Annexure C

FIRST SEMESTER

DETAILED SYLLABUS

Course No. PSSSTC 101 **Title: Real Analysis**

Credits: 4

Syllabus for the examinations to be held in December 2014, 2015 and 2016.

OBJECTIVES: This course introduces the students to concepts of Real Analysis.

Unit I

Introduction to Real number system, introduction to n-dimensional Euclidean space: Limit Points of a set, open sets, closed sets etc. (will be developed through general metric space and R^n will be considered as a special case, Compact sets, Bolzano-Weirsstrass theorem, Heine-Borel Theorem.

Unit II

Sequences and Series of real numbers, limit superior, limit inferior and limit of a sequence, their convergence, Cauchy sequence, Convergence of series, tests for convergence for series, absolute convergence, Cauchy products.

Unit III

Uniform convergence of sequences and series, Stone-Weirstrass theorem, power series, Fourier Series, Mean Value Theorem, Inverse function theorem, Implicit function theorem.

Unit IV

Improper integrals of first and second kind for one variable. Uniform convergence of improper integrals, differentiation under the sign of integral, Leibnitz rule, multiple integrals and their evaluation by repeated integration.

Books Recommended

1. Apostol, T.M. (1985): Mathematical Analysis, Narosa, Indian Edition.
2. Courant, R- and John F, (1965): Introduction to calculus and Analysis Wiley.
3. Miller, K.S (1957): Advanced Real calculus, Harper, New York.
4. Rudin, Walter (1976): Principles of Mathematical Analysis, McGraw.
5. Bartle, R.G (1976): Elements of Real Analysis (Wiley)

Course No. PSSSTC 102 **Title : Linear Algebra**

Credits: 4

OBJECTIVES: This course introduces the students to concepts of Linear Algebra.

Syllabus for the examinations to be held in December 2014, 2015 and 2016.

Unit I

Algebra of matrices, elementary matrices, linear transformations, row and column spaces of a matrix, rank and inverse of a matrix, null space and nullity, partitioned matrices, Kronecker product, fields, vector spaces, sub spaces, linear dependence and independence, basis and dimension of a vector space, finite, dimensional vector spaces, completion theorem, examples of vector spaces over real and complex fields.

Unit II

Vector spaces with an inner product, Gram-Schmidt Orthognalization process, Hermite canonical form, generalized inverse, Moore Penrose generalized inverse, left weak and right weak g-inverses, Idempotent matrices, solution of matrix equations. Gauss elimination method, triangulation method, Jacobin method and Gauss- Siedul iterative method.

Unit III

Real quadratic forms, reduction and classification of quadratic forms, index and signature, triangular reduction of a positive definite matrix, characteristic roots and vectors, Cayley-Hamilton theorem, similar matrices, Hermitian quadratic forms.

Unit IV

Algebraic and geometric multiplicity of a characteristic root, spectral decomposition of a real symmetric matrices, reduction of a pair of real symmetric matrices, singular values and singular value decomposition, vector and matrix differentiation.

Books Recommended:

1. Graybill, F.A (1983): Matrices with applications in Statistics, 2nd Edition Wadsworth.
2. Rao, C. R. (1973): Linear Statistical Inference and its Applications, 2nd Edition John wiley and Sons, Inc.
3. Searle, S.R. (1982): Matrix Algebra Useful for Statistics, John Wiley and Sons Inc.

Add References

1. Bellman, R. (170): Introduction to matrix Analysis 2nd Edition. Mc Graw Hill.
2. Biswas, S. (1984): Topics in Algebra of matrices Academic publications.
3. Hadley, G. (1987): Linear Algebra, Narosa Publishing House.
4. Halmos, P.R.(1958): Finite Dimensional Vector Spaces 2nd Edition D. Van Nostrand Company, Inc.

Course No. PSSSTC103 **Title: Distribution Theory**

Syllabus for the examinations to be held in December 2014, 2015 and 2016.

OBJECTIVES : The objectives of this course is to make the students familiar with Distribution Theory.

Unit-I

Review of random variable and basic distribution theory. Joint, marginal and conditional p.m.fs. and p.d.fs. Functions of random variable and their distribution using Jacobean transformation and other tools, Standard discrete distributions viz., Binomial, Poisson, Rectangular, Negative binomial, Hyper Geometric.

Unit II

Standard continuous distributions viz., Normal, Uniform, Cauchy, Beta, Gamma, Log normal, Exponential, Bivariate normal, Bivariate Exponential (Laplace); Order statistics and their distribution, Joint and marginal distributions of order statistics, Distribution of median and range

Unit III

Introduction to special distributions: Degenerate, Two-point, negative Hypergeometric, Multinomial, Pareto, Logistic, Weibul and Rayleigh distributions. Conditional expectations, Simple, partial and multiple correlations, linear and multiple regression.

Unit IV

Compound, truncated and mixture distributions, Sampling distributions, Central and Non-central Chi-square, t-and F- distributions and their properties, Chebyshevs, Markov, Holder, Jensen and Lyapunov inequalities.

Books Recommended:

1. Fisz: Theory and Mathematical Statistics.
2. Rohtagi, V.K & Ehsanes Saleh,A.K.: Statistics. Wiley — An Introduction to Probability Theory and Mathematical Series.
3. Kendall, M.G., Stuart, A: The Advanced Theory of Statistics: Distribution Theory. Vol. 1
4. Johnson and Kotz: Continous Univariate Distributons, vol 1 and vol. 2 Wiley.
5. Rohtagi, V.K.: An Introduction to Probability Theory and Mathematical Statistics.

Course No. PSSSTC 104 **Title: Sample Surveys**

Syllabus for the examinations to be held in December 2014, 2015 and 2016.

OBJECTIVES : The objectives of this course is to make the students familiar with various sampling methods.

Unit I

Estimation of sample size, Stratified random sampling, different methods of allocation, relative precision of stratified random sampling with S.R.S., formation and construction of strata, Post Stratification and Deep Stratification.

Unit-II

Systematic sampling, estimation of mean and sampling variance, comparison of systematic sampling with stratified and S.R.S., interpenetrating systematic sampling, Varying probability sampling methods of selecting sample with p.p.s, p.p.s, sampling W.R., efficiency of p.p.s. sampling. PPS WOR, H.T. estimator, Des Raj Sampling strategy, Murthy estimator, Sen-Midzuno method.

Unit-III

Ratio estimator, bias and mean square error, estimation of variance, comparison with SRS, ratio estimator in stratified sampling, unbiased type ratio estimators Difference estimator, regression estimator, comparison of regression estimator with SRS and ratio estimator, Cluster sampling with equal and unequal cluster sizes, relative efficiency with SRS and optimum cluster size.

Unit-IV

Two stage sampling with equal and unequal s.s.u's, estimation of mean and sampling variance. Successive sampling, sampling on two occasions. Randomized response Technique.

Books Recommended:

1. W.G. Cochran : Sampling techniques.
2. M.N. Murthy : Sampling Theory and Methods.
3. Des Raj : Sampling Theory.
4. P. Mukhopadhayay : Theory and methods of survey sampling.
5. D.Singh and F.S Chaudhary Theory and Analysis of sample Survey Designs.

Course No. PSSSPC 105 **Title: Software Lab-I**

Objectives: To make students familiar with the compilation and Statistical analysis of data using Statistical Software

Syllabus: Based on the Descriptive and inductive statistics

Course No. PSSSPC 106 **Title: Practical (Linear Algebra)**

Objectives: To make students familiar with the computation work based on Course No. PSSSTC 102.

Syllabus: Based on the Course PSSSTC 102 covering the following:

Topic	No. of Practicals
Algebra of matrixes and vector space	7
G-inverse, matrix equations and Gram-Schmidt Processes	10
Quadratic forms and characteristic roots and vectors	7
Total	**24**

Annexure D

SECOND SEMESTER

Course No. PSSSTC 201 **Title : Probability Theory**

Syllabus for the examinations to be held in May 2015, 2016 and 2017.

OBJECTIVES: This course introduces the students to concepts of Probability and Measure Theory.

Unit I

Fields, sigma minimal sigma field, sigma-field generated by a class of subsets, Borel fields. Sequence of sets, limsup and liminf of sequence of sets, Measure, probability measure, properties of a measure, Continuity theorem of measure, Caratheodory extension theorem (statement only), Idea of Lebesgue and Lebesgue-Steiltjes measure, Signed measure, Jordan-Hahn decomposition theorem.

Unit II

Measurable functions, integration of a measurable function with respect to a measure, Monotone convergence theorem, Fatou's lemma, dominated convergence theorem, Radon Nikodym Theorem, Product measure, Fubini's Theorem, Borel Cantelli Lemma, Zero-One Laws of Borel and Kolmogrov.

Unit III

Convergence of a sequence of r.v.s, Almost sure convergence, convergence in probability, convergence in distribution, weak law and strong law of large numbers of sequences, Convergence of series of random variables, Three series criterion, Martingales.

Unit IV

Characteristic functions, and their simple properties, Parseval relation, Uniqueness theorem, Inversion theorem, Levy's continuity theorem (statement only), CLT for lid random variables. CLT for a sequence of independent random variables under Lindeberg's condition, statements of Liapounov and Lindberg-Feller theorems.

Books Recommended

1. Ash, Robert (1972) Red Analysis and Probability, Academic Press.
2. Billinsley P. (1986) Probability and measure, Wiley.
3. Dubey, R.M. (1086) Real Analysis and Probability, Wadsworth and Brooks/cole.
4. Kingman JFC and Taylor SJ (1966) Introduction to measure and probability. Cambridge University press.
5. B R Bhat (1985) Modern Probability Theory
6. Basu, A.K. (2001) Probability and Measure theory, Narosa Pub.

7. Laha, R.G and Rohtagi, V K (1997) Probability theory, John Wiley
8. Rohtagi, V K and Saleh A K (2005) Probability Theory, John Wiley
9. Chung, K L (2001) A Course in Probability Theory, Academic Press
10 Feller, W. (1969) Introduction to Probability and its Application Vol. II (Wiley Eastern Ltd.)
11. Loeve, M. (1978). Probability theory (4^{th} edn) (Springer Verlag)
12. Gnedenko, B.V(1988) Probability Theory (Mir. Pub.)

Course No. PSSSTC 202 **Title : Design and Analysis of Experiments**

Syllabus for the examinations to be held in May 2015, 2016, and 2017

OBJECTIVES : The aim of this course is to provide the knowledge of Design and Analysis of Experiments.

Unit I

Introduction to Design Experiments: General Block Design and its information matrix (c), Criteria for connectedness, balance and orthogonolity, intrablock analysis (estimability), best point estimates/interval estimates of estimable linear parametric functions and testing of linear hypothesis). Fixed mixed and random effects models, variance components estimation, study of various methods.

Unit II

Missing plot techniques in RBD and LSD, Symmetrical Factorial experiments with factors at two and three levels (2^n, 3^2, 3^3), Confounding-Total and Partial in factorial experiments, Split plot Design.

Unit III

Incomplete and Balanced incomplete block designs, Lattice and Youden squares, partially balanced incomplete block design and its analysis.

Unit IV

Analysis of Covariance in RBD, LSD and CRD, Analysis of Covariance in Non-orthogonal Data in two way classification, Covariance and Analysis of experiments with missing observation.

BOOKS RECOMMENDED:

1. D.D. Joshi : Linear Estimation and Design of Experiments.
2. O. Kempthorne Design and Analysis of Experiments.
3. Das and Giri Design and Analysis of Experiment.
4. Cochran and Cox Design of Experiments.
5. Aloke Dey (1986): Theory of Block Designs, Wiley Eastern.
6. Giri, M.N and Giri N (1979) Design and Analysis of Experiments, Wiley Eastern.
7. Montogomery C.D (1976) Design and Analysis of Experiments, Wiley, New York
8. Rao, C.R. and Kleffe J. (1988) Estimation of Variance Components and applications,
9. Searle, S.R. Casella G. and McCulloch, C.E (1992) Variance Components, Wiley.

Course No. PSSC 203 **Title : Inference-I**

Syllabus for the examinations to be held in May 2015, 2016 and 2017

OBJECTIVES : The aim of this course is to provide the knowledge of Inference to the students.

Unit I

Introduction to estimation; unbiasedness, consistency, sufficiency and Minimal sufficiency, CAN estimators, Mean Square Error, Completeness and Bounded completeness, Factorization Criterion, Finite and asymptotic efficiency.

Unit II

UMVUE, Cramer-Rao inequality, Chapman-Robbins-Keifer lower bound, Rao-Blackwell Theorem, Lehmann Scheffe Theorem, Exponential and Pitman families

Methods of Estimation: Maximum Likelihood method, methods of moments and percentiles.

Unit III

Testing of hypothesis; Basic concepts, randomized and nonrandomized test procedures, Neyman-Pearson Lemma, Families with MLR property, Examples of UMP unbiased tests for two sided hypothesis (Only for exponential families), Wald's SPRT, Likelihood ratio test and its properties (without proof) and applications to normal distribution.

Unit IV

U- Statistics, its definition, properties as an estimator of its expectation, One-Sample and 2-Sample non parametric tests for Location (only standard test), Non parametric confidence intervals for percentiles, Interval estimation, confidence level, construction of confidence, intervals using pivots, shortest expected length confidence interval.

Books Recommended

1. Kale, B.K (1999): A first course a Parametric Inference, Narosa Publishing House.
2. Rohtagi, V.K. (1988): An introduction to probability and Mathematics Statistics, Wiley Eastern Ltd. New Delhi (Student Edition)
3. Fergusan T.S. (1967) Mathematical Statistics, Academic Press.
4. Zacks, S. (1971): Theory of Statistical Inference, John Wiley and sons, New York.
5. Lehman, E.L. (1988)- Theory of Point Estimation.
6. Lehman , E.L. (1988)- Testing Statistical Hypothesis.
7. Rao, C.R. (1973): Linear Statistical Inference.

Course No. PSSSTC 204 **Title : Multivariate Analysis**

Syllabus for the examinations to be held in May 2015, 2016 and 2017

OBJECTIVES : The aim of this course is to provide the knowledge of Multivariate Analysis to the students.

Unit I

Multivariate normal distribution, Maximum likelihood estimates of mean vector and dispersion matrix, Distribution of sample mean vector, Wishart matrix-its distribution and properties, Null distribution of simple, partial and multiple correlation coefficients and their testing of significance.

Unit II

Hotelling's T^2 statistic-its distribution and application in testing of mean vector for one and more multivariate normal populations, Mahalonobis D2 staistics and its application. Problem of classification, probabilities of misclassification and their estimation, classification into more than two multivariate normal populations, Discrimination procedures for discriminating between two multivariate populations-sample discriminant function.

Unit III

Multivariate linear regression model-estimation of parameters, Distribution of sample regression coefficients, tests of linear hypothesis about regression coefficients, Multivariate Analysis of Variance (MANOVA) of one and two way classified data.

Unit IV

Principal Components Analysis, Factor Analysis Canonical variates and canonical correlations.

Books Recommended

1. Anderson, T.W: An introduction to Multivariate Statistical Analysis.
2. Morrison, D.F.: Multivariate Analysis.
3. Johnson, R. and Wychern: Applied Multivariate Statistical Analysis.
4. Jobson, D.B.: Applied Multivariate Analysis.

Course No. PSSSPC 205 **Title: Practical (Design of Experiments)**

Objective: To make students familiar with the computation work based on Course No. PSSSTC 202

Course No. PSSSPC 206 **Title: Practical (Multivariate Analysis)**

Objective: To make students familiar with the computation work based on Course No. PSSSTC 204

Further, each student will have to submit a small project on application of any multivariate Analysis using statistical software.

Annexure I

Semester III

Syllabus for the examinations to be held in December 2015, 2016 and 2017

PSSSTC 301: Linear Models & Regression Analysis **4 Credits**

OBJECTIVES: The aim of this course to provide the knowledge of Linear Models and Regression analysis.

Unit I

Gauss-Markov set-up, Normal equations and Least squares estimates, Error and estimation spaces, variances and covariances of least squares estimates, estimation of error variance, estimation with correlated observations, least squares estimates with restriction on parameters.

Unit II

Simultaneous Estimates of linear Parametric functions, Tests of hypothesis for one and more than one linear parametric functions, confidence intervals and regions, Analysis of Variance, Power of F-test, Multiple comparison tests due to Tukey and Scheffe, simultaneous confidence intervals.

Unit III

Introduction to One-way random effects linear models and estimation of variance components, Simple linear Regression, multiple and polynomial regression, orthogonal polynomials.

Unit IV

Residuals and their plots as tests for departure from assumptions such as fitness of the model, normality, homogeneity of variances and detection of outliers, Remedies, Introduction to non-linear models; least squares in non-linear case, estimating the parameters of a non linear system, reparameterization of the model, the geometry of linear and non linear least squares.

Books Recommended:

Cook, R.D. and Weisber, S. (1982), Residual and Influence in Regression, Chapman and Hall.

Draper, N.R. and Smith, H. (1988), Applied Regression Analysis 3rd Ed. Wiley.

Gunst, R.F. and Mason, R.L. (1980). Regression Analysis and its Application-A Data Oriented Approach, Marcel and Dekker.

Rao, C.R. (1973), Linear Statistical Inference and Its

Weisber S. (1985) Applied Linear Regression, Wiley Eastern.

Wiley. D.C. Montegomery and EA Peck (1982). Introduction to Linear Regression Analysis, John Wiley and sons.

F.A Graybill (1976) Theory and Application of the Linear Models.

Applications, Wiley.

PSSSTC 302: Inference II **4 Credits**

OBJECTIVES : To provide advanced knowledge of Inferential Statistics for decision making.

Unit I

Generalization of Neyman-Pearson Lemma (without proof), Unbiasedness in hypothesis testing, UMPU tests for two sided hypothesis – in case of exponential families, similar tests and tests of Neyman structure and its relation to bounded completeness, UMPU test for multiparameter exponential families and its applications to Binomial and Poisson populations.

Unit II

Review of maximum likelihood estimation, MLE in Pitman family, MLE in censored and truncated distribution, Cramer family, Cramer-Huzurbazar theorem, solution of likelihood equation by method of scoring, Introduction to Sequential Estimation and Sequential Cramer –Rao inequality.

Unit III

Consistency and relative efficiency in non-parametric set-up, Method of estimating ARE, U-Statistics, Mann-whitney U-test, Rank tests a) For location-Wilcxon two sample and Terry-Hoeffding, b) For dispersion- Mood test and Freund-Ansari Test. The K-Sample problem-Kruskal-wallis Test, General simple linear rank statistic, Tests for Goodness of fit, Tests of independence: chi-square Contingency Table, Kendall's tau and Spearman's Rank correlation.

Unit IV

Statistical decision problem: non-randomized, and randomized decision rules, loss function, risk function, admissibility, Bayes rule, minimax rule, least favourable distribution, priori and posterior distributions, Admissible, Bayes and minimax estimators with illustrations.

Books Recommended:

1. Lehman, E.L.: Testing Statistical Hypothesis.
2. Goon, Gupta, Des Gupta: An outline of Statistical Theory, Vol-2.
3. Rohtagi, V.K.: An Introduction to Probability Theory and Mathematical Statistics., Wiley.
4. V.K. Rohtagi: Statistical Inference, Wiley.
5. B.K. Kale: Parametric Inference.
6. S. Zacks: Theory of Statistical Inference.
7. T.S. Ferguson: Mathematical Statistics:- A Decision Theoretic Approach.

PSSSTC 303: Optimization Techniques **4 Credits**

OBJECTIVES: The aim of this course is to provide the knowledge of Decision Theory to the students.

Unit I

Linear programming problem, formulation of LPP, Graphical method for solving LPP's, Slack and surplus variables, FS, BS, BFS, Simplex method for solving LPP, two phase method (Artificial Variable Technique), Big-M-Method and degeneracy in LPP and its resolution.

Unit II

Duality in LPP, Correspondence between dual and primal, theorems on duality, Fundamental duality theorem, Basic duality theorem, existence theorem, Revised Simplex Method, Standard form for revised simplex method, formulation of LPP in standard form, Application of computation procedure for standard form, sensitivity analysis.

Unit III

Transportation problem (TP), formulation of TP, FS, BFS and optimum solution, existence of FS, optimal solution method, Methods for finding BFS, U-V (MODI's) method for finding optimal solution, unbalance transportation problem, assignment problems, fundamental theorems of assignment problems, Hungarian method for assignment problems, Routing problems, Theory of games, rectangular games Minimax (Maximin) Criterion and optimal strategy, saddle point, optimal strategies and value of Game, sdution of saddle point, Minimax-Mximin principle missed strategy Games and their solutions through different methods including LPP, Minimax theorem.

Unit IV

CPM and PERT, Determination of critical path's different float times crashing, applications of CPM, PERT and Job sequencing, solutions of sequencing problems, processing n-job's through two-machines, Johnson's algorithm for n-jobs's for 2- machines, processing 2-job's through n-machines graphical method, processing n-job's through m-machines.

Books Recommended:

1. H.A. Taha : Operations Research.
2. S.S. Rao : Optimization and applications.
3. Kanti Swarup and M.M. Gupta : Operations Research
4. S.D. Sharma : Operations Research
5. Harris : Queueing Theory.

PSSSTO 304 : Applied Statistical Methods-I **4 Credits**

Unit I

Concept of statistical population, Attributes and variables (discrete and Continuous). Different types of scales – nominal, ordinal, ratio and interval. Primary data – designing a questionnaire and schedule, collection of primary data, checking their consistency. Secondary data; scrutiny of data for internal consistency and detection of errors of recording. Ideas of cross validation. Presentation of data; classification, tabulation, diagrammatic & graphical representation of grouped data. Frequency distributions, cumulative frequency distributions and their graphical representations, histogram, frequency polygon , Ogives. Stem & Leaf Plot and Box Plot

Unit II

Measures of Central tendency and dispersion, merits and demerits of these measures. Moments and factorial moments. Skewness and Kurtosis and their measures. Measures based on Partition values.

Unit III

Bivariate data, Method of least squares for curve fitting. Correlation and regression, Their properties and interrelationship, rank correlation (Spearman's and Kendall's measure). Intra-class correlation, Correlation ratio. Partial and Multiple Correlation & Multiple Regression for Trivariate data.

Unit IV

Testing of hypotheses :Statistical Hypotheses (null, alternative simple and composite)., Type I and Type II errors, significance level, p-values, power of a test. Point and confidence Interval Estimation. Standard error, Tests based on t, F and $\chi 2$ distributions. Large sample tests .

Note: Emphasis would be on applied aspects of the course rather than theoretical derivations.

Books Recommended:

1. Goon A.M., Gupta M.K. and Dasgupta B. (2005): Fundamentals of Statistics, Vol. I, 8th Edn. World Press, Kolkata.
2. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): An Outline of Statistical Theory, Vol. I, 4th Edn. World Press, Kolkata.
3. Yule, G.U. and Kendall, M.G.: An Introduction to the theory of statistics. Charles Griffin & Company Ltd.
4. C. E. Weatherburn: Mathematical Statistics
5 .Kapoor and Gupta(2007): Fundamentals of Mathematical Statistics, S Chand and Co.
6. Gupta, S.P.: Statistical Methods.

PSSSPC 305: Practical (Linear Models) **4 Credits**

Objective: To make students familiar with the computation work based on Course No. PSSSTC 301

PSSSPC 306 :Practical(Applied Industrial Statistics & Numerical analysis) **4 Credits**

Objective: To make students familiar with the computation work based on Industrial Statistics, Reliability and Numerical Computations.

5. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8th Edn. World Press, Kolkata
7. Johnson and Wichern : Applied Multivariate Analysis Statistical Analysis. PHI

Annexure J

Semester IV

Syllabus for the examinations to be held in May 2016, 2017 and 2018.

PSSSTC 401: Stochastic Processes **4 Credits**

Objectives : The aim of this course is to provide the knowledge of Stochastic Processes to the students.

Unit I

Introduction to stochastic processes (SP's), Classification of SP's according to state space 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's, Kolomogorav-Feller differential equations, Poisson Process, Birth and Death processes, 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, stationary process, weakly stationary and strongly stationary process.

Unit IV

Branching process, Galton-Watson branching process, probability of ultimate extinction, distribution of populations size, Martingale in discrete time, convergence and smoothing properties, Statistical inference in MC and Markov processes.

Books Recommended:

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. Karline, S. and Taylor, H.M. (1975): A First course in stochastic Process, Vol. I Academic Press.

4. Medhi, J. (1982) Stochastic Processes Wiley Eastern.

5. Parzen, E (1962): Stochastic Processes.

PSSSTC 402: C++ **4 Credits**

Objectives : The aim of this course is to provide the knowledge of programming in C++ to the students.

Unit I

Flowchart, Algorithm and problem solving. General concepts of programming. C++ character set, C++ tokens (identifiers, keywords, constants, and operators), structure of C++ program, cout, cin, Use of I/O operators, Cascading of I/O operators. Data Types: Built-in data types- int , char, float, double, Integer constants, Character Constants, String Constants.Variable: Declaration of variable of built in data types. Operators: Arithmetic operators, Relational Operators. Logical operators. Increment and decrement operator. Conditional operator, Precedence of operators. Type Conversion: Automatic type conversion, type casting. C++ short hands (--, ++, =), Assignment statement, variables initialization.

Unit II

Flow of control: Conditional statements, General form of if-else statement, if else if ladder, Nested if? As an alternative to if, General form of switch, Nested Switch. Simple control statement, for loop statement, while loop, do while loop. Variation in loop statements;Nested Loops, Loop termination: break, continue, go to, exit (), Single character input get char (), single character output (put char ()), gets and puts functions.Structured Data Type: Array, General form of Declaration and Use: one dimensional array, String two dimensional, Array initialization.

Unit III

Functions: General form, Function Prototype, definition of function, accessing a function. Passing arguments to function, Specifying argument Data type, Default argument, Constant argument, Call by value and Call by reference, returning value and their types, Calling function with arrays, Scope rules of function and variables, Local and Global variables, Storage class specifiers: extern, auto, register and static. Standard Header files – string.h, math.h, stdlib.h , iostream.h. Standard library functions-string and char related functions: isalnum(), isalpha(), isdigit(), islower(), isupper(), tolower(), toupper(), strcpy(), strcat(), strlen(), strcmp (). Mathmatical functions: fabs(), frexp() ,fmod (), log(), log10(), pow(), sqrt(), cos(), abs().

Unit IV

Structures: specifying a structure, defining a structure variable, accessing structure members .Functions and structures, arrays of structures, arrays within a structure, Structure within structure Class: Specifying a class, public and private data members and member functions, defining objects , calling member function, constructor and destructor functions.

Books Recommended:

1. Robert Lafure : C ++ Programming
2. Satish Jain : Computer fundamentals and C++ Programming Vol. I, Ratna Sagar Pvt. Ltd., Delhi.
3. Al Stevens : Teach Yourself C++, fourth Edition Publications, New Delhi.
4. Ravichandran : Programming in C++.
5. Ankit Asthana :Programming in C++.Narosa Publication,Delhi.

TE 403: Econometrics & Time Series **4 Credits**

Objectives: The aim of this course is to provide the knowledge of Econometric methods to the students.

Unit I

A review of least squares and maximum likelihood methods of estimation of parameters in classical linear regression model and their properties (BLUE), Generalized Least Square Models, construction of confidence regions and tests of hypothesis, prediction, use of extraneous information in the form of exact and stochastic linear constraints, Restricted regression and mixed regression methods of estimation and their properties. Testing of extraneous information.

Unit II

Multicollinearity, its effects and deletion, Remedial methods including the ridge regression. Specification error analysis, inclusion of irrelevant variables and deletion of dominant variables, their effects on the efficiency of optimization procedure.

Unit III

Hetroscedasticity, consequences and tests for it, estimation procedures under heteroskedastic disturbances. Auto correlated disturbances, Effects on estimation of parameters, Cochran Orcutt and Prais-Winston transformation, Durbin-Watson test. Errors-in-variables model, Inconsistency of least squares procedures, Consistent estimation of Parameters by instrumental variables.

Unit IV

Seemingly unrelated regression equation model, Ordinary least squares and feasible generalized least squares methods and their asymptotic properties.

Simultaneous equation model, problem of identification, A necessary and sufficient condition for the identifiability of Parameters in a structural equation, Ordinary Least squares, indirect least squares, two stage least squares and limited information maximum likelihood method, K-class estimators, Asymptotic properties of estimators.

BOOKS RECOMMENDED:

1. Vinod, H.D. and A. Ullah : Recent Advances in Regression Methods, (Marcel-Dekkar)
2. Jonsten, J. : Econometric Methods, (McGraw Hill Book Company.
3. Srivastava, V.K. & D.E Giles Seemingly unrelated Regression Equations Models: (Marcel Debbar).
4. Maddala, G.S. : Econometrics (McGraw Hill Koga Kusha Ltd.)
5. Koutsoyiannis, A : Theory of Econometric (Macmillan)
6. Theil, H. : Principles of Econometrics (John Wiley).
7. Gujarati, D. : Econometric Theory.
8. Madanani : Introduction to Econometrics.
9. Baltagi : Econometrics (Springer rer log)

PSSSTO 404: APPLIED STATISTICAL METHODS –II

Unit I **4 Credits**

Sampling versus complete enumeration : sampling units and frame. Precision and efficiency of estimators. Simple Random sampling with and without replacement. Stratified random sampling. Problem of allocation, proportional allocation, optimum allocation. Systematic sampling, PPS sampling , estimation of population mean and population total, standard errors of these estimators. Use of random number tables in selection of random samples. Sample size determination.

Unit II

Analysis of Variance. One way classification. Assumptions regarding model. Two way classification with equal number of observations per cell. Duncan's multiple comparison test. Principles of Design of experiments: randomization, replication and local control. Randomized block design. Concept and definition of efficiency of design. Comparison of efficiency between CRD and RBD. Latin square Design : Lay-out, ANOVA table. Comparison of efficiencies between LSD and RBD; LSD and CRD. Factorial Experiments : Basic Concepts and examples.

Unit III

Non-parametric tests – Tests for randomness and test for goodness of fit. One sample tests : sign test, Wilcoxon signed rank tests. Two sample tests : run test, Kolmogorov – Smirnov's test. Median test and Mann-Whitney U test. Mood tests and Sukhatme test for scale parameter, Spearman's rank correlation test, Kruskal Wallis and Friedman test.

Unit IV

Multivariate Data. Definition, Concept and applications of Multivariate analytical techniques: Multiple Linear Regression, MANOVA-One way, Factor Analysis, Discriminant and Classification Analysis, Case studies to understand applications of multivariate techniques.

Note: Emphasis would be on applied aspects of the course rather than theoretical derivations.

Books Recommended:

1. Gupta, S.C. and Kapoor, V.K. (2008): Fundamentals of Applied Statistics, 11 th Edn., , Sultan Chand and Sons.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Singh, D. and Chaudhary, F.S. (1995): Theory and Analysis of Sample Survey Designs. New Age International (P) Ltd.
4. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984): Sampling Theory of Surveys with Applications. Iowa State University Press, Iowa, USA.
5. Gibbons, J. D. and Chakraborty, S. (2003): Non parametric Statistical Inference, 4th Edition, Marcel Dekker, CRC.

PSSSTO 404: APPLIED STATISTICAL METHODS –II

4 Credits

Unit I

Sampling versus complete enumeration : sampling units and frame. Precision and efficiency of estimators. Simple Random sampling with and without replacement. Stratified random sampling. Problem of allocation, proportional allocation, optimum allocation. Systematic sampling, PPS sampling , estimation of population mean and population total, standard errors of these estimators. Use of random number tables in selection of random samples. Sample size determination.

Unit II

Analysis of Variance. One way classification. Assumptions regarding model. Two way classification with equal number of observations per cell. Duncan's multiple comparison test. Principles of Design of experiments: randomization, replication and local control. Randomized block design. Concept and definition of efficiency of design. Comparison of efficiency between CRD and RBD. Latin square Design : Lay-out, ANOVA table. Comparison of efficiencies between LSD and RBD; LSD and CRD. Factorial Experiments : Basic Concepts and examples.

Unit III

Non-parametric tests – Tests for randomness and test for goodness of fit. One sample tests : sign test, Wilcoxon signed rank tests. Two sample tests : run test, Kolmogorov – Smirnov's test. Median test and Mann-Whitney U test. Mood tests and Sukhatme test for scale parameter, Spearman's rank correlation test, Kruskal Wallis and Friedman test.

Unit IV

Multivariate Data. Definition, Concept and applications of Multivariate analytical techniques: Multiple Linear Regression, MANOVA-One way, Factor Analysis, Discriminant and Classification Analysis, Case studies to understand applications of multivariate techniques.

Note: Emphasis would be on applied aspects of the course rather than theoretical derivations.

Books Recommended:

1. Gupta, S.C. and Kapoor, V.K. (2008): Fundamentals of Applied Statistics, 11 th Edn., , Sultan Chand and Sons.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Singh, D. and Chaudhary, F.S. (1995): Theory and Analysis of Sample Survey Designs. New Age International (P) Ltd.
4. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984): Sampling Theory of Surveys with Applications. Iowa State University Press, Iowa, USA.
5. Gibbons, J. D. and Chakraborty, S. (2003): Non parametric Statistical Inference, 4th Edition, Marcel Dekker, CRC.

6. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8th Edn. World Press, Kolkata
7. Johnson and Wichern : Applied Multivariate Analysis Statistical Analysis. PHI

PSSSPC 405: Practical(C++) **4 Credits**

Objective: To make students familiar with the computation work based on Course No. PSSSTC 402

PSSSPC 406: Software Lab-II **4 Credits**

Objective: To make students familiar with the computation work based on Standard Statistical softwares.

PSSSTE 407: Operations Research **4 Credits**

Objectives: This course introduces the students to various optimization techniques of operations Research and some models of queuing theory.

Unit I

Inventory control, Introduction, Deterministic models, Economic lot size model with and without shortages, Probabilistic models, Single period model with uniform and continuous demand, models with price breaks, news papers boy problems.

Unit II

Introduction of queueing theory, concepts and various definitions, classification of queues and their problems, distribution of arrivals and service time, theorems based on arrival and departure times. Different queuing models M/M/1(FCFS, ∞, ∞), Probability distribution of different times and their expected values, Generalized M/M/1 Model, M/M/1 (FCFS, N) and M/M/C (∞, ∞, FCFS)

Unit III

Replacement Problems, Replacement of items that deteriorate, Replacement of items that fail completely, Recruitment and production problems, equipment renewal problems. Simulation, Types of Simulation, limitations of simulation, generation of random numbers and Monte-Carlo Simulation, Applications of Simulation to inventory control and Queuing problems.

Unit IV

Introduction to decision theory, Types of decision, Decision models, Types of Environment, EMV, EVPI, EOL. Decision making under uncertainly, Conflict and Decision Tree Analysis. Decision making under utilities: utility functions, curves and their construction. Posterior probabilities and Bayesian Analysis.

BOOKS RECOMMENDED:

1. Achoff. R.L. and M.W. Sariens : Fundamentals of Operational Research
2. S. D. Sharma : Operations Research
3. N.U. Prabhu : Queues and Inventions , Wiley
4. D. Gross and C.M. Marris : Fundamentals of Queuing Theory.
5. Taha, H.A. : Operations Research- An introduction.
6. N.D.Vohra : Quantitative Techniques , TataMcgraw.

PSSSTE 408: Information Theory **4 Credits**

Objectives: To introduce information theoretic concepts.

Unit I

Concept of Entropy and information measures, Formal requirements of the average uncertainty, Shanon's measure of information and its properties, Joint and Conditional Entropy, Relative entropy and mutual information, Uniqueness of the entropy function Jensen's Inequality and its consequences, Fano's Inequality, Asymptotic Equipartition Property, Entropy Rate.

Unit-II

Elements of encoding, redundancy and efficiency, binary codes , Shanon Fano Encoding ,Necessary and sufficient condition for noiseless coding, Average length of encoded message Kraft Inequality, McMillan Inequality, Optimal Codes, Huffman Code, Fundamental theorem of discrete noiseless coding.

Unit-III

Differential Entropy, Joint and Conditional Differential Entropy, Properties of Differential and Relative Entropy, Differential Entropy of distribution, Relationship of Differential Entropy to Discrete Entropy, Differential entropy bound on discrete entropy Entropy Optimization Principles, Maximum Entropy Principle, MaxEnt Formalism, Maximum Entropy Distribution

Unit-IV

Channel capacity, symmetric channels, Binary symmetric channel, Binary Erasure channel, Properties of channel capacity. Joint AEP theorem, channel coding theorem (statement only), Fano's inequality and converse to the coding theorem, Hamming codes.

Books Recommended:

1. Shannon CE (1948) : The mathematical theory of communication. *Bell Syst. Tech. J, Vol.* 27, *pp.* 379-423 and pp 623-656.
2. VanderLubbe (1996): Information Theory, Cambridge University Press.
3. Thomas T. M. and Cover (2006): Elements of Information Theory. Wiley , New York.
4. Kapur, J.N. and Kesavan H.K. (1993) :Entropy Optimization Principles with Applications, Academic Press, New York.
5. Reza, F.M. (2007): An Introduction to Information Theory, Dover Publications.
6. Robert Ash Information Theory .

PSSSTE 409 : Non Parametric Inference **4 Credits**

Objectives: To make students familiar with non-parametric concepts related to inference.

Unit I

Distribution of F(x), Order Statistics and their distributions, Coverage probabilities and confidence intervals, empirical distribution function and its properties, asymptotic distributions of order-statistics, bounds on expected values.

Unit II

Single Sample problems, problem of location, Mathisen-Median test, Rosenbaum Statistics I and II, Linear rank statistics, Prediction intervals, Goodness of fit tests, Kolmogrov-Smirnov-one sample Statistic, sign test, Wilcoxon- Signed rank statistics, Walsh averages, general Linear rank statistics, Noether's Conditions, asymptotic distributions of above statistics.

Unit III

Two sample problems, Mann-Whitney-Wilcoxon test, Wilcoxon test, general linear rank statistic, Vander Warden Statistic, Scale problems-Statements and applications of Mood Statistic, freund-Ansari-Bradley-David-Barton statistics, Siegel-Tukey Statistic, Sukhatme test.

Unit IV

Efficiency of tests, asymptotic relative efficiencies Hoffding's, U-Statistics, Asymptotic distribution of U-Statistics, K-Sample problem, Kruskal-Wallis test, Kandall's Tau coefficient and its sample estimate, Spearman's rank Correlation Coefficient.

Books Recommended:

1. J D Gibbons : Non-parametric Statistical Inference.
2. DAS Fraser : Non-parametric Methods in Statistics.
3. Rohatgi, V .K. : An Introduction to Probability Theory & Mathematical Statistics
4. H.A. David : Order Statistics
5. S.C. Supta, V.K. Kapoor : Fundamentals of Mathematical Statistics, Vol.1.

PSSSTE 410 : Demography **4 Credits**

Objectives: To introduce application of Statistics in the field of Vital statistics Demography and Population studies.

UNIT-I

Vital statistics: Methods of collection, their merits and demerits, various fertility rates and their computations, factors affecting fertility rates, differential fertilities, graduation of fertility rates, Gross and net reproduction rates.

UNIT-II

Crude mortality rates, infant mortality rates standardized fertility and mortality rates. Life tables: its classification, properties and methods of action with special reference to King, Graville-Reed-Morrel and Chiang methods for construction of abridged life tables.

UNIT-III

Financial calculation, cause deleted tables and multiple detection, Sample variance of life table functions, Probability distribution of life table functions- Probability distribution of the number of survivors and observed expectation of life, joint probability distribution of the number of survivors and the number of distribution.

UNIT-IV

Makeham's and Gompertz curves, Population estimation and projection. Mathematical and component methods of projection. A brief account of other methods of population projection. Migration its concepts and estimation.

Books Recommended:

1. Spigelman : Introduction to Demography.
2. Cox : Demography.
3. Keyfitz : Applied Mathematical Demography.
4. Chiang : Introduction to Bio-Statistics

PSSSTE 411: BioStatistics **4 Credits**

Objectives: This course introduces the students to various applications of statistics in biology and medical fields.

UNIT-I

Basic biological concepts in genetics, Mendel's law, Hardy- Weinberg equilibrium, random mating, distribution of allele frequency (dominant/co-dominant cases), Approach to equilibrium for X-linked genes, natural selection, mutation, and genetic drift, equilibrium when both natural selection and mutation are operative.

UNIT-II

Planning and design of clinical trials, Phase I, II, and III trials. Consideration in planning a clinical trial, designs for comparative trials. Sample size determination in fixed sample designs.

UNIT-III

Functions of survival time, survival distributions and their applications viz. Exponential, Gamma, Weibull, Rayleigh, lognormal, death density function for a distribution having bath-tub shape hazard function. Tests of goodness of fit for survival distributions (WE test for exponential distribution, W-test for lognormal distribution, Chi-square test for uncensored observations).

UNIT-IV

Type I, Type II and progressive or random censoring with biological examples, Estimation of mean survival time and variance of the estimator for type I and type II censored data with numerical examples. Idea of Stochastic epidemic models: Simple epidemic models (by use of random variable technique).

Books recommended:

1. Biswas, S. (1995): Applied Stochastic Processes. A Biostatistical and Population Oriented Approach, Wiley Eastern Ltd.
2. Cox, D.R. and Oakes, D. (1984) : Analysis of Survival Data, Chapman and Hall.
3. Elandt, R.C. and Johnson (1975): Probability Models and Statistical Methods in Genetics, John Wiley & Sons.
4. Ewens, W. J. (1979) : Mathematics of Population Genetics, Springer Verlag.
5. Ewens, W. J. and Grant, G.R. (2001): Statistical methods in Bio informatics.: An Introduction, Springer.
6. Friedman, L.M., Furburg, C. and DeMets, D.L. (1998): Fundamentals of Clinical Trials, Springer Verlag.
7. Gross, A. J. And Clark V.A. (1975) : Survival Distribution; Reliability Applications in Biomedical Sciences, John Wiley & Sons.
8. Lee, Elisa, T. (1992) : Statistical Methods for Survival Data Analysis, John Wiley & Sons.
9. Li, C.C. (1976): First Course of Population Genetics, Boxwood Press.
10. Miller, R.G. (1981): Survival Analysis, John Wiley & Sons.

PSSSTE 412: Actuarial Statistics **4 Credits**

Objectives: To introduce and expose students to application of statistics in actuarial field.

Unit-I

Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality. Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables. Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws.

Unit-II

Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations. Distribution of aggregate claims, compound Poisson distribution and its applications.

Unit-III

Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding.

Life insurance: Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, deferred insurance and varying benefit insurance, recursions, commutation functions.

Unit-IV

Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities-immediate and apportionable annuities-due.

Books Recommended:

1. Atkinson, M.E. and Dickson, D.C.M. (2000) : An Introduction to Actuarial Studies, Elgar Publishing.
2. Bedford, T. and Cooke, R. (2001): Probabilistic risk analysis,Cambridge.
3. Bowers, N. L., Gerber, H. U., Hickman, J. C., Jones D.A. and Nesbitt, C. J. (1986): 'Actuarial Mathematics', Society of Actuaries, Ithaca, Illinois, U.S.A., Second Edition (1997)
4. Medina, P. K. and Merino, S. (2003): A discrete introduction : Mathematical finance and Probability, Birkhauser.
5. Neill, A. (1977): Life Contingencies, Heineman.
6. Philip, M. et. al (1999): Modern Actuarial Theory and Practice, Chapman and Hall.
7. Rolski, T., Schmidli, H., Schmidt, V. and Teugels, J. (1998): Stochastic Processes for Insurance and Finance, Wiley.
8. Spurgeon, E.T. (1972): Life Contingencies, Cambridge University Press.
9. Relevant Publications of the Actuarial Education Co., 31, Bath Street, Abingdon, Oxfordshire OX143FF (U.K.)

PSSSTE 413: Statistical Computing **4 Credits**

Objective: To introduce Statistical Computing.

Unit-I

Random numbers: Pseudo-Random number generation, tests. Generation of non—uniform random deviates– general methods, generation from specific distributions.

Unit-II

Simulation-Random Walk, Monte-Carlo integration, Applications. Simulating multivariate distributions; simulating stochastic processes.

Unit-III

Variance reduction. Stochastic differential equations: introduction. Numerical solutions. Markov Chain Monte Carlo methods-Gibbs sampling; Simulated annealing, cooling schedule, convergence, application.

Unit-IV

Non-linear regression: Method; Estimation; Intrinsic and Parameter-effects curvature; application. EM algorithm and applications. Smoothing with kernels: density estimation, choice of kernels.

Books Recommended:

1. Bishop, C.M. Neural Networks for pattern Recognition, Oxford University Press.
2. Duda, R.O., Hart, P.E. and Strok, D.G. Pattern Classification, 2nd Edition, John Wiley & Sons.
3. Gentle, J.E., Härdle W. and Mori Y., (2004). Handbook of computational statistics — Concepts and methods, Springer-Verlag.
4. Han, J. and Kamber, M. (2000). Data Mining: Concepts and Techniques, Morgan Kaufmann.
5. Hand, David, Mannila, Heikki, and Smyth, Padhraic, (2001). Principles of Data Mining, MIT Press.
6. Haykin, S. Neural Networks-A Comprehensive Foundation, 2nd Edition, Prentics Hall.
7. McLachlan, G.J. and Krishnan, T. (1997). The EM Algorithms and Extensions, Wiley.
8. Nakhaeizadeh, G. and Taylor G.C., (1997). Machine Learning and Statistics, John Wiley & Sons.
9. Pooch, Udo W. and Wall, James A. (1993). Discrete Event Simulation (A practical approach), CRC Press.
10. Rubinstein, R.Y. (1981). Simulation and the Monte Carlo Method, John Wiley & Sons.
11. Simonoff, J.S. (1996). Smoothing Methods in Statistics, Springer.