P.G. 2nd Semester

Paper: STA801C (Core)
Linear Algebra
Credits: 4 = 4+0+0 (64 Lectures)

Unit I: **(Lectures: 14)**
Fields, linear spaces, subspaces, linear dependence and independence, basis and dimension of a linear space. Theory of linear equations. Introduction to n dimensional Euclidian Space.
Inner product. Linear space with inner product. Orthogonalization of vectors. Orthonormal basis of a linear space.

Unit II: **(Lectures: 16)**
Linear Transformations, Kernel and Image of a linear transformation, Rank and Nullity, Matrix representation of a linear operator, Change of Basis, Similarity, Inner product spaces with examples, Cauchy-Schwarz inequality with applications, Orthogonality, Orthonormal sets and Bases, Gram Schmidt Orthogonalization Process.

Unit III: **(Lectures: 16)**
Eigen values and eigen vectors, Spectral decomposition of a symmetrical matrix (Full rank and non-full rank cases), Example of spectral decomposition, Spectral decomposition of asymmetric matrix, Cayley Hamilton theorem, Algebraic and geometric multiplicity of characteristic roots, Diagonalization of matrices, Factorization of a matrix, Eigen values and eigen vectors for solution of Differential equations.

Unit IV: (Lectures: 18)
Generalized inverse of a matrix, Different classes of generalized inverse, Properties of g-inverse, Reflexive g-inverse, left weak and right weak g-inverse, Moore- Penrose (MP) g-inverse and its properties, Real quadratic form, Linear transformation of quadratic forms,
Index and signature, Reduction of quadratic form into sum of squares, Gram matrix with example, Jordan canonical form. Lagrange's method of transformation of a positive definite quadratic form, Cochran's theorem.

SUGGESTED READING:

1. Biswas, S. (1997): A Text Book of Matrix Algebra, 2nd Edition, New Age International Publishers.
2. Golub, G.H. and Van Loan, C.F. (1989): Matrix Computations, 2nd edition, John Hopkins University Press, Baltimore-London.
3. Graybill, F.A. (1983): Matrices with applications in Statistics, 2nd Ed. Wadsworth.
4. Hadley, G. (2002): Linear Algebra. Narosa Publishing House (Reprint).
5. Rao, C.R. (1973): Linear Statistical Inferences and its Applications, 2nd edition, John Wiley and Sons.
6. Robinson, D.J.S. (1991): A Course in Linear Algebra with Applications, World Scientific, Singapore.
7. Searle, S.R. (1982): Matrix Algebra useful for Statistics. John Wiley and Sons. Inc.
8. Strang, G. (1980): Linear Algebra and its Application, 2nd edition, Academic Press, London, New York.

Paper: STA802C (Core)
Multivariate Analysis
Credits: 4 = 4+0+0 (64 Lectures)

Unit I: **(Lectures: 14)**
Multivariate normal distribution, Transformation of variables, Random sampling from a multivariate normal distribution, Maximum likelihood estimators of parameters, Distribution of sample mean vector, Inference concerning the mean vector when the covariance matrix is known, Multivariate Central Limit Theorem.

Unit II: **(Lectures: 14)**
Wishart matrix: its distribution and properties. Distribution of sample generalized variance. Hotelling's T^2 statistic: its distribution and properties. Applications in tests on mean vector for one and more multivariate normal populations and also on symmetry of organs. Mahalanobis' D^2.

Unit III: **(Lectures: 14)**
Likelihood ratio test criteria for testing independence of sets of variables, equality of covariance matrices, identity of several multivariate normal populations.
Distribution of the matrix of sample regression coefficients and the matrix of residual sum of squares and cross products, Rao's U-statistic, its distribution and applications, Multivariate analysis of variance (MANOVA) of one way classified data.
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Unit IV: **(Lectures: 22)**
Classification and discrimination procedures for discrimination between two multivariate normal populations - sample discriminant function, tests associated with discriminant functions, probabilities of misclassification and their estimation, Classification into more than two multivariate normal populations.
Dimension reduction, Principal component, Canonical variables and Canonical correlation – definition, use, estimation and computation; Idea of Factor Analysis.

SUGGESTED READING:

1. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3rd Edition, John Wiley.
2. Chakravarti, I.M, Lahe, R.G & Roy, A Hand Book of Methods of Applied Statistics,Vol 1, John Wiley.
3. Giri, N. C. (1977): Multivariate Statistical inference, Academic Press.
4. Hardle, W. K. and Simar, L. (2015): Applied Multivariate Statistical Analysis, 4th Edition, Springer. Pearson Education India.
5. Johnson, R. A. and Wichern, D. W. (2015): Applied Multivariate Statistical Analysis, 6th Edition, Prectice Hall
6. Kshirsagar, A. M. (1996): Multivariate Analysis, 2nd Edition, Marcel Dekker.
7. Lawley, D. N. and Maxwell, A. E. (1971): Factor Analysis as a Statistical Method, Second Edition, London Butterworths.
8. Muirhead, R. J. (1982): Aspects of Multivariate Statistical Theory, Wiley.
9. Rao, C. R. (1972): Linear Statistical inference and its Application, John Wiley
10. Srivastava, M. S. and Khatri, C. G. (1979): An introduction to Multivariate Statistics, North-Holland.

Paper: STA803C (Core)
Statistical Inference-I
Credits: 4 = 4+0+0 (64 Lectures)

Unit I: **(Lectures: 20)**
Theory of point Estimation: Sufficiency- Factorization theorem and Invariance property. UMVUE related theorems including Necessary and sufficient condition of UMVUE. Rao-Blackwell theorem and Lehmann- Scheffe theorem.
Bounds for variance of Estimators: Frechet-Cramer- Rao lower bound, Frechet- Cramer- Rao lower bound for multi parameter case, Bhattacharyya bound and Chapman- Robins-Kiefer lower bound.
Method of estimation: Method of Maximum likelihood (with properties and related theorems), Method of moments, Minimum chi square and Method of minimum distance.
Introduction to BAN and CAN estimators and related theorems

Unit II: (Lectures: 14)
Interval estimation, confidence level, construction of shortest expected length confidence interval, Uniformly most accurate one-sided confidence Interval and its relation to UMP tests for one-sided null against one-sided alternative hypotheses.

Unit III: (Lectures: 18)
Basic concepts of randomised and non-randomised tests; Neyman-Pearson Fundamental Lemma and Generalisation, MP and UMP tests, Consistency, monotonicity and invariance principle of tests and their construction.
UMPU- tests, Type A and Type A1 critical regions, Optimum Region and Sufficient statistic, Similar Regions.

Unit IV: (Lectures:12)
Likelihood Ratio Tests, Asymptotic distribution of Likelihood ratio. Randomised test: Test function, Neyman-Pearson theorem, Monotone Likelihood Ratio.

SUGGESTED READING:

1. Bartoszynski, R. and Bugaj, M.N. (2007): Probability and Statistical Inference, John Wiley & Sons.
2. Ferguson, T.S. (1967): Mathematical Statistics, Academic Press. 3. Kale, B.K. (1999). A First Course on Parametric Inference, Narosa Publishing House.
3. George Cassella & Roger L. Berger (1994): Statistical Inference. Wadsworth & Brooks, California.
4. Goon, A. M., Gupta, M. K., and Dasgupta (1987): An Outline of Statistical Theory. Vol.-II, World Press.
5. Kale B. K. (1999): A First Course on Parametric Inference
6. Kendal, M. G. & Stuart, A (1960): The Advanced Theory of Statistics. Vol 2. Charles Griffin, London.
7. Lehman E.L (2011): Theory of Point Estimation, 2nd Edition, Springer
8. Lehmann, E L., Romano, J. P. (2008): Testing Statistical Hypotheses. 3rd Edition, Springer.

9. Parimal Mukhopadhyay (1996): Mathematical Statistics. New Central Book Agency, Kolkata.
10. Rao, C. R. (1973): Linear Statistical Inference and Its Application, 2/e Wiley Eastern
11. Rohatgi V.K. (2015): An Introduction to Probability and Statistics, 3rd Edition, Wiley Eastern Limited. New Delhi, (Student Edition)
12. Saxena H & Surendran P (1994): Statistical Inference, S Chand & Company Pvt. Limited
13. Zacks, S. (1971): Theory of Statistical Inference, John Wiley & Sons.

Paper: STA804C (Core)
Design of Experiments
Credits: 4 = 4+0+0 (64 Lectures)

Unit I: (Lectures: 12)
Review of basic designs. Variance Component Analysis: Introduction, analysis in a two way classification.
Idea of Orthogonal Latin Square Design, Graceo Latin Square Design, Circular design.

Unit II: **(Lectures: 18)**
Review of factorial experiments, Fractional replication of factorial experiment, Asymmetrical factorial experiments: Introduction, analysis, different types of asymmetrical factorial experiments.
Designs for Bio-assays (without analysis). Response Surface designs: Introduction, 1st and 2nd order designs with analysis.
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Unit III: **(Lectures: 18)**
Incomplete block designs (IBD): Introduction and properties- Concepts of Connectedness, Orthogonality and Balance. Intra block analysis of IBD.
Balanced Incomplete Block Design (BIBD). Partially Balanced Incomplete Block Design (PBIBD) with 2 associated classes. Lattice designs. Youden square design.

Unit IV: **(Lectures: 16)**
Galois fields, Finite Projective Geometry and Finite Euclidean Geometry.
Construction of Mutually Orthogonal Latin Squares (MOLS).Construction of BIBD by using Galois fields and MOLS.

SUGGESTED READING:

1. Bhuyan K.C. (2017): Design of experiments and Sampling Methods, 1st Edition, New Central Book Agency (P) Ltd, New Delhi.
2. Bose R.C (1984): Introduction to combinatorial Theory, Wiley Series of Probability and Statistics
3. Chakrabarti, M.C. (1962): Mathematics of Design and Analysis of Experiments, Asia Publishing House, Bombay.
4. Das M.N and Giri N.C (1986): Designs and Analysis of experiments, Wiley Eastern Limited, New Delhi.

5. Dean, A. and Voss, D. (1999): Design and Analysis of Experiments, Springer. First Indian Reprint 2006.
6. Dey, A. (1986): Theory of Block Designs, John Wiley & Sons.
7. Hinkelmann, K. and Kempthorne, O. (2005): Design and Analysis of Experiments, Vol. Advanced Experimental Design, John Wiley & Sons.
8. John, P.W.M. (1971): Statistical Design and Analysis of Experiments, Macmillan Co., New York.
9. Kshirsagar, A.M. (1983): A Course in Linear Models, Marcel Dekker, Inc., N.Y.
10. Montgomery D.C (2017): Design and Analysis of experiments, 9th Edition, Wiley Eastern Limited, New Delhi.
11. Mukhopadhyay P (2005): Applied Statistics, 2nd Edition, Books and Allied (P) Ltd, Kolkata.
12. Raghavarao, D. (1970): Construction and Combinatorial Problems in Design of Experiments, John Wiley & Sons.
13. Raghavarao, D. and Padgett, L. V. (2005): Block Designs: Analysis, Combinatory, and Applications, World Scientific.

Paper: STA805L (Lab)
Lab 2: Numerical Analysis and Computation
Credits: 4 = 2+0+2 (32 Lectures)

Lab based on STA802C, STA803C and STA804C