P.G. 1st Semester

Paper: STA701C (Core)
Mathematical Analysis
Credits: 4 = 4+0+0 (64 Lectures)

Unit I: (Lectures: 16)
Review of sequence of real numbers; sequence and series of real valued functions, Cauchy's criterion and Weierstrass's M- test, uniform convergence and its relation to continuity, Uniform convergence and its relation to continuity, differentiability and integration, Convergence of Improper Integrals.

Unit II: (Lectures: 16)
Concept of Multiple integrals, Double integral over rectangle, Double integral over region, simple examples involving change of variables in multiple integrals, Dirichlet integral and Liouville's extension.

Unit III: **(Lectures: 16)**
Properties of complex numbers. Region in complex plane. Analytic function. Contour integration: Cauchy's theorem, Cauchy integral formula. Liouville's theorem. Fundamental theorem of Algebra.

Unit IV: (Lectures: 16)
Power series and radius of convergence. Taylor's and Laurent's series. Singular points and their types. Residue at singular point and residue at infinity. Cauchy residue theorem. Evaluation of real integrals involving sine and cosine using residue.

SUGGESTED READING:

1. Apostol, T.M. (1985): Mathematical Analysis, Narosa, Indian Ed.
2. Bak, J. and Newman, D. J. (2010): Complex Analysis,3rd Edition, Springer.
3. Bartle, R.G. and Sherbert, D.R. (2011): Introduction to Real Analysis, 4th Edition, Wiley, New York.
4. Conway, J.B. (1978): Functions of one complex variable, Springer-Verlag.
5. Mardsen, J. E., Tromba, A.J. Weinstein, A(2005): Basic Multivariable Calculus, Springer Verlag, New Delhi
6. Mathews, J. Howell, R.W. (2011): Complex Analysis for Mathematics and Engineering, Jones and Bartlett, New Delhi.
7. Rudin, W. (1985): Principles of Mathematical Analysis, McGraw Hill.
8. Tyagi, B.S. (2017): Functions of a Complex Variable, Kedar Nath Ram Nath, Meerut

Paper: STA702C (Core)
Measure Theory and Probability
Credits: 4 = 4+0+0 (64 Lectures)

Unit I: (Lectures: 16)
Concepts of classes of sets, fields, σ -fields, minimal σ -field, Borel σ – field, sequence of sets, limsup and liminf of a sequence of sets. Measure, Probability measure, properties of a

measure, Lebesgue-Stieltjes measure, Idea of product space and product measure. Outer measure, outer measurability, class of outer measurable sets in a Sigma field.

Unit II: (Lectures: 16)

Construction of outer measure function, Lebesgue measure, Lebesgue Measurable sets, extension of measure on a field, complete measure space.

Measurable transformation and function, random variable, simple and Elementary function, induced measure and distribution function, properties of measurable functions, measurable function as the limit of simple function. Integration of a measurable function with respect to a measure, Monotone convergence theorem, Fatou's lemma, Dominated convergence theorem.

Unit III: (Lectures: 16)

Moment inequalities:Markov's, Cramer's, Holder's and Kolmogorov's, Jenson, Liapounov, and Minkowsky's inequalities. Characteristic functions, uniqueness/inversion/Levy continuity theorems, Helly's theorem, Helly-Bray Theorem.

Sequence of random variables and modes of convergence (convergence in probability, almost surely, mean squareand and in distribution) and their interrelations. Statement of Slutsky's theorem. Borel –Cantelli lemma and Borel 0-1 law.

Unit IV: (Lectures: 16)

Laws of large numbers, Chebyshev's and Khinchine's WLLN, necessary and sufficient condition for the WLLN, three series criterion, strong law of large numbers and Kolmogorov's theorem. Central limit theorem, Lindeberg-Levy, Liapunov and Lindeberg-Feller forms of CLT. Basic concept of Martingals (Definition and simple problems).

SUGGESTED READING:

1. Ash, R. B. and Doléans-Dade, C.A. (1999): Probability and Measure Theory, Second Edition, Academic Press, New York.
2. Basu,A.K. (2004): Measure Theory and Probability , Prentice Hall of India.
3. Bhat, B.R. (1999): Modern Probability Theory, 3rd Edition, New Age International Publishers.
4. Billingsley, P. (2012): Probability and Measure, Anniversery Edition, John Wiley & Sons.
5. Capinski, M. and Zastawniah (2001): Probability through Problems, Springer.
6. Chae, S.B. (1995): Lebesgue Integration, 2nd Edition, Springer Verlag, New York
7. David, S (1996): Elementary Probability, Oxford Press
8. Edward P.J, Ford J.S. and Lin (1974): Probability for Statistical Decision- Making, Prentice Hall.
9. Feller, W. (1968): An Introduction to Probability Theory and its Applications, Vol. 1, 3rd Edition, John Wiley & Sons.
10. Goon A.M., Gupta M.K. Dasgupta B. (1999): Fundamental of Statistics, Vol. II, World Press, Calcutta.
11. Mood A.M, Graybill F.A and Bose D.C (1974): Introduction to the Theory of Statistics, McGraw Hill.
12. Hoel P.G (1971): Introduction to Mathematical Statistics, Asia Publishing House.

Paper: STA703C (Core)
Distribution Theory
Credits: 4 = 4+0+0 (64 Lectures)

Unit I: (Lectures: 18)
Moments (raw, central, and factorial) in terms of Stirling numbers, Functions of random variables and their distributions using Jacobian of transformation and other tools.
Probability distributions: Logarithmic, positive and negative multinomial, distributions of extremes: Grumble, Freichet, Weibull and their properties. Symmetric distributions, Generalized power series distributions, Exponential family of distributions.

Unit II: (Lectures: 22)
Censoring, Truncation and weighted distributions. Truncated Binomial, Poisson, Logarithmic, Normal and Cauchy distributions.
Mixture distributions: Definition, finite mixtures, Zero modified and inflated distributions with examples, Mixed Poisson distributions and its properties and examples of Poisson mixtures, Mixtures of Binomial distributions with examples.

Unit III: (Lectures: 14)
Sampling distributions: Non-central chi-square, t, and F distributions, their properties and the related distributions.

Unit IV: (Lectures: 10)
Order statistics - their distributions and properties; Joint and marginal distributions of order statistics (discrete and continuous).

SUGGESTED READING:

1. Arnold, B.C., Balakrishnan, N., and Nagaraja, H.N. (1992): A First Course in Order Statistics, John Wiley & Sons.
2. David, H.A., and Nagaraja, H.N. (2003): Order Statistics, Third Edition, John Wiley and Sons.
3. Dudewicz, E.J.and Mishra, S.N. (1988): Modern Mathematical Statistics, Wiley, Int'l Students' Edition.
4. Johnson, N.L., Kemp, and Kotz, S. (2005): Univariate Discrete Distributions, Wiley, 3rd Edition.
5. Mukhopadhyay, P. (2015): Mathematical Statistics. New Central Book Agency
6. Rao, C.R. (1973): Linear Statistical Inference and Its Applications, 2/e, Wiley Eastern
7. Rohatgi, V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.

Paper: STA704C (Core)
Survey Sampling
Credits: 4 = 4+0+0 (64 Lectures)

Unit I: (Lectures: 12)
Basic ideas and distinctive features of sampling. Probability sampling designs, sampling schemes. Review of important results in simple and stratified random sampling, Fixed (Design-based) and Super population (Model-based) approaches. Non-sampling errors with special reference to non-response. Sample size determination.

Unit II: (Lectures: 18)
Sampling with varying probabilities (Unequal probability sampling) with and without replacement methods including Lahiri's scheme: pps, πps and non- πps sampling procedures. Related estimators of a finite population mean: Horvitz-Thompson, Yates and Grundy estimator, Hansen-Hurwitz and Des Raj estimators for general sample size, Murthy's estimators.

Unit III: (Lectures: 16)
Stratified random sampling: Two-way stratification, Construction of strata, Number of strata, Method of collapsed strata, Post stratification.
Double sampling with special reference to the selection with unequal probabilities in at least one of the phases. Two phase sampling for stratification.

Unit IV: (Lectures: 18)
Systematic sampling and its applications to structured populations: population with linear trend, periodic population, auto correlated population and stratified population. Cluster sampling with varying sizes of clusters. Two stage sampling with varying sizes of first stage units. Concept of randomized response technique for sensitive characteristics.

SUGGESTED READING:

1. Cassel, C.M., Sarndal, C-E and Wretman, J.H. (1977): Foundations of Inference in Survey Sampling, Wiley Inter-Science, New York.
2. Chaudhari, A. and Stenger, H. (2005): Survey Sampling Theory and methods, 2nd Edn., Chapman and Hall.
3. Chaudhari, A. and Vos, J.W.E. (1988): Unified Theory and Strategies of Survey Sampling, North –Holland, Amsterdam.
4. Cochran, W.G. (1977): Sampling Techniques, John Wiley & Sons, New York .
5. Hedayat, A.S., and Sinha, B.K. (1991): Design and Inference in Finite Population Sampling, Wiley, New York.
6. Levy, P.S. and Lemeshow, S. (2008): Sampling of Populations-Methods and Applications, Wiley.
7. Mukhopadhyay, P. (2009): Theory and Methods of Survey Sampling, 2nd edition, Prentice Hall of India, New Delhi.
8. Murthy, M.N. (1967): Sampling Theory and Methods, Statistical Publishing Society, Calcutta
9. Raj, D. and Chandhok, P. (1998): Sample Survey Theory. Narosa Publishing House.
10. Sarndal, C.E., Swensson, B. and Wretman, J.H. (1992): Model Assisted Survey Sampling, Springer-Verlag, New York.

11. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984): Sampling Theory of Surveys with Applications, Iowa State University Press, Iowa, USA.
12. Thompson, S. K. (2002): Sampling, John Wiley and Sons, New York.

Paper: STA705L (Lab)
Lab 1
Credits: 4 = 0+0+4

Lab based on STA703C and STA704C

Paper: STA706S (SEC)
Statistical Computing With R
Credits 2 = 0+0+2

Unit I

Introduction to R: Some basics- Performing simple arithmetic, creating a vector, computing basic statistics, Comparing vectors, selecting vector elements, Combining Multiple Vectors into one vector, performing vector Arithmetic, appending data to a vector, inserting data to a vector.

Creating factors: converting a vector of character string into factors, Combining Multiple factors into one Factor.

Graphics: Basics of graphs in R, Creating scatter plot (single and multiple groups), Bar charts, Box plot, Histogram and Q-Q plot.

Unit II

Matrix operation: Initializing a Matrix, Performing Matrix operations- finding determinant, inverse, eigen values and eigen vectors. Solution of non- homogeneous simultaneous linear equations.

Working with Data frames: Creating a Data frame, appending rows to a Data frame, Selecting Data frame columns by name, combining two data frames, performing operations on Data frames.

Probability: Calculating probabilities and cdf for some basic distributions, converting probabilities into quantiles. Generating Random numbers and plotting density functions.

Unit III

General statistics and tests of significance: Calculating Relative frequencies, constructing continuous frequency tables tabulating factors and creating contingency tables. One and two sample t-tests, Testing for sample proportions (one, two and multi samples), Chi- square test of goodness of fit and independence of attributes, Calculation of correlation coefficient and test for its significance. Performing simple regression, one and two way ANOVA.

Unit IV

Writing functions in R (Functions for mean, sd, cv, correlation coefficient, regression coefficient, test functions based on t- statistics, Chi- square statistic)

References:

1. Kerns, G. J. (2011): Introduction to Probability; First Edition; IPSUR
2. Nenadic, O., Zucchini, W. (2004): Statistical Analysis with R- a quick start
3. Peter Dalgaard, P. (2008): Introductory Statistics with R; Second Edition,springer
4. Teeror, P. (2011): R Cookbook; Published by O'Reilly Media, Inc.