT PROJECT
Data Centre / Institutions / Companies and etc.,

<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 404</td><td rowspan="2">STUDENT PROJECT</td><td>Theory</td><td>Practical</td><td rowspan="2">4</td></tr>
<tr><td>Dissertation submission 4</td><td>----</td></tr>
<tr><td>Course Objective</td><td colspan="4">1. To collect primary data from industry, institutions, etc.
2. To collect secondary data from internet or any records.
3. To analyze the collected data and submit a report in the form a dissertation.</td></tr>
<tr><td>Course Out comes</td><td colspan="4">1. Students collected primary data or secondary data and enter the data in particular software, analyzed the data and interpret it.
2. Students submitted the report in the form of dissertation.</td></tr>
</table>

ST 406 (a) 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.

Subject Code	Subject Name	Credits Allotted		Total
ST 406 - (a)	**Business Analytics**	Theory	Practical	4
		4	----	
Course Objective	1. To learn basic statistics and their worked out examples. 2. To discuss different tests like t, F, χ^2 and Z fro means, proportions, variances, standard deviation etc. with an illustrations. 3. To study ANOVA and ANCOVA for one way and two way classification and their importance in analysis. 4. To use special statistical tools and multivariate analysis.			
Course Out comes	1. Students learnt Graphs, measures of averages, measures of dispersion etc. 2. Students studied basic probability and important distributions with workout examples. 3. Students used t, F, χ^2 , ANOVA and ANCOVA and non-parametric tests and discussed with examples. 4. Students performed advanced statistics tools for solving the problems.			

ST406 (b) : SURVIVAL ANALYSIS

UNIT – I: Functions of Survival Time – Definition, Relationship of Survival Functions; Nonparametric Methods of Estimating Survival Functions: Product-Limit Estimate of Survival Function – Kaplan-Meier Estimator of Survival Function.

UNIT – II: Nonparametric Methods for Comparing Two Survival Distributions – Gehan's Generalized Wilcoxon Test, Cox - Mantel test, Logrank Test, Peto and Peto's Generalized Wilcoxon Test, Cox's F-test and Mantel-Haenszel Test.

UNIT – III: Parametric Methods for Comparing Two Survival Distributions: Exponential, Weibull and Gamma distributions only. Nonparametric and Parametric Methods for Identifications of Prognostic Factor Relating to Survival Time, Cox Proportional Hazard (PH) Model for Survival Data.

UNIT – IV: Analytical Estimation Procedures for Survival Distributions: Exponential, Weibull, Log-Normal and Gamma distributions only.Graphical Methods for Survival Distributions Fitting: Probability Plotting, Hazard Plotting Methods, Tests of Goodness-of-Fit, A Regression Method for Fitting Survival Distribution.

REFERENCES:

1. Elisa T.Lee (1992): Statistical Methods for Survival Data Analysis, John Wiley Sons.
2. Miller, R.G. (1981): Survival Analysis, New York, John Wiley & Sons, Inc.
3. Cross A.J. and Clark V.A. (1975): Survival Distribution, Reliability Applications in the Biomedical Sciences, John Wiley and Sons.
4. Elandt Johnson, R.C., Johnson N.L. (1999): Survival Models and Data Analysis, New York, John Wiley & Sons, Inc.
5. Collett, D. (1994), Modeling Survival Data in Medical Research, London: Chapman & Hall.
6. Cox, D. R. and Oakes, D. (1984), Analysis of Survival Data, London: Chapman & Hall.
7. Lawless, J. F. (1982), Survival Models and Methods for Lifetime Data, New York: John Wiley & Sons, Inc.

Subject Code	Subject Name	Credits Allotted		Total
ST 406 (b)	**Survival analysis**	Theory	Practical	4
		4	----	
Course Objective	1. To learn Survival functions and their estimation models. 2. To discuss Distributions relating to survival analysis.			
Course Out comes	Students learnt about survival functions, their estimating methods, Distributions and their comparison for survival distributions.			

M.Sc., APPLIED STATISTICS

SEMESTER – I

APST 101: LINEAR ALGEBRA

Unit-I: Algebra of matrices; Elementary transformations; Rank and Inverse of a matrix; Nullity; Partitioned matrices; Kronecker product; Generalized inverse of matrix; Moore-Penrose generalized inverse; Solutions of simultaneous equations.

Unit-II: Finite dimensional Vector Spaces; VectorSpaces and Subspaces; Linear dependence and independence; Basis and dimension of a vector space; Completion theorem; Inner product Spaces; Orthonormal basis and Gram-Schmidt orthogonalization process; Orthogonal projection of a vector.

Unit-III: Linear transformationsand properties; Orthogonal and unitary transformations; Real quadratic forms; Reduction and classification of quadratic forms; Hermitian forms; Sylvesters law of inertia; Canonical reduction of quadratic form.

Unit-IV: Characteristic roots and vectors; Cayley – Hamilton theorem; Minimal polynomial; Similar matrices; Spectral decomposition of a real symmetric matrix; Reduction of a pair of real symmetric matrices; Hermitian matrices.

References

1. Graybill, F.A. (1983). Matrices with applications in statistics, 2nd ed. Wadsworth, Belmont (California).
2. Rao, C. R. (1985). Linear statistical inference and its applications, Wiley Eastern Ltd., New Delhi.
3. Searle, S. R. (1982). Matrix Algebra useful for Statistics, John Wiley and Sons. Inc.
4. Bellman, R. (1970), Introduction to Matrix Analysis, 2nd ed. McGraw Hill, New York.
5. Campbell, H.G. (1980), Linear Algebra with Applications, 2nd Edition, Prentice-Hall, Englewood Cliffs (new Jersey), 1980.
6. Biswas, S. (1984), Topics in Algebra of Matrices, Academic Publications.
7. Hadley, G. (1987), Linear Algebra, Narosa Publishing House.
8. Halmos, P.R. (1958), Finite-dimensional Vector Spaces 2nd ed. D.Van Nostrand Company, Inc.
9. Hoffman, K. and Kunze, R, (1971). Linear Algebra, 2nd ed., Prentice Hall
10. Rao, A.R. and Bhimasankaram, P. (1992), Linear Algebra, Tata McGraw Hill Publishing Company Ltd.
11. Rao, C.R. and Mitra, S.K. (1971), Generalized Inverse of Matrices and its Applications, John Wiley and Sons, Inc.
12. Narayan, S. (1970), Theory of Matrices, S. Chand &Company, New Delhi.

Subject Code	Subject Name	Credits Allotted		Total
APST-101	**Linear Algebra**	Theory	Practical	4
		4	---	
Course Objective	1. To Prepare Students about algebra of matrices and vector spaces. 2. To explain about roots vectors and linear transformations with an examples			
Course Out comes	Students understood for estimation of elementary transformations in matrix and their solutions. Students learnt about characteristic roots and vectors with numerical examples. They also know theoretical proofs of theorems.			

APST 102: PROBABILITY AND DISTRIBUTIONS

Unit-I: Classes of sets, fields, σ -fields, minimal σ -field, Borel σ – 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-Stieltjes measures, Measurable functions, Random variables, sequence of random variables, almost sure convergence, convergence in probability (and in measure). Monotone convergence theorem, Fatou's lemma, Dominated convergence theorem.

Unit-II: Expectation of a random variable, inequalities on expectations, Markov, Holder, Jensen and Liapiunov inequalities. Borel- Cantelli - Lemma, Independence, Weak law and strong law of large numbers for iid sequences, Chebyshev's theorem, khinchine's theorem, Kolmogorov theorems (statements only), convergence in distribution.

Unit-III: Laplace and Weibull distributions.Functions of random variables and their distributions, sampling distributions: central Chi Square, t and F distributions and its properties, applications, relation between t and F, F and χ^2; Fisher's Z-distribution, fisher's Z-transformation. Non-central chi-square, t and F distributions and their properties.

Unit-IV: Multiple and partial correlation coefficients, multiple linear regression, inter relationship among partial and multiple correlation and regression coefficients. Null distributions of simple, partial and multiple correlation coefficients. Order statistics and their distributions, joint and marginal distributions of order statistics, distribution of range. Extreme values and their asymptotic distributions.

References

1. Ash, Robert. (1972). Real Analysis and Probability. Academic Press.
2. Billingsley, P. (P. (1986) Probability and Measure. Wiley.
3. Kingman, J F C and Taylor, S. J. (1966). Introduction to Measure and Probability. Cambridge University Press.
4. Loeve, M (1963), Probability theory
5. Bhatt B.R (1998), Modern Probability theory, Wiley Eastern
6. Rohatgi V.K. (1984): An Introduction to probability theory and mathematical statistics.
7. Rao C.R (1973): Linear Statistical Inference and its Applications, 2/e, Wiley Eastern.
8. Pitman J. (1993): Probability, Narosa Publishing House.
9. Johnson, N.L and Kotz, S.M. (1972): Distributions in Statistics, Vol. I , II & III. Houghton and Miffin.
10. David H.A (1981): Order Statistics, II Edition, and John Wiley.
11. Feller W (1966): Introduction to probability theory and its applications, Vol. III, second edition. Wiley Eastern.

<table>
<tr><td>Subject Code</td><td>Subject Name</td><td colspan="2">Credits Allotted</td><td>Total</td></tr>
<tr><td rowspan="2">APST-102</td><td rowspan="2">Probability and Distributions</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">1. To Explain about classes of sets and Probability measures
2. To discuss on random variables and convergence in probability and the important theorems with proofs.
3. To discuss about inequalities on expectations with their derivations and laws of numbers.
4. To explain about different discrete and continuous distributions and their Properties.
5. To learn about derivations and properties of various sampling distributions.
6. To explain order Statistics and their properties</td></tr>
<tr><td>Course Out comes</td><td colspan="4">1. Students must have knowledge about random variables, expectations, sets and their properties and inequalities where ever necessary.
2. Students also know the weak law, strong law and central limit theorem and their importance
3. Students know about different continuous and discrete distributions and their properties.
4. They have awareness about central and non central sampling distributions and order Statistics. Idea about simple, partial and multiple correlation coefficients.</td></tr>
</table>

APST 103 (a) : SAMPLING TECHNIQUES

Unit-I: Review of basic concepts of sampling theory such as sampling design, sampling scheme, sampling strategy etc., Sampling with varying probability with and without replacement, PPS WR/WOR methods – Lahiri's sample scheme, Hansen – Hurwitz, Des Raj estimators for a general sample size and Murthy estimator for a sample of size 2, Symmentrized Des Raj estimator.

Unit-II: Hurwitz – Thompson estimator (HTE) of a finite population total / mean, expression for V(HTE) and its unbiased estimator. IPPS scheme of a sampling due to Midzuno – Sen and JNK Rao (sample size 2 only). Rao – Hartley-Cochran sampling scheme for a sample of size n with random grouping.

Unit-III: Ratio and Regression methods of estimation, Two stage sampling, Multi stage sampling, Cluster sampling. Resampling methods and its applications.

Unit-IV: Double sampling for difference, ratio, regression and PPS estimators; Large scale sample surveys, Errors in surveys, A mathematical model for errors of measurement, Sampling and Non-sampling errors, Sources and types of non-sampling errors, Remedies for non-sampling errors.

References

1. Chaudhuri. A and Mukerji. R (1988): Randomized Response Theory and Techniques, New Yory, Marcel Dekker Inc.
2. Cochran W.G (1988): Sampling Techniques III Edition (1977) Wiley.
3. Des Raj and Chandak (1988): Sampling Theory. Narosa.
4. Murthy M.N (1977): Sampling Theory and Methods. Statistical Publishing Society.
5. Sukhatme et al (1984): Sampling Theory of Surveys with Applications. Iowa State University Press & IARS
6. Sing D and Chudary F.S (1986): Theory and Analysis of Sample Survey Designs. New Age International Publishers.
7. Hedayat A.S and Sinha B.K. (1991): Design and Inference in Finite Population Sampling. Wiley.
8. Mukhopadhyay P(1996): Inferential problems in Survey Sampling. New Age International.
9. Wolter K.M (1985): Introduction to Variance Estimator. Springer. Verlag.
10. Hansen M.M and Hurwitz W.M and Mandow W.G (1954): Sample Survey Methods and Theory, Vol. I and Methods and Applications Vol. II, John Wiley and Sons.
11. Philli. I. Good (2013):Introduction to statistics through resampling methods and R, 2nd edition.

Subject Code	Subject Name	Credits Allotted		Total
ST-103 (a)	**Sampling Techniques**	Theory	Practical	4
		4	----	
Course Objective	1. Discuss about basic concepts of sampling techniques PPS WR/WOR models. 2. To study about Hurwitz Thompson estimator, PPS scheme. 3. To learn about Ratio and Regression methods and their properties. 4. To explain Double sampling for difference estimators using ratio regression and PPS's, Non sampling error and their remedies.			
Course Out comes	1. Students learnt different sampling techniques of with replacement/ without replacement and Different sampling models. 2. Students studied Non-Sampling errors and different remedies.			

APST 103 (b) : STOCHASTIC PROCESSES

Unit-I: Introduction to stochastic processes (sp's): classification of sp's according to state apace and time domain. Countable state Markov chains (MC's), Chapman – Kolmogorov equations, calculation of n – step transition probability and its limit. Stationary distribution, classification of states,, transient MC, random walk and gambler's ruin problem.

Unit-II: Discrete state space continuous time MC: Kolmogorov – Feller differential equations, Poisson process, birth and death process; Applications to queues and storage problems. Wiener process as a limit of random walk, first – passage time and other problems.

Unit-III: Renewal theory: Elementary renewal theorem and applications. Statement and uses of key renewal theorem, study of residual life time process: weakly stationary and strongly stationary process; Moving averages and auto regressive process.

Unit-IV: Branching process: Galton – Watson branching process, probability of ultimate extinction, distribution of population size. Martingale in discrete time, inequality, convergence and smoothing properties. Statistical inference in MC and Markov process.

References

1. Adke, S.R and Manjunath, S.M (1984): An Introduction to Finite Markov Processes, Wiley Eastern.
2. Bhat, B.R (2000): stochastic Models: Analysis and Applications, New Age International, India.
3. Cinlar, E (1975): Introduction to Stochastic Processes, Prentice Hall.
4. Feller, W (1968): Introduction to Probability and its Applications, Vol. 1, Wiley Eastern.
5. Harris, T.E (1963): The Theory of Branching Processes, Springer – Verlag.
6. Hoel, P.G., Port, S.C and Stone, J.C (1972): Introduction to Stochastic Processes, Houghton Miffin & Co.
7. Jagers, P (1974): Branching Process with Biological Applications, Wiley.
8. Karlin, S and Taylor, H.M (1975): A First Course in Stochastic Processes, Vol. 1, and Academic Press.
9. Medhi, J (1982): Stochastic Processes, Wiley Eastern.
10. Parzen, E (1962): Stochastic Processes, Holden – Day.

Subject Code	Subject Name	Credits Allotted		Total
APST-103 (b)	**Stochastic Process**	Theory	Practical	4
		4	----	
Course Objective	1. To explain stochastic process and their classification according to space and domain. 2. To discuss about Birth and death process, Renewal theory and its applications, stochastic process and their importance, Markov chains, Poisson process, Renewal theory, Branching process etc.			
Course Out comes	Students understood stochastic processes, Markov chains, Poisson process, Renewal theory, Branching process, etc.			

APST 104 : PRACTICAL-I

At least 20 practicals covering papers relating to the subjects Linear Algebra, Probability and Distributions in this semester must be carried out. (75 marks for practical examination + 25 marks for record in the semester)

<table>
<tr><td>Subject Code</td><td>Subject Name</td><td colspan="2">Credits Allotted</td><td>Total</td></tr>
<tr><td rowspan="2">APST-104</td><td rowspan="2"><u>PRACTICALS</u></td><td>Theory</td><td>Practical</td><td rowspan="2">4</td></tr>
<tr><td>----</td><td>4</td></tr>
<tr><td>Course
Objective</td><td colspan="4">1. To write different problems manually solving through calculators.

2. To write problems and solving them on computers using Statistical software like Excel, C, C++ etc.,</td></tr>
<tr><td>Course
Out comes</td><td colspan="4">Numerical problems related to distribution theory, statistical analysis, linear algebra etc., are solved by executing programs on computers.
.</td></tr>
</table>

APST 105: STATISTICAL COMPUTING

Unit-I: Programming in C: Identifiers and Key words, data types and their declaration. Data input and output, operators and expressions. Control statements, if, if-else, case, go to statements. Loops, while, do-while and for statements. One and two-dimensional arrays.Concept of structures, Unions and pointers.Simple programs.

Unit-II: Structure of C++ program, Concept of OOP, tokens, key words, data types, dynamic initialization, manipulators, operator overloading. Function prototyping, inline functions, friend function and virtual functions with examples. Data binding using class, creating objects, defining member functions with simple examples. The concept of inheritance and polymorphism. Dynamic memory allocation and processing of linked lists.

Unit-III: Review of Excel, sorting, filtering and construction of charts. Curve fitting and interpretation of the output. Statistical functions in Excel - Calculating theoretical probability using Binomial, Poisson and Normal distributions. Matrix operations- Transpose, Product and Inverse operations using Excel. Pivot tables and look up functions.

Unit-IV: Data bases using MS-Access – working with tables and forms. Various types of queries – make table, update, crosstab and delete quires and their SQL code. Creating reports using Access. Crystal reports tool - standard and cross tab reports using Access and Excel data. Group expert, sort expert, select expert and section expert. Running totals and formulas. Simple statistical charts like Bar graph and Pie Diagrams.

References

1. Balaguruswamy, E (2007), Programming in ANSI C, 4E, Tata Publishing McGraw-Hill Publishing Ltd.
2. Balaguruswamy, E (1998), Object Oriented Programming with C++, Tata Publishing McGraw-Hill Publishing Ltd.
3. Ravi Chandran. D (2002), Programminig with C++, Tata Publishing McGraw-Hill Publishing Ltd.
4. Sarma K.V.S. (2010), Statistics Made Simple Do it Yourself on PC, Prentice Hall.

Subject Code	Subject Name	Credits Allotted		Total
APST-105	**STATISTICAL COMPUTING**	Theory	Practical	4
		4	----	
Course Objective	1. To learn about C and C++ and writing programs. 2. To study Excel operations to statistical charts, distributions both discrete and continuous, matrix operations like transpose, product and inverse. 3. To learn MS-access working with tables and forms entry of queries and their operations, SQL code for queries			
Course Out comes	1. Students wrote programs in C and C++. 2. They understood about MS-Excel for statistical distributions, charts and matrix operations. 3. They know MS-Access for tables and forms and their SQL codes.			

APST 106 : PRACTICAL-II

At least 20 practicals covering papers relating to the subjects Sampling Techniques and Statistical Computing in this semester must be carried out. (75 marks for practical examination + 25 marks for record in the semester)

<table>
<tr><td>Subject Code</td><td>Subject Name</td><td colspan="2">Credits Allotted</td><td>Total</td></tr>
<tr><td rowspan="2">APST-106</td><td rowspan="2"><u>PRACTICALS</u></td><td>Theory</td><td>Practical</td><td rowspan="2">4</td></tr>
<tr><td>----</td><td>4</td></tr>
<tr><td>Course Objective</td><td colspan="4">1. To write different problems manually solving through calculators.
2. To write problems and solving them on computers using Statistical software like Excel, C, C++ etc.,</td></tr>
<tr><td>Course Out comes</td><td colspan="4">Numerical problems related to distribution theory, statistical analysis, linear algebra etc., are solved by executing programs on computers.
.</td></tr>
</table>

SEMESTER – II

APST 201: STATISTICAL INFERENCE

Unit-I: Point estimation - Unbiasedness, Consistency, Efficiency and Sufficiency; Fisher-Neyman factorization theorem, complete sufficient statistics, minimum variance unbiased estimator (MVUE), Cramer - Rao inequality, Bhattacharya's inequality, Rao – Blackwell theorem. Exponential family, Maximum Likelihood estimation method, method of moments, method of minimum chi-squares and interval estimation.

Unit-II: Tests of hypothesis: Basic concepts, Most Powerful (MP) test, Neyman – Pearson Lemma, Consistency and Unbiased tests, Uniformly Most Powerful (UMP) test, UMP Unbiased tests, similar critical regions, Lehmann –Scheffe theorem, Likelihood Ratio Tests, Asymptotic Distribution of LR test, Bartlett's test for homogeneity of variances and Wald Test.

Unit-III: Non – Parametric tests of significance; Sign Test, Wilcoxon-Mann-Whitney U-test, Run test, Kolmogorov-Simrnov one and two sample tests, Median test, Kendall's τ test. Concept of asymptotic relative efficiency, CAN, BAN, CAUN and BEST CAUN estimators, MLE in Pitman family and Double Exponential distribution, MLE in Censored Truncated distribution.

Unit-IV: Statistical decision theory – decision problems and two person games, problems of inference viewed as decision problems, non-randomized and randomized decision rules, Loss and Risk functions, admissibility, complete and essentially complete class, complete class theorem. Bayes principle, determination of Bayes rule Minimax principle, determination of minimax rule, minimax theorem. Minimax estimates of parameters of Binomial, Poisson and Normal distributions.

References

1. Rohtagi, V.K (1988): An Introduction to Probability and Mathematical Statistics, Wiley Eastern
2. Rao C.R (1973), Linear Statistical Inference and its applications, (Revised Edition), Wiley Eastern
3. Lehmann, E.L (1986), Theory of point estimation, (Student Edition)
4. Lehmann, E.L (1986), Testing Statistical Hypothesis (Student Edition)
5. Gibbons, J.D (1985), Non-parametric statistical inference, 2nd Edition, Mercel Dacker Inc
6. Siegal Sidney (1987), Non-parametric Statistics for behavioral sciences, 3rd Edition, Springer Verlog
7. Kendal, M.G and Stuart, A (1968), The advanced theory of statistics, Vol-II, Chales Griffin and Co., London
8. Ferguson,T.S (1967), Mathematical Statistics - a decision theoretic approach, Academic Press
9. Goon, A.M, Gupta, M and Das Gupta, B (1980), An outline of statistical theory, Vol-II, World Press, Calcutta.

Subject Code	Subject Name	Credits Allotted		Total
APST 201	**STATISTICAL INFERENCE**	Theory	Practical	4
		4	----	
Course Objective	1. To study the Estimation methods of point and their different measures and theorems, inequality. 2. To discuss about Testing of hypothesis that contains NP Lemma, UHP test, Bartlett's, Wald test, LR test and some theorems relates to hypothesis testing. 3. To discuss different Non-parametric tests with examples. Asymptotic relative efficiency and truncated distributions. 4. To study the Game theory and their problems, minimax rule, minimax theorem and minimum estimates of parameters using different distributions.			
Course Out comes	Students know about point estimation, testing of hypothesis, Non parametric models, Game theory, theorems and Proofs where ever necessary.			

APST 202: MULTIVARIATE ANALYSIS

Unit-I: Multivariate normal distribution, marginal and conditional distributions, characteristics functions, Maximum likelihood estimators of parameters, distribution of sample mean vector and dispersion matrix, distribution of quadratic form in the exponent of the multivariate normal density.

Unit-II: Hotelling's T^2 and its applications – T^2 distribution, application of T^2 to single sample, two sample and multiple sample problems, optimum properties of T^2 test. Mahalobis D^2 statistic and its distribution, Multivariate Analysis of Variance (MANOVA) of one and two-way classified data.

Unit-III: Classification and discrimination: procedures for classification into two multivariate normal populations, Fisher's Discriminant function, classification into more than two multivariate normal populations, Wishart distribution and its properties, concept of sample generalized variance and its distribution.

Unit-IV: Principal Component Analysis – properties, method of extraction of principal components; Canonical variables and canonical correlations; Factor Analysis – mathematical model, estimation of factor loading, concept of factor rotation; Cluster Analysis – similarities and dissimilarities, Hierarchical clustering: single and complete linkage method.

References

1. Anderson, T.W (1983), An introduction to Multivariate Statistical Analysis, Wiley, 2nd Edition.
2. Rao, C.R (1973), Linear Statistical Inference and its applications, 2nd edition, Wiley
3. Srivastava. M.S and Khatri, C.G (1979), An introduction to Multivariate Statistics, North Holland
4. Morrison,F(1985): Multivariate Statistical Methods, Mc Graw Hill Book Company.
5. Johnson A.R and Wishern, D.W (1996), Applied Multivariate Statistical Analysis, Prentice Hall of India
6. Sharma, S (1996), Applied Multivariate Techniques, Wiley
7. Krishisagar, A.M (1972), Multivariate Analysis, Marcel Dekker
8. K.C. Bhuyan(2005): Multivariate Analysis and its Applications, Central

Subject Code	Subject Name	Credits Allotted		Total
APST 202	**Multivariate analysis**	Theory	Practical	4
		4	----	
Course Objective	1. To study about Multivariate normal distributions and their properties, it's importance. 2. To discuss Hotelling's T^2, Mahalanobis D^2 statistic and its applications and properties. 3. To explain MANOVA with one and two way classified data. 4. To discuss about Principal Component Analysis, Factor Analysis and Cluster Analysis with appropriate methods.			
Course Out comes	1. Students learnt about importance of multivariate variables and their distributions 2. T^2, D^2, MANOVA models are understood and know it's importance. 3. Classification analysis methods explained according to their classification algorithm.			

APST 203(a): LINEAR MODELS AND APPLIED REGRESSION ANALYSIS

Unit-I: Two and Three variable Linear Regression models; General linear model: Assumptions; OLS estimation; BLUE; Tests of significance of individual regression coefficients; Testing the equality between two regressions coefficients; Test of significance of complete regression.

Unit-II: Criteria for model selection; Goodness of fit measures; R^2 and adjusted R^2 Criteria; C_p criterion; testing the general linear hypothesis; Chow test for Equality between sets of regression coefficients in two linear models; test for structural change; restricted least squares estimation; Generalized Mean Squared error criterion.

Unit-III: Non-normal disturbances and their consequences; test for normality; Jarque-Bera test; Shapiro-Wilk test, Minimum Absolute Deviation (MAD) estimation; Box-Cox transformations.

Statistical analysis of residuals, OLS residuals, BLUS residual, Studentised residual, Predicted residual, tests against heteroscadasticity.

Unit-IV: Non-Linear regression; Non linear least squares estimation; Maximum Likehoodestimation; Idea of computational methods; Gradient methods, Steepest descent method and Newton-raphson method; testing general Nonlinear hypothesis; Wald test, Lagrange multiplier test and likelihood ratio Test. Robust , probit, binomial logistic ,multiple logistic regression.

References

1. Johnston, J (1984): Econometric Methods, III rd edition. MC Graw Hill.
2. Gujarathi, D (1979): Basic Econometrics, MC Graw Hill.
3. Judge, C.G., Griffiths, R.C.Hill, W.E ., Lutkephol, H and Lee, T.C (1985): The Theory and Practice of Econometrics, John Wiley and Sons.
4. Draper, N and Smith, B (1981): Applied Regression Analysis, Second Edition

Subject Code	Subject Name	Credits Allotted		Total
APST 203(a)	**Linear models and Applied Regression Analysis**	Theory	Practical	4
		4	----	
Course Objective	1. To discuss about linear regression models and their assumptions. 2. To study about different criteria for model selection and their Goodness of fit measures. 3. To explain Non normal disturbances and their consequences and statistical analysis of residuals. 4. To discuss about Non-linear regression estimation methods.			
Course Out comes	1. Students learnt about different linear and non-linear regression models and their appropriate computational procedures. 2. They know R^2, adjusted R^2 and C_p criteria for model selection.			

APST 203(b): 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
APST 203(b)	**Demography and official statistics**	Theory	Practical	4
		4	----	
Course Objective	1. To study about demography and their importance, different reproduction. 2. To explain population Genetics, CSO, NSSO and their scope and contents in population census in India.			
Course Out comes	1. Students know the growth rates, life tables, GRR, NRR and growth models. 2. Students understood about gene frequencies, genotypes, phenotypes etc. 3. Students learnt about population census methods, organizations in India and their functions			

APST 204: PRACTICAL –III

At least 20 practicals covering all papers relating to the subject in this semester must be carried out. (75 marks for practical examination + 15 marks for viva-voce + 10 marks for record in the semester)

Subject Code	Subject Name	Credits Allotted		Total
APST-204	**PRACTICALS**	Theory	Practical	4
		----	4	
Course Objective	1. To exercise different practical problems manually through calculators. 2. To discuss problems relates to semester - II papers.			
Course Out comes	Students know about the solving of Numerical problems related to semester –II. . .			

APST 205 : DESIGN AND ANALYSIS OF EXPERIMENTS

Unit-I: Linear Model; Estimability of linear parametric functions; BLUE, Gauss-Markoff theorem; Generalized Gauss-Markoff theorem, ANOVA model, ANOVA for Two way and three way classifications, ANCOVA technique for one way and two-way classifications. Multiple comparisons tests using Tukey's, Duncans, Sheffe's and Dunnet's tests.

Unit-II: Latin squares and their construction, Mutually orthogonal Latin squares; Missing plot technique in Latin square Design, Graeco-Latin square Design; Analysis of Factorial Experiments involving factors with two and three levels in randomized blocks.

Unit-III: Necessity of confounding, Types of confounding, complete and partial confounding in 2^n, 3^2 and 3^3 factorial designs, Analysis of confounded factorial designs; Fractional Replication, Split Plot design.

Unit-IV: Incomplete Block Designs; B I B D, Inter and Intra Block analysis of a BIBD, Types of BIBD, construction of BIBD's using Mutually orthogonal Latin squares; Concepts of Youden square and lattice Design, Two-Associate PBIB design, Analysis of P B I B design.

References

1. M.N. Das and N.C.Giri (1979), Design and Analysis of Experiments, Wiley, Eastern, Pvt. Ltd., New Delhi.
2. C.D. Montgomery (1976), Design and Analysis of Experiments, Wiley & Sons, New York
3. M.C.Chakbravarthy, (1962), Mathematics of Design of Experiments, Asia Publishing House, Calcutta.
4. Oscar Kempthrone (1974), The Design and Analysis of Experiments, Wiley Eastern, Pvt. Ltd., New Delhi.
5. W.T. Federer (1972), Experimental Designs Theory and Application, Mac Millan Company, New York.
6. Angela Dean and Daniel Ross (1999), Design and Analysis of Experiments, Springer-Verlag.
7. D.D.Joshi (1987), Linear Estimation and Design of Experiments, Wiley Eastern, Pvt. Ltd., New Delhi.
8. P.W.M.John (1971), Statistical Design and Analysis of Experiments, Macmillan
9. F.Pukelshiem (1993), Optimal Design of Experiments, Wiley & Sons
10. D.Raghava Rao (1971), Construction and combinatorial problems in Design of Experiments, Wiley & Sons
11. Aloke Day (1986), Theory of Block Designs, Wiley Eastern, Pvt. Ltd., 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 205</td><td rowspan="2">Design and Analysis of Experiments</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">1. To learn ANOVA and ANCOVA for one and two way classifications analysis and their multiple comparison tests.
2. To explain Latin squares, different types of Latin squares and their missing plots.
3. To discuss on Confounding, their types, confounding 2^n, 3^2 and 3^3 factorial designs etc.
4. To discuss about BIBD, PBIBD construction analysis.</td></tr>
<tr><td>Course Out comes</td><td colspan="4">1. Students learnt ANOVA, ANCOVA technique for one way and two-way classifications. Multiple comparisons tests using Tukey’s, Duncans, Sheffe’s and Dunnet’s tests.
2. Students understood about Latin squares and their construction, missing plot technique etc.
3. Students explained about Incomplete Block Designs and their analysis, etc.</td></tr>
</table>

ST 206 : PRACTICAL-IV

At least 20 practicals covering all papers relating to the subject in this semester must be carried out. (75 marks for practical examination + 15 marks for viva-voce + 10 marks for record in the semester)

Subject Code	Subject Name	Credits Allotted		Total
ST-206	**PRACTICALS**	Theory	Practical	4
		----	4	
Course Objective	1. To exercise different practical problems manually through calculators. 2. To discuss problems relates to semester - II papers.			
Course Out comes	Students know about the solving of Numerical problems related to semester –II. . .			

SEMESTER – III

APST 301: APPLIED ECONOMETRICS

Unit-I: Quick review of inference in classical linear regression model; Estimation and tests of significance of linear and compound growth rates; Incremental analysis; Testing the function form of regression; choosing between linear and log-linear regression models; Likelihood Ratio, Wald and Lagrange Multiplier tests.

Unit-II: Multicollinearity; Sources, consequences and detection of Multicollinearityl Farrar-Glauber test; remedial measures; Heteroscedasticity: Sources and consequences; Tests for Heteroscedasticity; Glejser's test, Goldfield-Quandt test and Breusch-Pagan-Godfrey test; Estimation of parameters under Heteroscedasticity;

Unit-III: Autocorrelation; sources and consequences; first order autoregressive scheme; tests for autocorrelation Durbin-Watson test; Remedies; Estimation of parameters under Autocorrelation; Stochastic Regressors; Errors in variables linear model, IV and ML methods of estimation.

Unit-IV: Finite distributed lag models; Almon's Polynomial approach; Infinite distributed lag models; Geometric lag model; Koyck's approach; IV method; simultaneous linear equations models; Problem of identification; Indirect least squares, LIML, Two stage least squares; three stage least squares and FIML estimation methods.

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. Intrilligator, M.D (1980): Econometric Models, Techniques and Applications, Prentice Hall.

Subject Code	Subject Name	Credits Allotted		Total
APST-301	**APPLIED ECONOMETRICS**	Theory	Practical	4
		4	----	
Course Objective	1. To study about classical linear regression model and their estimation. 2. To discuss about Autocorrelation, different orders of Autocorrelation and their estimation procedures. 3. To explain different lag models and their estimate procedures. 4. To explain about simultaneous linear equations model and their different methods and estimation.			
Course Out comes	1. Students know about heteroscedasticity, multicollinearity and autocorrelation and their estimation procedures. 2. Students understood about different lag models and simultaneous linear equations model with their estimation methods.			

APST 302: APPLIED 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-I1: 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. 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.

Unit-IV: Queuing models-specifications and effectiveness measures. Steady state solutions of M/M/1 and M/M/c models with associated distributions of queue length and waiting time. M/G/1 Queue and Pollazcek Khinchine result. Steady-state solutions of M/Ek/1 and Ek/M/1 queues. Bulk queues.

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.

Subject Code	Subject Name	Credits Allotted		Total
APST-302	**APPLIED OPERATIONS RESEARCH**	Theory	Practical	4
		4	----	
Course Objective	1. To explain different queuing models like M/M/I, M/M/C, M/G/I and bulk queues etc. 2. To learn about Non-linear programming and integer programming and their related problems. 3. To discuss about Network flow charts, CPM and PERT, project management models. 4. To study about Game theory of 2×2, 2×m, m×n and non-zero sum games with their illustrations.			
Course Out comes	1. Students understood about Dual primal, Revised simplex methods. 2. Students gains the knowledge related to non-linear programming, integer programming, CPM, PERT and different models of games.			

APST 303 : PRACTICAL - V

At least 20 practicals covering all papers relating to the subject in this semester must be carried out. (75 marks for practical examination + 25 marks for record in the semester)

Subject Code	Subject Name	Credits Allotted		Total
APST-303	**PRACTICAL-V**	Theory	Practical	4
		----	4	
Course Objective	1. To perform different practical problems manually through calculators and computers. 2. To solve Practical problems related to semester - III papers.			
Course Out comes	Students obtained the solutions related to Numerical problems and also to semester -III theory papers.			

APST 304 (a) : COMPUTER PROGRAMMING AND DATA ANALYSIS

Unit-I: Essentials of R-language – Expressions and objects, assignments, creating vectors, vectorized arithmetic, creating matrices, operations on matrices, lists, data frame creation, indexing, sorting and conditional selection with examples. Programming using conditional statements and loops, data editor, reading data from text files.

Unit-II: Obtaining summary statistics, generating tables, bar plots, pie charts, box plots, histograms. Random sampling from discrete and continuous distributions, plotting density and cumulative density curves, Q-Q plots with suitable examples.

Unit-III: Data Analysis Pak in Excel, descriptive statistics, tests of hypothesis, ANOVA, Correlation and Regression, Random Number Generation from different distributions, Binomial, Poisson, Uniform, Normal and from discrete distributions with given mean and variance. Forecasting Using Excel – Moving Averages and Exponential Smoothing, Use of functions, Linest, Logest, Forecast , Growth, Trend for trend analysis. The use of solver for optimization – Application to LPP.

Unit-IV: Data handling using SPSS: Opening Excel files in SPSS. Merging of files, selection of records, recoding. Analysis tools, descriptive statistics, cross tabs (with stress on procedures and syntax). Post-hoc analysis for multiple comparisons using Tukey's test, Duncan's Multiple Range Test, Dunnet's test and Scheffe's test with interpretation. Selection of variables in Multiple Linear Regression – stepwise procedures and analysis of residuals. Procedure for Binary Logistic regression, Factor analysis, Linear Discriminant analysis and Cluster analysis.

References

1. Introductory Statistics with R by Peter Dalgaard, Springer, 2nd editions, 2008
2. The R book by Micheal J. Crawley, John Wiley and Sons, Ltd, 2007
3. Sarma, K.V.S (2010), Statistics Made Simple, Do it Yourself on PC, Prentice Hall of India.
4. Johnson and Wichern, Multivariate Analysis, Prentice Hall

Subject Code	Subject Name	Credits Allotted		Total
APST-304 (a)	**COMPUTER PROGRAMMING AND DATA ANALYSIS**	Theory	Practical	4
		4	----	
Course Objective	1. To learn various computer languages such as R language, simple programming relating to statistics, different discrete and continuous distributions using R 2. To study Excel analysis pak for t, F, ANOVA etc. with examples 3. To perform SPSS for ANOVA with post hoc analysis, correlation, regression etc. with illustrations.			
Course Out comes	1. Students learnt various softwares such as R, SPSS and Excel pak for statistical tools. 2. Students written programs in R, enter data and analyse using Excel and SPSS			

APST 304 (b) : ADVANCED BIOSTATISTICS

Unit-I: Structure of Biological assay, Direct assays, Potency ratio, Feller's theorem and its generalization. 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-II:: 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-III: 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.

Unit-IV: Statistical Methods in Clinical Trials- phase I, II, III and IV trails. Statistical design for clinical trials- fixed sample trials. Simple randomized design, stratified randomized design, crossover and sequential designs – open and close sequential design. Dynamic randomization, Permuted block randomization; Single, double and triple blinding methods.

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 Genitics Research Technique, Kalyani Publishers, New Delhi.
7. Elisa T. Lee &John Wenyu Wang (2003): Statistical methods for Survival Data analysis, 3rd Edition, John Wiley
8. Jerrold H. Zar (1999): Biostatistical Analysis, 4th edition, Pearson.
9. Armitage, P, Berry G and Mathews J.N.S. (2002): Statistical Methods in Medical Research, 4/e, Blockwell Scientific Publications.
10. Rastogi. V.B. (2006), Fundamental of Biostatistics. ANE Books, India.

Subject Code	Subject Name	Credits Allotted		Total
ST 304 (b)	**ADVANCED BIOSTATISTICS**	Theory	Practical	4
		4	----	
Course Objective	1. To discuss about Clinical trials and their statistical designs. 2. To know the Dose response relationships, their estimation, transformations. 3. To study Geno types and phenol types, Matrix operations to base mattings of single gen cross etc. 4. To estimate Gene frequency using different methods.			
Course Out comes	Students are familiar about Biological assay, their distribution and theorem, dose response relationships, basic concepts of biological assay, estimation methods of gene frequencies.			

APST 304 (c): DATA MINING AND INFORMATION SECURITY

UNIT-I: Data warehousing components: Introduction, Access tools, Data Marts, Data Mining data warehousing, Industry, Methodology. Classical Techniques, Statistics, Neighborhoods, clustering, The classics, Nearest Neighbor, Tree Network and Rules, Neural Network – Rule Induction.

UNIT-II: Basic Data Mining Taks, classification, regression, time series analysis, prediction, clustering, summarization, association rules, sequence discovery. Data mining versus knowledge discovery in data bases. The development of data mining issues. Data mining metrics, social implications of data mining, data mining from a data base perspective. Exploratory Data Analysis.

UNIT-III: Security Trends-The OSI architecture-Security Attacks-Security Services – Security Mechanisms- A Model for Network Security Classical Encryption Techniques, Symmetric Cipher Model, Substitution Techniques Transportation Techniques, Rotor Machines –Steganography. Public-Key Encryption and Hash Functions Introduction to Number Theory Prime Numbers – Fermat's and Euler's Theorems, Testing for Primality – The Chinese Remainder Theorem, Discrete Logarithms.

UNIT-IV: Public-key Cryptography and RSA: Principles of Public-Key Cryptosystems, The RSA Algorithm, Digital Signatures and Authentication Protocols**:** Digital Signatures, Authentication Protocols-Digital Signature Standard Authentication Applications **:** Kerberos-X.509 Authentication Service, Public Key Infrastructure .

References

1. Margaret H. Dunham (2006), Data Mining – Introductory and Advanced Topics, Pearson Education.
2. Tukey, (1997), Exploratory Data Analysis
3. Cleveland, (1993), Visualizing Data
4. Tufte, (1983), Visual Display of Quantitative Information Anything on statistics by Jacob Cohen or Paul Meehl.
5. Cryptography and Network Security Principles and Practices – Fourth Edition –By William Stallings- Pearson Prentice Hall Publishers.

Subject Code	Subject Name	Credits Allotted		Total
APST 304 (c)	**DATA MINING AND INFORMATION SECURITY**	Theory	Practical	4
		4	----	
Course Objective	1. To explain about Data mining tools and their classifies 2. To learn Data mining techniques for data analysis 3. To study Security services, cryptography, algorithms and some applications			
Course Out comes	Students learnt about data mining techniques, trees, security trends, different statistical techniques with illustrations and proto calls etc.			

APST 305 : PRACTICAL - VI

At least 20 practicals covering all papers relating to the subject in this semester must be carried out. (75 marks for practical examination + 25 marks for record in the semester)

<table>
<tr><td>Subject Code</td><td>Subject Name</td><td colspan="2">Credits Allotted</td><td>Total</td></tr>
<tr><td rowspan="2">APST-305</td><td rowspan="2">PRACTICAL-VI</td><td>Theory</td><td>Practical</td><td rowspan="2">4</td></tr>
<tr><td>----</td><td>4</td></tr>
<tr><td>Course Objective</td><td colspan="4">1. To perform different practical problems manually through calculators and computers.
2. To solve Practical problems related to semester - III papers.</td></tr>
<tr><td>Course Out comes</td><td colspan="4">Students obtained the solutions related to Numerical problems and also to semester -III theory papers.</td></tr>
</table>

APST 306 (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 Analysia, Third edition, Prentice Hall of India, New Delhi.
6. Federer, W.T.(1969), Experimental Designs and its appliucations.

<table>
<tr><td>Subject Code</td><td>Subject Name</td><td colspan="2">Credits Allotted</td><td>Total</td></tr>
<tr><td rowspan="2">APST 306 (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">1. To learn about basic statistics and their worked out examples.
2. To study Different tests such as t, F, χ^2 and Z fro means, proportions, variances, standard deviation etc. with illustrations.
3. To study ANOVA and ANCOVA for one way and two way classification and their importance in analysis
4. To discuss Special statistical tools and multivariate analysis.</td></tr>
<tr><td>Course Out comes</td><td colspan="4">1. Students learnt about Graphs, measures of averages, measures of dispersion etc.
2. Students studied Basic probability and important distributions with workout examples.
3. Students performed t, F, χ^2, ANOVA and ANCOVA and non-parametric tests with examples.
4. Students studied Advanced statistics tools with illustrations.</td></tr>
</table>

APST 306 (b): STATISTICS FOR SOCIAL AND BEHAVIOURAL SCIENCES

Unit- I: Statistical Measures: Measures of central tendency: Arithmetic Mean, Median and Mode; Measures of Variation: Range, Quartile Deviation, Standard Deviation, Coefficient of Variation, Measures of Skewness.

Unit- II: Probability and Distributions: Concept of Probability, Laws of Probability (statements only); Random Variable; Probability Distributions: Binomial, Poisson and Normal distributions (properties and applications).

Unit- III: Tests of Significance: Basic concepts; Random sampling techniques; Standard error of statistic; Large sample tests for proportions and means; Small sample tests: Applications of t, χ^2 and F tests; Analysis of Variance (ANOVA) and Analysis of Covariance (ANCOVA) techniques for one way and two way classifications (single observation per cell); Nonparametric tests: Wilcoxon Signed Rank test, Median test and Mann-Whitney U-test.

Unit- IV: Special statistical tools: Computation of Linear and Compound Growth rates and their tests of significance; Chow test for Structural change; Granger Causality test; Stepwise regression; R^2 and $\overline{R}^2$ statistics; Multiple Range tests: LSD. test and Duncan's test: ANOVA for Ranked data; Krushkal-wallis test, Friedman test; Elements of Factor analysis and Discriminant analysis.

References

1. Gupta, S.C.(1997), Fundamentals of Statistics, Himalayan Publishers, Mumbai.
2. Kshirasagar, A.M. (1972), Multivariate Analysis, Marcel Decker, New York.
3. Gujarati, D.(1995), Basic Econometrics, Mc Graw Hill.
4. Ferguson, C.A.(1971), Statistical Analysis in Psychology and Education, McGraw Hill.
5. Johnson, R.A., and Wichern, D.W. (2001), Applied Multivariate Statistical Analysis, Third Edition, Prentice-Hall of India (p) Ltd.,. New Delhi.

Subject Code	Subject Name	Credits Allotted		Total
ST 306 (b)	**Statistics for social and behavioural sciences**	Theory	Practical	4
		4	----	
Course Objective	1. To learn Basic statistics measures with examples 2. To discuss about important concepts, probability distributions like Binomial, Poisson and Normal properties and applications 3. To perform Parametric and non-parametric test with illustrations. 4. To study advanced statistical tools with examples.			
Course Out comes	1. Students learnt Graphs, measures of averages, measures of dispersion etc. 2. Students understood about Basic probability and important distributions and studied with workout examples. 3. Students performed t, F, χ^2, ANOVA and ANCOVA and non-parametric tests and discussed with examples. 4. Students learnt about Advanced statistics tools with working illustrations			

SEMESTER – IV

APST 401: APPLIED FORECASTING METHODS

Unit-I: 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-II: Exponential smoothing methods: trend adjusted exponential smoothing, double and triple exponential smoothing, winten'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-III: Auto regressive series, yules series, markoff series, deseasonalisting and detrending an observed time series, auto-covariance, Auto Correlation Function(ACF),Partial Auto Correlation Function(PACF) and their properties, conditions for stationary and invertibility. Period gram and correlogram analysis.

Unit-IV: Box-Jenkin's time series methods: Moving average , Autoregressive , ARMA and 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 relation for outline.

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
APST401	**APPLIED FORECASTING METHODS**	Theory	Practical	4
		4	----	
Course Objective	1. To fit growth curves, measurement of cyclical and irregular component with simple examples. 2. To discuss Single, Double, Triple, adoptive exponential smoothing models and its importance. 3. To explain Auto correlation functions and their properties. 4. To discuss about Box Jenkins time series models and their estimation of parameters, fitting and diagnostic checking.			
Course Out comes	1. Students understood Time series analysis with some important growth models and their fitting 2. Students forecasting using regression, non-linear regression techniques, single, double, triple and adoptive exponential smoothing models. 3. Students obtained knowledge on AR, MA, ARMA, ARIMA, models fitting, diagnostic checking, etc.			

APST 402: RELIABILITY AND SURVIVAL ANALYSIS

Unit-I: Reliability: Concept and Measures of Reliability, bath tub curve, Reliability and failure density in terms of hazard rate; Hazard models, System Reliability Models: Reliability of Series and parallel systems, Mixed configuration models, Non-series-parallel systems; r-out of n- systems, Fault tree analysis.

Unit-II: Reliability improvement methods: Redundancy, element, unit and stand by redundancies; Maintainability and availability; Reliability allocation; Life testing and Reliability estimation; Exponential failure model, Normal, Gamma and weibull distributions and their applications in reliability estimation.

Unit-III: Functions of Survival time: Definitions, Relationships of Survival Functions; Non-parametric Methods of Estimating Survival Functions: Kaplan Meier Product limit Estimate; Non-parametric methods for comparing two survival distributions: Gehan's generalized wilcoxon test, Cox-Mantel test, log rank test, Peto and peto's generalized wilcoxon test, Cox's F test and Mantel-Haenszel test.

Unit-IV: Graphical Methods for survival distributions fitting: Probability plotting, hazard plotting methods, testing of goodness of fit; Analytical Estimation Procedures for Survival distributions: Exponential, Weibull, Lognormal and Gamma Distributions only; Regression method for fitting Survival distributions; Parametric methods for comparing two survival distributions: Exponential, Weibull and Gamma Distributions only; Non-parametric and Parametric methods for identification of Prognostic factor relating survival time

References

1. L.S. Srinath (1998): Reliability Engineering, Applied East west Press PVT Ltd., New Delhi.

2. E. Balaguruswamy (1984): Reliability Engineering, Tata MC Graw Hill publishing company, New Delhi.

3. S.K. Sinha and B.K. Kale (1980): Life Testing and reliability Estimation, Wiley Eastern Ltd, New Delhi.

4. S.K. Sinha (1986): Reliability and Life Testing, Wiley Eastern Ltd, New Delhi.

5. Elisa T.Lee (1992), Statistical methods for survival data analysis, John Wiley sons.

6. Miller, R.G (1981), Survival Analysis, John Wiley

7. Cross A.J and Clark, V.A (1975), Survival distribution, reliability applications in the biomedical sciences, John Wiley and sons.

8. Elandt Johnson, R.E., Johnson, N.L.,(1999), Survival Models and Data Analysis, John Wiley and sons

<table>
<tr><td>Subject Code</td><td>Subject Name</td><td colspan="2">Credits Allotted</td><td>Total</td></tr>
<tr><td rowspan="2">APST402</td><td rowspan="2">RELIABILITY AND SURVIVAL ANALYSIS</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">1. To discuss about reliability and their measures, analysis mixed configuration, series and parallel systems with examples.
2. To explain Redundancy for unit, element and stand by with simple applications.
3. To discuss Distributions for life testing and reliability estimation with their applications.
4. To understand Survival functions, survival distributions and fittings.</td></tr>
<tr><td>Course Out comes</td><td colspan="4">Students learnt about and survival analysis with their related distributions, relationships, non-parametric methods for computing survival analysis.
.</td></tr>
</table>

APST 403 : PRACTICALS - VII

At least 20 practicals covering all papers relating to the subject in this semester must be carried out. (75 marks for practical examination + 15 marks for viva-voce + 10 marks for record in the semester)

<table>
<tr><td>Subject Code</td><td>Subject Name</td><td colspan="2">Credits Allotted</td><td>Total</td></tr>
<tr><td rowspan="2">APST 403</td><td rowspan="2">PRACTICAL –VII</td><td>Theory</td><td>Practical</td><td rowspan="2">4</td></tr>
<tr><td>-----</td><td>4</td></tr>
<tr><td>Course Objective</td><td colspan="4">1. To solve different practical problems manually through calculators and computers.

2. To do Practical problems related to semester - VII papers.</td></tr>
<tr><td>Course Out comes</td><td colspan="4">Students solved Numerical problems related to semester –IV theory papers .
.</td></tr>
</table>

APST 404 (a) : STATISTICAL QUALITY CONTROL

Unit-I: Basic concepts of quality, causes of variation, principle of Shewart's control chart, control charts for attributes and variables. Control limits and probability limits. Process monitoring and control, process capability, modified control chart. Capability indices C_p, C_{pk}, and C_{pm}. Concept of Six sigma and its relationship with process capability.

Unit-II: The OC and ARL of Shewart's control charts. Control by gauging, Moving Average and Exponentially Weighted Moving Average charts. CUSUM charts using V-mask and decision interval methods. Multivariate control charts – Control Ellipsoid, Hotelling's T^2 chart.

Unit-III: Acceptance sampling plans for attribute inspection – Type-A and Type-B OC curves. Single, double and sequential sampling plans and their properties. Sampling plans with rectifying inspection-concept of AOQ, AOQL. Construction of Dodge CSP-1, CSP-2 and Multi level plans and their properties. Chain sampling and its applications. Design of Skip lot sampling plan and its ASN.

Unit-IV: Total Quality Management - Quality as a corporate strategy, six magnificent tools of process control, quality planning, costs of quality, analysis of quality costs, Zero Defects programme, quality circles, ISO 9000 and its modifications. Taguchi's contributions to Quality Engineering.

References

1. Montgomery D.C (2009), Introduction to Statistical Quality Control, 6/e, John Wiley and Sons, New York.
2. Edward G. Schilling, Dean V. Neubauer, (2009), Acceptance sampling in quality control Second Edition, Taylor & Francis.
3. Mittage, H.J and Rinne, H (1993): Statistical Methods of Quality Assurance, Chapmann Hall, London, UK.
4. Ott. E.R (1975), Process Quality Control, Mc Graw Hill
5. Phadke, M.S (1989), Quality Engineering through Robust Design, Prentice Hall
6. Duncan, A.J (1974), Quality Control and Industrial Statistics, 3rd Ed., New York, Irwin.
7. Philip J. Ross (1989), Taguchi techniques for quality engineering, McGraw Hill

Subject Code	Subject Name	Credits Allotted		Total
APST 404(a)	**Statistical Quality Control**	Theory	Practical	4
		4	----	
Course Objective	1. To discuss the basic concepts of control charts for variables and their indices. 2. To explain different control charts like Shewart's moving average, multivariate etc. with their applications. 3. To understand different sequential sampling plans and six sigma tool etc. with their properties and applications.			
Course Out comes	1. Students with their knowledge in C and C++ programming languages, MS-Excel for statistical distributions, charts and matrix operations are done individually. 2. They used MS-Access for tables and forms and their SQL codes.			

APST 404(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.
5. Taha, H.A. (1992), Operations Research, An Introduction, Fourth Edition,

<table>
<tr><td>Subject Code</td><td>Subject Name</td><td colspan="2">Credits Allotted</td><td>Total</td></tr>
<tr><td rowspan="2">APST 404(b)</td><td rowspan="2">STATISTICS FOR RESEARCH, INDUSTRY AND COMMUNITYDEVELOPMENT</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">1. To understand Response surface models, stepwise, partially linear and non-parametric regression models with their applications.
2. To discuss Simulation models, demand analysis and their related tools
3. To explain Social server, steps in social server measurements with examples.</td></tr>
<tr><td>Course Out comes</td><td colspan="4">Students have done Simulation models, response surface models, demand analysis, social survey and their related measures.</td></tr>
</table>

APST404 (c): ACTUARIAL STATISTICS

Unit I : Basic deterministic model: Cash flows, discount function, interest and discount rates, balances and reserves, internal rate of return, The life table: Basic definitions, probabilities, construction of life tables, life expectancy, Life annuities: Introduction, calculating annuity premium, interest and survivorship discount function, guaranteed payments, deferred annuities.

Unit II : Life insurance: Introduction, calculation of life insurance premiums, types of life insurance, combined benefits, insurances viewed as annuities, Insurance and annuity reserves: The general pattern reserves, recursion, detailed analysis of an insurance, bases for reserves, non forfeiture values, policies involving a return of the reserve, premium difference and paid-up formula.

Unit III : Fractional durations: Life annuities paid monthly, immediate annuities, fractional period premium and reserves, reserves at fractional durations, Continuous payments: Continuous annuities, force of discount, force of mortality, Insurance payable at the moment of death, premiums and reserves. The general insurance – annuity identity, Select morality: Select an ultimate tables, Changed in formulas.

Unit IV : Multiple life contracts: Joint life status, joint annuities and insurances, last survivor annuities and insurances, moment of death insurances. The general two life annuity and insurance contracts, contingent insurances

Reference

1. Neill, A. (1977) Life contingencies, Heinemann, London.
2. Newton L. Bowers, Jr, Hans U. Gerber, James C. Hickmann, Donald A. Jones and Cecil J. Nesbitt (1997) Actuarial Mathematics, The Society of Actuaries.
3. King, G. Institute of Actuaries Text Book. Part 11, Second edition, Charles and Edwin Layton, London.
4. Donald D.W.A. (1970) Compound Interest and Annuities, Heinemann, London.
5. Jordan, C.W. Jr. (1967) Life Contingencies, Second edition, Chicago Society Actuaries
6. Hooker, P.F. and Longley Cook, L.W. (1953) Life and other Contingencies, Volume I and Volume II (1957) Cambridge University Press.
7. Spurgeon, E.T. (1972), Life Contingencies, Third edition, Cambridge University Press.

Subject Code	Subject Name	Credits Allotted		Total
APST404 (c)	**ACTUARIAL STATISTICS**	Theory	Practical	4
		4	----	
Course Objective	1. To discuss Basic deterministic model and Life annuities information. 2. To understand Life insurance importance and related information. 3. To explain Fractional durations and Multiple life contracts and their information.			
Course Out comes	Students understood about Life annuities, Insurance and annuity reserves, Continuous annuities, the general two life annuity and insurance contracts, contingent insurances etc.			

APST 405: STUDENT PROJECT

Data Centre / Institutions / Companies and etc.,

<table>
<tr><td>Subject Code</td><td>Subject Name</td><td colspan="2">Credits Allotted</td><td>Total</td></tr>
<tr><td rowspan="2">APST 405</td><td rowspan="2">STUDENT PROJECT</td><td>Theory</td><td>Practical</td><td rowspan="2">4</td></tr>
<tr><td>Dissertation submission 4</td><td>----</td></tr>
<tr><td>Course Objective</td><td colspan="4">1. To take primary data from industry, institutions, etc. for analysis.
2. To collect data through internet or any records called secondary data for analysis.</td></tr>
<tr><td>Course Out comes</td><td colspan="4">3. Students collected the primary data or secondary data and questioner preparation, data entry in particular software, analysis and interpretation and submitted in the form of a report.</td></tr>
</table>

APST 406 (a) : STATISTICS FOR MARKETING RESEARCH

UNIT-I: RESEARCH METHODOLOGY: Types of Research; Hypotheses; Research Design; Collection of Data; Marketing Surveys; Sampling Techniques; Research Tools: Scaling Techniques; Problems in Marketing Research; Case study Method; Preparation of Research Report.

UNIT-II: STATISTICS FOR MARKETING: Statistical Measures: Mean, Median and Mode; Standard Deviation and Coefficient of Variation; Correlation and Regression analysis; Multiple correlation and Regression; Coefficient of Association; Linear and Compound growth rates.

UNIT-III: MARKETING INFERENTIAL TECHNIQUES: Elements of probability; Concepts of Binomial, Poisson and Normal distributions; Tests of Significance: z, t, χ^2 and F tests, ANOVA Technique; Non parametric Tests; Components of Experimental Designs: CRD, RBD and LSD.

UNIT-IV: ADVANCED STATISTICS FOR MARKETING: Basic Time Series and Forecasting Methods; Determination of Trend; Process and Product control; control charts$\bar{X}$,R, p, npand c-charts; Operation Research Techniques: Linear Programming Problem-Graphical Method, concept of PERT, CPM; Concepts of Multivariate Statistical Techniques: Factor Analysis, Discriminant Analysis, Cluster Analysis, Computer Applications to Marketing Research.

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

Subject Code	Subject Name	Credits Allotted		Total
APST 406(a)	**STATISTICS FOR MARKETING RESEARCH**	Theory	Practical	4
		4	----	
Course Objective	1. To give introduction about Research Design and Statistics for Research. 2. To discuss on different Statistical measures like measures of central tendency, measures of dispersion etc. 3. To explain univariate and multivariate statistical techniques with simple applications.			
Course Out comes	1. Students learnt about Research design and how to frame questionnaire etc. 2. Statistics relating to research like univaraite test like Z, t, F, ANOVA, CRD, RBD and LSD are done. 3. Multivariate statistical techniques like factor analysis, dissemination analysis and cluster analysis are used.			

APST 406(b) : STATISTICAL ANALYSIS USING SPSS

Unit-I: Introduction to SPSS, Different Menu's in SPSS, creating a data file, opening excel files, variables and labels, selecting cases by filtering, recoding of data, merging of files,

Unit-II : Sorting of Cases and Variable, SPSS Output and its transfer to excel and word. Analysis categorical data- Scales of Measurements, Data reliability-test rest method, Cronbach's alpha.

Unit-III : Analysis tools – frequency tables, descriptive, cross tabulations, chi square tests. Compare-Means, ANOVA, Independent Sample t-test, Paired Sample t-test, One-way ANOVA.

Unit-IV: General Linear Model - Univariate, Multivariate, Repeated Measures. Correlation – Simple and Partial, Multiple Linear Regression-Selection variables into the model-Stepwise Multiple Linear Regression.

References

1. Statistics Made Simple-Do it Yourself on PC by K.V.S. Sarma
2. A Handbook of Statistical Analyses using SPSS-Sabine Landau and Brian S. Everitt
3. SPSS for Beginners -Vijay Gupta

Subject Code	Subject Name	Credits Allotted		Total
APST 406 (b)	**Statistical analysis using SPSS**	Theory	Practical	4
		4	----	
Course Objective	1. To understand SPSS software data entry, import and export of data 2. To use Statistical analysis tools using SPSS 3. To explain Bivariate, Multivariate statistics measures using SPSS .			
Course Out comes	Students obtained knowledge about enter the data and analyzed the data using SPSS software.			