Department of Statistics
University of Lucknow
Lucknow

National Education Policy-2020

Syllabus for M.A./M.Sc. (Statistics)

Academic Session
2025-26

University of Lucknow

Master of STATISTICS Programme

1. Applicability

These regulations shall apply to the Master in Statistics Programme from the session 2025-26.

2. Minimum Eligibility for admission

A Bachelor's degree or equivalent degree awarded by a University or Institute established as per law and recognized as equivalent by this University with minimum 45% marks or equivalent grade with Statistics as one of the subject at Graduation level shall constitute the minimum requirement for admission to the Master in Statistics programme.

3. Programme Objectives

M. A. / M. Sc. Statistics program is of 80 credits spread over four semesters. The program emphasizes both theory and applications of statistics and is structured to provide knowledge and skills in depth necessary for the employability of students in industry, other organizations, as well as in academics. The program has some unique features such as independent projects, number of elective courses, extensive computer training of statistical computations including standard software packages such as R, STATA, SPSS and Python. The department has the academic autonomy and it has been utilized to add the new and need based elective courses. The Dissertation is one of the important components of this program. Semesters are constituted of core, value added and elective courses along with internships and dissertation. The syllabus has been framed to have a good balance of theory, methods and applications of statistics.

It is possible for the students to study basic courses from other disciplines such as economics, life sciences, computer science and mathematics in place of electives.

4. Programme Outcomes

The degree focuses on algorithms, designs and development to give solutions to real life problems. It is designed to develop student's knowledge in subjects like Probability, Bayesian Inference, Multivariate Analysis, Stochastic, Design of Experiments, Sampling, Linear Models etc. that will make them employable in Multinational companies, Railways, MOSPI, etc. specializing in Data Analytics, Business insurance and finance. Extensive knowledge of a plethora of Statistical Software namely R, STATA, SPSS, TEXT ANALYTICS, Python etc. are also necessitated under its preview. The Key Program Outcomes are:

i. To inculcate and develop aptitude to understand and apply statistical tools at a number of data generating fields in real life problems.
ii. To train students to handle large data sets and carry out data analysis using software and programming language.
iii. To teach a wide range of statistical skills, including problem-solving, project work and presentation so as enable students to take prominent roles in a wide spectrum of employment and research.

5. **Programme Specific Outcomes**

At the Department of Statistics, University of Lucknow the course matter has been specifically moulded towards targeted achievements in the advanced fields of Indian Statistical Services (ISS), Civil Services Examination, UPPSC, etc., Illustrious achievement by many students in these fields from the Department every year, lend itself as veritable proof.

On successful completion of the programme, the student will be able to:

i. Gain sound knowledge in theoretical and practical aspects of Statistics.
ii. Describe complex statistical ideas to non-statisticians.
iii. Handle and analyze large databases with computer skills and use their results and interpretations to make practical suggestions for improvement.
iv. Get wide range of job opportunities in industry as well as in government sector.

Department of Statistics

University of Lucknow

Syllabus for M.A./M.Sc. Statistics (**PG 2 Year**) Programme

Proposed to be implemented from July 2025

Year	Semester	Course No.	Course Name	Course Type	Credits	Total
1	Semester 1	STAT2CC501	Mathematical Analysis and Linear Algebra	Core Course 1	4	20
		STAT2CC502	Advanced Probability Theory	Core Course 2	4	
		STAT2CC503	Advanced Sampling Techniques	Core Course 3	4	
		STAT2CC504	Linear Model and Regression Analysis	Core Course 4	4	
		STAT2CC505	Practical	Core Course 5	2	
		STAT2VC501	Statistical Analysis using SPSS	Value Added Credited Course (Intradepartmental)	2	
	Semester 2	STAT2CC506	Machine Learning	Core Course 6	4	20
		STAT2CC507	Estimation Theory	Core Course 7	4	
		STAT2CC508	Multivariate Analysis	Core Course 8	4	
		STAT2CC509	Stochastic Processes	Core Course 9	4	
		STAT2CC510	Practical	Core Course 10	2	
		STAT2IER501	Applied Statistics.	Interdepartmental Course	2	
2	Semester 3	STAT2CC601	Block Design and Their Analysis	Core Course 11	4	20
		STAT2CC602	Econometrics	Core Course 12	4	
		STAT2CC603	Testing of Hypothesis	Core Course 13	4	
		STAT2EL601A	Population Studies	Elective Course 14a	4	
		STAT2EL601B	Advanced Machine Learning	Elective Course 14b		
		STAT2EL601C	Qualitative Data Analysis	Elective Course 14c		
		STAT2EL602A	Practical	Elective Course 15a	2	
		STAT2EL602B	Practical using SPSS	Elective Course 15b		
		STAT2EL602C	Practical using R	Elective Course 15c		
		STAT2IN601	Internship Field Work		2	
	Semester 4	STAT2CC604	Decision Theory & Bayesian Analysis	Core Course 16	4	20
		STAT2EL603A	Time Series Analysis	Elective Course 17a	4	
		STAT2EL603B	Artificial Intelligence	Elective Course 17b		
		STAT2EL603C	Reliability Theory	Elective Course 17c		
		STAT2EL604A	Factorial Experiments and Response Surfaces Theory	Elective Course 18a	4	
		STAT2EL604B	Ethics, Integrity and Aptitude	Elective Course 18b		
		STAT2EL604C	Computer Intensive Statistical Methods	Elective Course 18c		
		STAT2D601	Dissertation		8	
					Total Credits	80

SYLLABUS OF M.A./M.Sc. (Statistics)

SEMESTER I

STAT2CC501: Mathematical Analysis and Linear Algebra
(4 Credits – 4 hours of teaching per week)

Course Outcome:

The main objective of this course is to introduce students the knowledge of mathematical analysis and linear algebra. These concepts and relations provide grounds for Probability Theory and help in theoretical research in Statistics.

Course Specific Outcomes:

After successful completion of this course, student will be able to:

1. Understand the open, closed and compact sets with related theorems.
2. Understand the sequence and series convergence of real valued function.
3. Find maxima-minima of functions of several variables.
4. Understand multiple integral their applications for area and volumes of figures.
5. Understand improper integrals, convex functions and related applications
6. Understand role of complex variable functions, their differentiation and integration
7. Whole system of equations with multiple dimensions/variables.
8. Importance of concept of linear algebra in multiple area of science.
9. Concepts of Generalized inverse theory and applications.
10. Concepts and detailed theory of Eigen values and Eigen vectors.
11. Concepts of Decompositions of matrices

UNIT I

Introduction to real numbers, Real valued functions, Continuous functions, open, closed sets, Bolzano-Weirstrass theorem, compact sets and Heine - Borel theorem. Sequence and series with their convergence. Power series and Radius of convergence.

UNIT II

Maxima and Minima of functions, constrained maxima and minima of functions of several variables. Riemann integration, fundamental theorems of integral calculus, Mean value theorem of Integral Calculus, Multiple Integrals and their evaluation by repeated integration.

UNIT III

Improper integrals and their convergence. Introduction of complex variables, Limit, continuity and differentiability of complex functions, Cauchy-Reimann equations, Analytic functions. Taylors series, Evaluation of standard integrals by Contours Integration.

Unit IV

Matrix and Vectors, vector space, linear dependence and independence of vectors, basis and dimension of a vector space, inner product, orthogonal and orthonormal vectors, Gram-Schmidt process of orthogonalization, rank of a matrix, determinant of a matrix, inverse of a matrix, partition of matrices, their use in finding the inverse of matrix, Eigen roots and Eigen vectors, Caley-Hamilton theorem, algebraic and geometric multiplicity of a characteristic root.

Unit V

Generalized inverse, Moore-Penrose inverse, Solutions of simultaneous linear equations using matrices and generalized inverse, Spectral decomposition of matrices: Lower Upper (LU) Decomposition, Eigen Value Decomposition, Singular values and singular value decomposition, Jordan decomposition, Vector and matrix differentiation.

REFERENCES:

1. Apostol, T.M. (1996): Mathematical Analysis, 2nd ed, Narosa, Indian Ed.
2. Bellman R. (1970): Introduction to Matrix Analysis, 2nd ed. Mc Graw Hill.
3. Biswas, S. (1984): Topics in Algebra of Matrices, Academic Publicat ions.
4. Courant, R. and John, F. (1965): Introduction to Calculus and Analysis, Wiley.
5. D. R. Sherbert & R.G. Bartle (2011): Introduction to Real Analysis, 4ed,Wiley.
6. Graybill, F.A. (1983): Matrices with applications in Statistics, 2nd Ed. Wadsworth.
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. & Kunze, R. (1971): Linear Algebra, 2nd ed., Prentice Hall, Inc.
10. Malik, S.C. and Arora, S.(2017): Mathematical Analysis, 5th ed., new age international.
11. Miller, K.S. (1957): Advanced Real Calculus, Harper, New York.
12. Rudin, Walter (2023) : Principles of Mathematical Analysis, 3rd ed. McGraw Hill
13. Rao C.R. (1973): Linear Statistical inference and its applications 2nd ed. John Wiley & Sons, Inc.
14. Rao A.R. and Bhimsankaran P. (1992): Linear Algebra, Tata McGraw Hill Publishing Company Ltd.
15. Rao CR and Mitra S.K. (1971): Generalized Inverse of Matrices and Its Applications, John Wiley & Sons, Inc.
16. Searle S.R.(1982): Matrix Algebra Useful For Statistics, John Wiley & Sons, Inc

STAT2CC502: Advanced Probability Theory

(4 Credits – 4 hours of teaching per week)

Course Outcome:

The main objective of this course is to provide in depth knowledge to students the measure theoretic approach to Probability. The present course provides insight to some important concepts that shall provide a solid foundation to several courses taught in this post graduate programme.

Course Specific Outcomes:

After successful completion of this course, student will be able to:

1. Appreciate the concepts related to measure and its use in definition of probability.
2. To gain insights to different important results of probability measure.
3. Appreciate the concept of measurable function and random variables.
4. Understand the concept of convergence of random variables and link between different types of convergences.
5. To gain knowledge about the importance of laws of large numbers and its use in Statistics.
6. To understand the central limit theorems and learn about their applications.

UNIT I

Sets and sequences of sets, classes of sets, fields, sigma-fields, minimal sigma-field, Borel sigma-field in R^k,sequence of sets, inferior and superior limits of a sequence of sets. Monotone class. Elements of Measure theory, Measure, Probability measure, properties of a measure, Caratheodory extension theorem, Lebesgue and Lebesgue-Stieltjes measures on R and R^k. Product Space, Radon – Nikodymn Theorem.

UNIT II

Measurable functions: simple, nonnegative, and general measurable functions, Random variables. Integration of a measurable function with respect to a simple, nonnegative, general measurable functions. Expectation, moments. Holder's, Cauchy-Schwartz, Jensen's and Kolmogorov's inequalities.

UNIT III

Sequence of random variables, convergence in probability, almost sure convergence, convergence in distribution, convergence in r-th mean. Interrelationship among differentmode of convergences.Slutsky's theorem.

UNIT IV

Monotone convergence theorem, Fatou's lemma, Dominated convergence theorem.

Borel– Cantelli Lemma, Borel Zero – One – Law, Kolmogorov's 0-1 law. Weak and strong laws of large numbers, Khinchine's theorem.

UNIT V

Characteristic function, inversion theorem, uniqueness theorem, Levy's continuity theorem. Central Limit Theorem (CLT): Lindberg Levy and Liapunoff's form of CLT. Applications of CLT.

References

1. Bhat, B.R. (2023).Modern Probability Theory, New Age International Publishers.
2. Ash,R. & Doleans-Dade, C.(2000). Probability and Measure Theory, Academic
3. Billingsley, P.(2012). Probability and Measure. Wiley.
4. Dudley, R.M. (2002). Real Analysis and Probability, Wadsworth and Brooks/Cole.
5. Kingman, J.F.C.& Taylor, S.J.(2008). Introduction to Measure and Probability, Cambridge University Press.
6. Resnick, S. (2014). A Probability Path, Springer
7. Basu, A. K. (2012).Measure Theory and Probability, PHI.
8. Athreya, K. B. &Lahiri, S. N. (2006).Measure Theory and Probability Theory, Springer
9. Rao, C.R. (2009).Linear Statistical Inference and its Applications, Wiley.
10. Pitman, J.(2012). Probability, Narosa Publishing House.
11. Rohatgi, V.& Salah A.K.M.E. (2015). An Introduction to Probability and Mathematical Statistics. Wiley.

STAT2CC503: Advanced Sampling Techniques

(4 Credits – 4 hours of teaching per week)

Course Outcome:

The main objective of this course is to learn techniques in survey sampling with practical applications in daily life which would be beneficial for the students to further their research.

Course Specific Outcomes:

After successful completion of this course, student will be able to:

1. Understand the distinctive features of advanced sampling schemes and its related estimation problems
2. Learn about various design-based approaches to estimate parameters, with and without replacement sampling scheme, sampling with varying probability of selection.
3. Learn about the methods of unequal probability of selection under unified theory of sampling.
4. Learn about the applications of repetitive sample surveys.
5. Understand the concept of small area estimation techniques.
6. Learn about the randomized response techniques.
7. To understand the technique to deal with non-response errors.

UNIT I

Probability Proportional to Size (PPS) with replacement sampling, Lahiri's method and cumulative total method, Hansen-Hurwitz estimator for population mean and total, its variance and estimate of variance.

UNIT II

PPS without replacement sampling. Ordered estimators. Desraj ordered estimator and unbiased estimate of variance. Unordered estimators. Murthy's unordered estimator, expressions of Murthy’s estimator and its unbiased estimator for a sample of size 2.

UNIT III

Introduction to the unified theory of sampling. Horvitz - Thompson Estimator (HTE) of a finite population total/mean, expressions for variance of HTE and its unbiased estimator. Yates and Grundy form of variance of HTE and its unbiased estimate.

IPPS schemes of sampling due to Midzuno-Lahiri-Sen, Brewer, Durbin, and Rao (sample size 2 only), Rao-Hartley-Cochran sampling scheme for sample size n with random grouping.

UNIT IV

Introduction to repetitive surveys using successive sampling for two occassions. Introduction to small area estimation - direct and synthetic estimators.

UNIT V

Randomized Response techniques, Warner's method: related and unrelated questionnaire methods, Randomized responses for variables.

Non-sampling errors, estimation in presence of non-response and observational errors.

References:

1. Sukhatme, P. V. & Sukhatme, B. V. (1984). Sampling theory of surveys with applications. Piyush Publications.
2. Singh, D. & Chaudhary, F.S. (2018).Theory and Analysis of Sample Survey Designs. New Age International Publishers.
3. Des Raj and Chandhok (2000). Sampling Theory. Narosa.
4. Hedayat, A. S. & Sinha, B. K.(1991). Design and inference in finite population sampling. Wiley.
5. Mukhopadhyay, P. (2010). Theory and methods of survey sampling. PHI.
6. Mukhopadhyay, P. Topics in survey sampling. Springer.
7. Murthy, M. N. (1967).Sampling theory and methods. Stat. Publ. House, Calcutta.
8. Chaudhuri, A. & Vos J.W.E. (1988). Unified Theory and Strategies of Survey Sampling. North-Holland.
9. Chaudhuri, A., & Mukerjee R. (1988). Randomized Response: Theory and Techniques, Marcel Dekker.
10. Cochran, W. G. (1977). Sampling Techniques. Wiley.

STAT2CC504: Linear Models and Regression Analysis

(4 Credits – 4 hours of teaching per week)

Course Outcomes:

The main objective of this course is to provide students the ability to learn and use linear and models for normal data in case of continuous variables as well as in case of dummy variables.

Course Specific Outcomes:

After successful completion of this course, student will:

1. Know about the distribution of quadratic forms.
2. Have the knowledge about multiple linear regression and its assumptions.
3. Understand the application of multiple linear regression for dummy variables.
4. Occupy with the knowledge of mixed effect and random effect models.
5. Acquire the knowledge for applying the linear models in real life datasets.

UNIT I

Quadratic forms, reduction of quadratic forms, index, signature and classification of quadratic forms, Distribution of quadratic forms in multivariate normally distributed random vectors, Cochran Theorem.

UNIT II

Linear models of full rank, Assumptions for linear models, Estimation of model parameters: least squares method, Likelihood method, Properties of the estimators, analysis of variance for full rank model distribution of different sum of squares, Selecting the best regression equation: Forward selection method, backward elimination method and Stepwise regression.

UNIT III

Linear models not of full rank: Estimation for model parameters: least squares method, Likelihood method, Estimation and error spaces, estimable functions and their BLUE (Gauss-Markov Theorem), analysis of variance for not of full rank model, distribution of different sum of squares, test for general linear hypothesis.

UNIT IV

Fixed effect models, One way classification model and Two way classification (with interaction) model, Multiple comparison tests due to Tukey and Scheffe, Simultaneous confidence intervals.

UNIT V

Random effect models: One way and two way classifications, Mixed effect models: Two way classification.

Variance components estimation: study of various methods, Tests for variance components.

REFERENCES:

1. Cook, R.D. and Weisberg, S. (1982): Residual and Influence in Regression. Chapman and Hall press.
2. Draper, N.R. and Smith, H. (1998): Applied Regression Analysis, Third Edition Wiley.
3. Guest, R.F. and Mason, R.L. (1980): Regression analysis and its Applications - A Data Oriented Approach, Marcel and Dekker Inc.
4. Gujarati D., Porter D.C. and Gunasekar S. (2017): Basic Econometrics, McGraw hill
5. Johnston, J (1984): Econometric methods, 3rd Ed. Mc-Graw Hill.
6. Koch K.R. (1999): Parameter Estimation and Hypothesis Testing in Linear Models, Springer-Verlag.
7. Rancher A.C., Schaalje G.B. (2008): Linear Model in Statistics, Wiley International.
8. Rao, C.R. (1973): Linear statistical inference and its Applications, Wiley Eastern.
9. Searle S.R. (2016): Linear Models, Wiley Publishers
10. Wang S.G., Chow S.C (1994): Advanced Linear Models Theory and Applications, CRC Press.
11. Weisberg, S. (1985): Applied Linear Regression, Wiley.

STAT2CC505: Practical
(02 Credits)

Based on all theory papers of the semester

STAT2VC501: Statistical Analysis Using SPSS

(2 Credits- 2 hours of teaching per week)

Course Outcome:

The objective of this course is to make students understand the significance of Data Preparation for Data Analysis and how to present and interpret data using statistical analysis software package SPSS. Discuss Data Analysis using Frequency Diagrams and Cross Tabulations. Introduce the visual representation of variables in graphs, bar charts and histograms. Understand the role and scope of Descriptive Statistics and Inferential Statistics

Course Specific Outcomes:

After successful completion of this course, student will be able to:

1. Discuss Data Analysis using Frequency Diagrams and Cross Tabulations
2. Introduce the visual representation of variables in graphs, bar charts and histograms.
3. Understand the role and scope of Descriptive Statistics and Inferential Statistics
4. Get an insight into use of SPSS for Data Analysis

UNIT I

SPSS Environment & Interface, Data Preparation, Data Transformation: File Handling, File Transformation. Exploratory Data Analysis: Frequencies, Descriptive Statistics, Explore, Cross-tabs, Graphs.

UNIT II

Parametric and Nonparametric Tests: One and Two Sample problems. ANOVA: One-Way, Two-way ANOVA, ANCOVA, Repeated Measures ANOVA, Kruskal Wallis test.

UNIT III

Correlation and Partial Correlation, Simple and Multiple Linear Regression Models, Regression Diagnostics, Generalized Linear Regression Models: Binary Logistic, Ordinal Logistic.

UNIT IV

Factor Analysis, Discriminant Analysis, Nearest Neighbour Analysis, Choosing Procedures for Clustering, Two Step Cluster analysis, K -Means Cluster Analysis, Hierarchical Cluster Analysis.

REFERENCES:

1. Aljandali A (2016): Quantitative Analysis and IBM® and SPSS® Statistics, Springer Inc.
2. Aljandali A (2017): Multivariate Methods and Forecasting with IBM® and SPSS® Statistics, Springer Inc.
3. Antonius R (2003): Interpreting Quantitative Data with SPSS, Sage Publication.
4. Babbie, E.R., Wagner, W.E. and Zaino, J.S. (2022): Adventures in Social Research: Data Analysis Using IBM SPSS Statistics.
5. Cunningham, J.B. and Aldrich, J.O. (2024): Using SPSS: An Interactive Hands-on Approach.
6. Denis D.J. (2019): SPSS Data Analysis for Univariate, Bivariate and Multivariate Statistics
7. Field, A. (2019): Discovering Statistics using IBM SPSS Statistics.
8. Leech, N.L., Barrett, K.C. and Morgan, G.A. (2014): IBM SPSS for intermediate statistics: use and interpretation.
9. Malhotra N.K., Briks D.F., (2022): Marketing Research: An Applied Approach, Prentice Hall.
10. Margan G A: SPSS for Introductory Statistics; Uses and Interpretation.
11. Marques de Sá J.P. (2003): Applied Statistics using SPSS, STATISTICA and MATLAB, Springer-Verlag.
12. Norris G., Qureshi F., Howitt D. and Cramer D. (2012): Introduction to Statistics with SPSS for Social Science.
13. Practical Work Book by Bristol Information Services: Introduction to SPSS for Windows.
14. Prasad L. and Mishra P. (2022): Data analysis using SPSS: Text and Cases.

SEMESTER II

STAT2CC506: Machine Learning

(4 Credits – 4 hours of teaching per week)

Course Outcome:

This course aims to empower the learners to leverage machine learning for strategic decision-making in the real-world decision making. The course demystifies machine learning concepts, providing a foundational understanding of its role in data-driven decision making. The course emphasizes the conceptual understanding and practical implications of machine learning, focusing on how it can be harnessed to uncover patterns, make informed predictions, and drive data-driven decision-making within various domain contexts.

Course Specific Outcome:

After successful completion of this course, student will be able to:

1. Gain a broad introduction to Machine Learning and statistical pattern recognition.
2. Develop a deep understanding of machine learning algorithms.
3. Apply machine learning techniques for modelling of data.
4. Build the conceptual and practical skills to apply machine learning models to the real-life decision-making situations.

UNIT I

Understanding Data Science and its variants: Differentiating between Data Science (DS), Artificial Intelligence (AI), Data Mining (DM), Machine Learning (ML), Types of Machines Learning algorithms – Supervised, Unsupervised, Reinforcement learning algorithms.

Steps for developing machine learning algorithms: CRISP-DM.

Introduction to Python Programming: Python basics: syntax and styles, data types, operators and expressions; Decision and looping statements; Python Data Structure: List, Tuples, Sets and Dictionary. Core python libraries: NumPy, Pandas, Matplotlib, Seaborn.

UNIT II

Pre-processing data – gathering & cleaning data, handling Missing values, and outliers; feature engineering: standardization, normalization, transformations to achieve normality, transforming categorical variables; exploratory data analysis and descriptive analytics – univariate and bivariate analysis, exploring data using visualization.

UNIT III

Machine learning mathematics- Gradient descent and learning rates, Momentum; Constrained optimization: Lagrange multiplier, KT conditions, KKT conditions; Singular value decomposition, Markov chain and hidden Markov models, Kernel methods.

UNIT IV

Supervised learning regression- regression analysis, gradient descent: batch gradient descent, stochastic gradient descent, mini-batch gradient descent. Regularization: ridge regression, LASSO regression, elastic net regression, grid search, machine leaning pipeline; debugging learning algorithms, machine learning diagnostics.

Supervised learning classification-logistic regression, K-nearest neighbour classifier, naïve Bayes classifier, support vector machine, decision tree, ensemble learning, bagging algorithm: random forest classifier, boosting algorithm: adaptive boosting, gradient boosting, extreme gradient boosting.

UNIT V

Unsupervised learning- clustering: k-mean clustering, hierarchical clustering, DBSCAN; dimensionality reduction, anomaly detection algorithms.

Recommender systems: association rule mining, content-based recommendation, Collaborative filtering-user-based similarity, Collaborative filtering-item-based similarity, mean-normalization

References:

1. Christopher M. Bishop(2006), Pattern Recognition and Machine Learning, Springer
2. D. P. Kroese, Z. I. Botev, T. Taimre and R. Vaisman(2020), Data Science and Machine Learning, Chapman and Hall/ CRC Press.
3. James G., Witten D., Hastie T., Tibshirani R. and Taylor J.(2023), An Introduction to Statistical Learning with Applications in Python, Springer
4. M. Pradhan and U Dinesh Kumar (2019), Machine Learning using Python, Wiley Publication.
5. R. O. Duda, P. E. Hart and D. G. Stork (2021), Pattern Classification, Wiley Publication.
6. Trevor Hastie, Robert Tibshirani and Jerome Friedman (2017), The Elements of Statistical Learning: Data Mining, Inference and Prediction, Springer Series in Statistics.
7. Kaggle website: https://www.kaggle.com/
8. Medium website: https://medium.com/
9. Github website: https://github.com/

STAT2CC507: Estimation Theory

(4 Credits – 4 hours of teaching per week)

Course Outcome:

The main objective of this course is to provide in depth knowledge to students the advanced topics in estimation theory. The present course provides insight to some important concepts that shall provide a solid foundation to several courses taught in this post graduate programme.

Course Specific Outcomes:

After successful completion of this course, student will be able to:

1. Appreciate the concepts related to information and its use in definition of sufficiency.
2. To gain insights to different important concepts like completeness and minimal sufficiency.
3. Appreciate the concepts of consistency and accuracy.
4. Understand the concept of minimum variance unbiased estimation and its linkage lower bounds.
5. To gain knowledge about the maximum likelihood estimation and BAN.
6. To understand the sequential and learn its applications.

UNIT I

Information in Likelihood Function, Sufficiency, Neyman Factorizability Criterion, likelihood Equivalence, Minimal Sufficient Statistic. Completeness, Bounded Completeness. Exponential families and Location-Scale Families, Invariance property of sufficiency under one-one transformation of sample space and parameter space.

UNIT II

Consistent Estimation of real and vector valued parameter. Invariance of Consistent estimator under continuous transformation. Asymptotic relative efficiency, Error probabilities and their rates of convergence, Minimum sample size required to attain given level of accuracy.

UNIT III

Minimum variance unbiased estimators. Rao-Blackwell Theorem, Lehmann – Scheffe theorem, necessary and sufficient conditions for MVUE, Cramer – Rao lower bound approach, Fisher Information for one and several parameters' models. Chapman Robins Theorem, Bhattacharya Bounds.

UNIT IV

Method of maximum likelihood, Solution of likelihood equations, Method of scoring, Newton - Raphson and other iterative procedures, CAN (Consistent Asymptotic Normal),Best Asymptotic Normal (BAN) estimators, Cramer - Huzurbazar theorem.

UNIT V

Sequential Unbiased Estimation, Wald's equation, Wolfowitz inequality, Sequential Estimation of normal population mean.

References:

1. Rohatgi, V.& Salah A.K.M.E. (2015). An Introduction to Probability and Mathematical Statistics. Wiley.
2. Lehmann, E. L. (2005). Theory of Point Estimation, Springer.
3. Rao, C. R. (2001). Linear Statistical Inference, Wiley.
4. Dudewicz, E. J. and Mishra, S. N.(1998). Modern Mathematical Statistics. Wiley.
5. Kale, B. K. (2005). A first Course on Parametric Inference, Narosa Publishing House.
6. Srivastava, M., Khan, A.H. and Srivastava, N.(2009). Statistical Inference: Theory of Estimation, PHI.
7. Ferguson, T. S. (1967). Mathematical Statistics. Academic Press.
8. Ferguson, T. S. (1996).A course on Large Sample Theory. Chapman and Hall.
9. Zacks, S. (1971). Theory of Statistical Inference, Wiley.
10. Wald, A. (2004).Sequential Analysis, Dover.
11. Goon, A.M., Gupta, M.K. & Dasgupta B. An Outline of Statistical Theory: Volume I, World Press.
12. Mukhopadhyay, N. & de Silva, B. M. Sequential methods and their applications, CRC Press.

STAT2CC508: Multivariate Analysis

(4 Credits – 4 hours of teaching per week)

Course Outcome:

The main objective of this course is to introduce students to the analysis of observations on several correlated random variables for a number of individuals. Such analysis becomes necessary in Anthropology, Psychology, Biology, Medicine, Education, Agriculture and Economics when one deals with several variables simultaneously.

Course Specific Outcomes:

After successful completion of this course, student will be able to:

1. Account for important theorems and concepts in multivariate analysis.
2. Summarize and interpret multivariate data.
3. Appreciate the range of multivariate techniques available.
4. Understand the link between multivariate techniques and corresponding univariate techniques.
5. Conduct statistical inference about multivariate means including hypothesis testing, confidence region calculation, etc.
6. Use multivariate techniques appropriately and draw appropriate conclusions.

UNIT I

Review of Multivariate Normal distribution theory, Multivariate central limit theorem. Wishart distribution and its properties, Null and non-null distribution of simple correlation coefficient, Null distribution of partial and multiple correlation coefficient, Distribution of sample regression coefficients, Applications in testing and interval estimation.

UNIT II

Hotelling's T^2 statistic and its Null distribution, its application: tests on mean vector for one and more multivariate normal population, test for equality of the components of a mean vector in a multivariate normal population. Mahalanobis D^2, Wilk's Lambda Criterion.

UNIT III

Classification and discrimination procedures for discrimination between two multivariate normal populations-sample discriminant function, test associated with discriminant functions, probabilities of misclassification and their estimation, classification into more than two multivariate normal populations, Fisher Behrens Problem.

UNIT IV

Canonical variables and canonical correlations: definition, use, estimation, and computation. Dimensionality reduction, Principal components analysis, Scree Plot.

Factor analysis, Linear factor models, Estimation of factor loadings, Factor rotation, Estimation of factor scores, goodness of fit of model.

UNIT V

Multivariate Analysis of variance (MANOVA) for one-way and two – way classified data only.

Cluster analysis, K-means, Hierarchical clustering, dendrogram.

REFERENCES:

1. Afifi, A., May, S., Donatello, R., & Clark, V. A. (2019). Practical Multivariate Analysis. CRC Press.
2. Johnson, R. A., Wichern, D. W. (2019). Applied Multivariate Statistical Analysis. Pearson
3. Raykov, T., & Marcoulides, G. A. (2008). An Introduction to Applied Multivariate Analysis. Routledge.
4. Izenman A.J. (2006), Modern Multivariate Statistical Techniques, Springer.
5. Rencher, A. C. (2003). Methods of Multivariate Analysis. John Wiley & Sons.
6. Sharma, S. (1996). Applied multivariate techniques. Wiley.
7. Johnson, R.A. & Wichern, D.W. (1992) Applied Multivariate Statistical Analysis. 3rd Edition, Prentice Hall, Upper Saddle River.
8. Seber, G.A.F. (1984). Multivariate observations. Wiley
9. Anderson T.W. (1983). An Introduction to Multivariate Statistical Analysis (Second Edition) Wiley.
10. Muirhead, R.J. (1982). Aspects of Multivariate Statistical Theory, John Wiley & Sons, Inc.
11. Srivastava M.S. & Khatri C.G. (1979). An Introduction to Multivariate Statistics. North Holland.
12. Giri, N.C. (1977). Multivariate Statistical Inference. Academic Press.
13. Morrison, D.F. (1976). Multivariate Statistical methods. 2nd. Ed. McGraw Hill.
14. Rao C.R. (1973). Linear Statistical Inference and its Applications 2nd. Ed. Wiley.

14\. Kshirsagar A.M. (1972). Multivariate analysis. Marcel Dekker.

STAT2CC509: Stochastic Processes

(4 Credits – 4 hours of teaching per week)

Course Outcome:

The main objective of this course is to develop awareness for the use of stochastic models for representing random phenomena evolving in time such as inventory or queuing situations or stock prices behaviour.

Course Specific Outcomes:

After successful completion of this course, student will be able to:

1. Use notions of long-time behaviour including transience, recurrence, and equilibrium in applied situations such as branching processes and random walk.
2. Construct transition matrices for Markov dependent behaviour and summarize process information.
3. Use selected statistical distributions for modelling various phenomena.
4. Understand the principles and objectives of model building based on Markov chains, Poisson processes and Brownian motion.

UNIT I

Introduction to stochastic processes, Classification of stochastic processes according to state space and time domain, Markov chains, transition probabilities, transition matrix, order of Markov chain, Chapman-Kolmogorov equations, calculation of n-step transition probability and its limit.

UNIT II

Classification of states, random walk and gambler's ruin problem, discrete state space continuous time Markov Chains: Kolmogorov-Feller differential equations, Wiener process as a limit of random walk.

UNIT III

Poisson process, Postulates for Poisson process, pure birth process, linear birth process, pure death process, linear death process, general birth and death process.

UNIT IV

Renewal theory: Preliminaries, Elementary renewal theorem, Statement and uses of key renewal theorem, study of residual life time process.

Stationary process, weakly stationary and strongly stationary process, Moving average and auto regressive processes.

UNIT V

Branching process: Galton-Watson branching process, probability of ultimate extinction, distribution of the total number of progeny.

Martingale: Definitions and some examples, Stopping time, Martingales stopping Theorem, Wald equation.

REFERENCES

1. Adke, S.R. and Munjunath, S.M. (1984): An Introduction to Finite Markov Processes, Wiley Eastern.
2. Allen, L.J.S. (2010): An Introduction to Stochastic Processes with Applications to Biology, Second Edition. CRC Press.
3. Basu, A.K. (2007): Introduction to Stochastic Process, Narosa Publishing House Pvt. Ltd.
4. Bhat, B.R. (2000): Stochastic Models: Analysis and Applications, New Age International, India.
5. Cinlar, E. (1975): Introduction to Stochastic Process, Prentice Hall.
6. Feller, W. (1968): Introduction to probability and its Applications, Vol.1, Wiley Eastern.
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8. Hoel, P.G., Port, S.C. and stone, C.J. (1972): Introduction to Stochastic Process, Houghton Miffin& Co.
9. Jagers, P. (1974): Branching Processes with Biological Applications, Wiley.
10. Karlin, S. and Taylor H.M. (1975): A First course in stochastic processes, Vol. I Academic press.
11. Kulkarni, V.G. (2017): Modeling and Analysis of Stochastic Systems. CRC Press.
12. Medhi, J. (1982): Stochastic Processes, Wiley Eastern.
13. Parzen E. (1962): Stochastic Processes. Holden –Day.

STAT2CC510: Practical

(2 Credits)

Practical based on all the theory papers of the semester

STAT2IER501: Applied Statistics

(2 Credits – 2 hours of teaching per week)

Course Outcome:

This program is designed to improve the knowledge of statistics and its application in applied fields. Our aim is to strengthen the students on application part with clear understanding of domain part.

Course Specific Outcomes:

This course will provide students with an opportunity to develop understanding of:

1. Statistical tools use for other discipline and their applications.
2. Critical thinking and problem solving in domain area.
3. Understanding the concepts of different sampling procedures.
4. Understand Basic Inferential Statistics.

Note: The topics will be discussed with suitable examples and don't involve any kind of derivations. The use of non-programmable scientific calculator is permissible.

UNIT I

Introduction to Statistics, Classification of data: On the basis of collection, on the basis of measurement scales, on the basis of its nature. Tabular representation of data: frequency Distributions and contingency tables. Diagrammatic and Graphical Representation of data

UNIT II

Measures of Central Tendency: Arithmetic Mean, Median, Mode, Geometric Mean and Harmonic Mean. Measures of Dispersion: Range, Mean deviation, Standard Deviation and Quartile deviation. Skewness and Kurtosis. Correlation and Regression.

UNIT III

Sample Surveys, Steps involved in survey sampling. Sampling techniques: Simple random sampling, Stratified sampling. Purposive sampling, Judgement sampling, Quota sampling, Snowball sampling.

UNIT IV

Introduction to Estimation theory: Point and Interval. Testing of Hypothesis. Null and alternative hypothesis, errors in testing of hypothesis, level of significance, power of test, p-value.

Parametric tests: single sample t-test, Independent sample t-test, Paired sample t-test.

References:

1. Goon A.M., Gupta M.K. and Dasgupta B.: Fundamentals of Statistics Vol.1, World Press.
2. Goon A.M., Gupta M.K. and Dasgupta B.: Fundamentals of Statistics Vol.2, World Press.
3. Cochran, W.G.: Sampling Techniques, Wiley.
4. Snedecor G.W. and Cochran W.G. (1989): Statistical Methods, Wiley.
5. Daniel W.W., Cross C.L. (2014): Biostatistics Basic concepts and methodology for Health Sciences, Wiley.

SEMESTER III

STAT2CC601: Block Design and Their Analysis

Course Outcomes:

This course provides the understanding to the students with both theoretical and practical knowledge of block designs, preparing them to design, conduct, and analyze experiments to draw meaningful conclusions.

Course Specific Outcomes:

After successful completion of this course, students will be able to:

1. Design and analyze incomplete block designs, and understand the concepts of connectedness, balance, and orthogonality.
2. Understand the applicability of Graeco Latin square and Youden square designs.
3. Understand the analysis of covariance and Split-plot designs and their analysis in practical situations.
4. Understand the concepts of MOLS and finite geometries, which are useful in the construction of BIBDs.
5. Understand the concept and role of partially balanced incomplete block design.
6. Learn how to handle more complex experimental designs with multiple layers of blocking for example split-plot designs where blocks themselves are subjected to additional treatments.
7. Understand how to draw conclusions based on experimental results, interpreting the statistical significance and practical implications.
8. Understand the effects of independence or dependence of different factors under study.

UNIT I

Concept of incomplete block design, Balanced Incomplete Block Design (BIBD): Parameters, Relationship among its parameters, incidence matrix and its properties, the relative efficiency of BIBD compared to RBD. Definitions and properties: symmetric, complement, resolvable, affine resolvable, residual, and dual BIBDs.

UNIT II

General block design and its information matrix, criteria for connectedness, balancing, orthogonality and efficiency. Intrablock analysis of general block incomplete block designs. Estimability, best point estimates/Interval estimates of estimable linear parametric functions and testing of linear hypotheses.

UNIT III

Analysis of BIBDs with and without recovery of interblock information. Lattice design, Partial BIBD, Graeco Latin square design, Youden square design and its Intrablock analysis.

UNIT IV

Finite group and finite field, Finite geometry: Projective and Euclidean, Construction of a complete set of mutually orthogonal Latin square (MOLS), Construction of BIBDs using MOLS, finite geometries and method of difference.

UNIT V

Analysis of covariance in a general Gauss-Markov model and its applications to standard designs, Missing plot technique - general theory and applications. Split plot design.

References

1. Chakrabarti, M.C. (1970): Mathematics of Design and Analysis of Experiments, Asia Publishing House.
2. Das, M.N. & Giri, N. (1979): Design and Analysis of Experiments, Wiley Eastern.
3. Das, M.N. & Giri, N. (2017): Design and Analysis of Experiments, New Age International.
4. Dean, A., Voss, D., & Draguljić, D. (2017): Design and Analysis of Experiments, Springer.
5. Dey, A. (2010): Incomplete Block Designs, Hindustan Book Agency.
6. Giri, N. (1986): Analysis of Variance, South Asian Publishers.
7. Gupta V. K. & Nigam A. K. (1978-79): Handbook an analysis of Agriculture Experiment, IASRI Publication.
8. John, P.W.M. (1971): Statistical design and analysis of experiments, Mc Millan.
9. Joshi, D.D. (1987): Linear Estimation and Design of Experiments, Wiley Eastern.
10. Lawson, J. (2015): Design and Analysis of Experiments with R, Chapman & Hall/CRC.
11. Montgomery, C.D. (2012): Design and analysis of experiments, Wiley, New York.
12. Nigam A. K, Puri P. D. & Gupta V. K. (1987-88): Characterisation and Analysis of Block Design, Wiley Eastern.
13. Panneerselvam, R. (2012): Design and Analysis of Experiments, PHI Learning Private Limited, Delhi.
14. Raghavarao, D. (1971): Construction and Combinatorial problems in Design of Experiments. Wiley
15. Searle, S.R., Casella, G. & McCulloch, C.E. (1992): Variance Components, Wiley.

STAT2CC602: Econometrics

(4 Credits – 4 hours of teaching per week)

Course Outcome:

The objective of this course is to study more advanced topics in econometrics, simultaneous linear equations, 2-SLS, 3-SLS estimators and simulation method used in case of econometrics.

Course Specific Outcomes:

After successful completion of this course, student will be able to:

1. Acquire knowledge of various advanced econometric models, estimation methods and related econometric theories.
2. Conduct econometric analysis of data.
3. Apply statistical techniques to model relationships between variables and make predictions.
4. Use the regression analysis in case of any of assumption of general linear model is violated.

UNIT I

Nature of econometrics, review of general linear model (GLM) and its assumptions, Residuals and its types: Simple, Standardized and Studentized.

Assumption of Normality, effect of violation of assumption of Normality in GLM, Various methods used for the detection of departure from Normality: Kolmogorv-Smirnov test for goodness of fit, Shapiro-Wilk's test, Jarque–Bera test, Anderson–Darling test, Remedial measures for violation of normality: transformation of variables, Box - Cox transformation.

UNIT II

Assumption of Homoscedasticity in GLM, Effect of presence of Heteroscedasticity on Ordinary Least Square (OLS) estimates, Different methods for the detection of Homoscedasticity: Residual plot, Park's Test, Glejser Test, Spearman's rank correlation test, Goldfled-Quandt Test, Breusch-Pagan-Godfrey Test, White's General Heteroscedasticity test.

Remedial measures for Heteroscedasticity.

Generalized least square method, weighted least square method, White's Heteroscedasticity-Consistent Variances and Standard Errors.

UNIT III

Assumption of Multicollinearity, Effect of presence of Multicollinearity on OLS estimates, Different methods for the detection of Multicollinearity: pair-wise correlation, coefficient of determination, partial correlation, auxiliary regressions, Eigen value and condition index, tolerance and variance inflation factor (VIF), Remedial measures for Multicollinearity, Ridge Regression.

UNIT IV

Autocorrelation and serial correlation, Effect of autocorrelation on OLS estimators, Detection of presence of autocorrelation: Graphical method, run test, Durbin-Watson test.

Simultaneous linear equations model, Examples, Identification problem, Restrictions on structural parameters - rank and order conditions, Restrictions on variances and covariances.

UNIT V

Estimation in simultaneous equations model, Recursive systems, 2 Stage Least Square (SLS) Estimators. Limited information estimators, k - class estimators. 3 SLS estimation, Full information maximum likelihood method, Prediction and simultaneous confidence intervals.

REFERENCES:

1. Apte, PG (1990): Text book of Econometrics. Tata McGraw Hill.
2. Cramer, J.S. (1971): Empirical Econometrics, North Holland.
3. Greene W.H. (2018), Econometrics Analysis, Pearson Publication
4. Gujarathi, D. (2012): Basic Econometrics, McGraw hill.
5. Intrulligator, MD, Bodkin R.G., Hsiao C. (1996): Econometric models - Techniques and applications, Prentice Hall of India.
6. Johnston, J (1984): Econometric methods, 3rd Ed. Mc Graw Hill.
7. Klein, L.R. (1968): An introduction to Econometrics, Prentice Hall of India.
8. Koutsoyiannis, A (1979): Theory of Econometrics, Macmillan Press.
9. Madala GS., Lahiri K. (2001), Introduction to Econometrics, John Wiley & Sons Inc.
10. Malinvaud, E (1975): Statistical methods of Econometrics, North Holland.
11. Srivastava, V.K. and Giles D.A.E. (2020): Seemingly unrelated regression equations models, Vol. 80, Maicel Dekker.
12. Theil, H. (1982): Introduction to the theory and practice of Econometrics, john Wiley.
13. Walters, A.A. (1970): An introduction to Econometrics, McMillan & Co.
14. Watherill, G.B. (1986): Regression analysis with applications, Chapman Hall.

STAT2CC603: Testing of Hypotheses

(4 Credits – 4 hours of teaching per week)

Course Outcome:

The main objective of this course is to provide in depth knowledge to students the testing of hypotheses. The present course provides insight to some important concepts that shall provide a solid foundation to several courses taught in this post graduate programme.

Course Specific Outcomes:

After successful completion of this course, student will be able to:

1. Appreciate the concepts related to tests of hypotheses and its applications.
2. To gain insights to different important results like NP Lemma, GNP Lemma and their applications.
3. Appreciate the concept of likelihood ratio tests and their asymptotic distribution.
4. Understand the concept of monotone likelihood ratio and its application to Karlin Rubin theorem.
5. To gain knowledge about the importance of confidence sets and its relation with tests.
6. To understand the sequential tests and learn about their various applications.

UNIT I

Tests of Hypotheses, Concepts of randomized and non-randomized tests, test functions, size function, power function, level of significance, p-value, MP and UMP tests in class of size α tests, Neyman - Pearson Fundamental Lemma, UMP tests for simple null hypothesis against onesided alternative and for one sided null against one sided alternative in one parameter exponential family.

UNIT II

Non-existence of UMP test for simple null against two sided alternatives in one parameter exponential family. Generalized NP Lemma, Construction of Type A and Type A1 critical regions. Similar Tests, UMP Similar Tests, Unbiased Tests, UMP Unbiased tests.

UNIT III

Monotone Likelihood Ratio, Karlin Rubin Theorem, and its applications.

Likelihood Ratio(LR) Test, Asymptotic distribution of LR test statistic. Some important LR tests. Large Sample Tests and confidence intervals based on BAN estimators, Variance stabilizing transformation and large sample tests. Consistency of Large Sample Tests, Asymptotic power of large sample tests.

UNIT IV

Confidence sets, confidence level, confidence intervals, construction of confidence intervals using pivots, shortest expected length confidence interval, uniformly most accurate (UMA) confidence intervals and its relation to UMP tests.

UNIT V

Sequential Tests, Stopping variables, Wald's equation for ASN, Sequential Probability Ratio Test and its properties – fundamental identity, OC and ASN functions. Stein two stage procedure.

References

1. Rohatgi, V.& Salah A.K.M.E. (2015). An Introduction to Probability and Mathematical Statistics. Wiley.
2. Lehmann, E. L.(2005). Theory of Point Estimation, Springer.
3. Rao, C. R. (2001). Linear Statistical Inference, Wiley.
4. Dudewicz, E. J. and Mishra, S. N. (1998). Modern Mathematical Statistics. Wiley.
5. Kale, B. K. (2005). A first Course on Parametric Inference, Narosa Publishing House.
6. Srivastava, M, Khan, A.H. and Srivastava, N.(2009). Statistical Inference: Theory of Estimation, PHI.
7. Ferguson, T. S. (1967). Mathematical Statistics. Academic Press.
8. Ferguson, T. S. (1996). A course on Large Sample Theory. Chapman and Hall.
9. Zacks, S. (1971). Theory of Statistical Inference, Wiley.
10. Wald, A. (2004). Sequential Analysis, Dover.
11. Ghosh, B.K. (1970). Sequential Tests of Statistical Hypotheses, Addison-Wesley.
12. Mukhopadhyay, N. & de Silva, B. M. (2008): Sequential methods and their applications, CRC.
13. Gun A.M., Gupta M.K., Dasgupta B. (2003), Outline to the theory of Statistics: Vol II, World Press Organization.
14. Casella G., Berger R.L. (2024), Statistical Inference, CRC Press.

STAT2EL601A: Population Studies

(4 Credits – 4 hours of teaching per week)

Course Outcome (CO):

This course provides an in-depth understanding of demographic data, theories of population growth, fertility, mortality, migration, and human development indices. Students will gain skills to analyze age-sex structures, adjust demographic data, and interpret trends and differentials in fertility, mortality, and migration. The course emphasizes advanced methods such as life tables, population growth models, and migration theories, enabling students to assess population dynamics. It also explores the interplay of gender and human development, equipping learners with tools to critically evaluate development indices and design evidence-based policies.

Course Specific Outcomes (CSOs):

Upon successful completion of the course, students will be able to:

1. Understand the profile and role of Indian Census data, population registers, and official statistics in demographic studies.
2. Analyze errors in demographic data using indices such as Chandrasekharan-Deming, Whipple, and Myer, and adjust age data effectively.
3. Evaluate theories of population growth, including the Malthusian Theory and the Theory of Demographic Transition, in historical and contemporary contexts.
4. Apply measures and determinants of fertility, mortality, and nuptiality, using advanced methods like Lexis Diagrams, life tables, and standardization techniques.
5. Interpret migration trends, differentials, and models, with a special focus on rural-urban migration and to understand migration and urbanization in India.
6. Develop population projections using algebraic, Gompertz, logistic, and cohort component models to assess growth dynamics.
7. Critically analyze gender and human development through indices like the Human Development Index (HDI), Gender Development Index (GDI), and Happiness Index, to inform equitable policymaking.

UNIT I

Demographic data: Profile of Indian Census, population registers and official statistics. Age-Sex structure of population, Population Pyramids. Errors and adjustments in demographic data. Chandrasekharan and Deming index. Age heaping and digit preference. Adjustment of age data using Whipple and Myer indices.

Theory of population growth- Malthusian Theory, Theory of Demographic Transition.

UNIT II

Period and Cohort fertility. Differentials and determinants of fertility. Trends of fertility in India. Measures of Fertility. Measures of Reproduction, Nuptiality and its indicators. Davis and Blake intermediate determinants of fertility, Bongaarts proximate determinants of fertility. Indirect estimation of fertility: Lexis Diagram and Reverse survival method.

UNIT III

Differentials and determinants of mortality. Measures of Mortality. Standardization of Death Rates. Morbidity, Reproductive morbidity, Co-morbidity. Life table: Construction of complete and abridged life tables; Types of life tables.

UNIT IV

Migration and its measures. Types of migration. Trends and differentials of migration with special reference to India. Migration theories- Lee's theory, Ravenstein Law; Migration models- Zipf' model, Stouffer's model, Harris Todaro model of rural-urban migration; Direct methods of estimation of migration from Census data. Concept of Urbanization and its association with migration.

UNIT V

Intrinsic growth rate; doubling time. Stable, quasi-stable and stationary population. Models of Population growth and projection: Algebraic models, Gompertz model, Logistic model; Cohort Component method.

Concept of gender and human development; Human Development Index; Inequality Adjusted Human Development Index; Gender Development Index, Happiness Index.

REFERENCES-

1. Bogue D. J.(1968).: Principles of Demography, John Wiley Publications
2. Ram F. & Pathak K.B.: Techniques of Demographic Analysis (1998). Himalaya Publishing House
3. Keyfitz N., Caswell H. (2005): Applied Mathematical Demography. Third Edition, Springer.
4. Cox P. R. (1970): Demography, Cambridge University Press.
5. Keyfitz N. (1968): Introduction to the mathematics of population. Addison Wesley Publishing Company.
6. Srinivasan K. (2011): Training Manuals on Demographic Techniques. UNFPA.
7. Pollard A.H., Yusuf F, Pollard G.N. (1981): Methods of Demographic Analysis. Springer Publication.
8. Bhinde A, Kanitkar T : Principles of Population Studies. Himalaya Publishing House
9. Preston S., Patrick H., Michel G.: Measuring and Modeling Population Processes. Wiley Publications
10. Hunt, J, 2004. 'Introduction to gender analysis concepts and steps', Development Bulletin.
11. Kimmel S Michael (2004) The Gendered Society; Reader. Oxford: Oxford University Press.
12. United Nations: Guidelines for producing Statistics on Asset Ownership from a gender perspective.

STAT2EL601B: Advanced Machine Learning

(4 Credits – 4 hours of teaching per week)

Course Outcome:

In this course students will be given an exposure to the details of neural networks as well as deep learning architectures and to develop end-to-end models for such tasks. Students will be able to learn to implement, train and debug the neural networks. This course aims to study the basics of deep learning and neural networks and their various applications that can be used to solve problems in various domains such as Computer Vision, Speech and NLP etc.

Course Specific Outcome:

After successful completion of this course, student will be able to:

1. Gain a broad introduction to the fundamental concepts of deep learning and artificial neural network
2. Develop a deep understanding of deep learning architecture and algorithms
3. Design, implement, and validate deep learning-based solutions to machine learning problems
4. Under and learn concept and applications of Convolutional Neural Networks (CNNs), Recurrent Neural Network (RNNs), Computer Vision and Natural Language Processing (NLP)

UNIT I

Introduction to Deep Learning, Neural Network: Introduction, Challenges of shallow neural networks and motivation of Deep Learning, Neural Network Architecture, Neural Network Models, Neural Network Classification, Cost function, Overfitting and Underfitting, bias and variance.

UNIT II

Gradient based optimization: Training a neural network, Activation functions, building a neural network, Binary class classification, Forward propagation: making predictions, Deep Feed-forward network, backpropagation algorithm, Random Initialization, Multi-class classification, multi-label classification, regularization and optimization Techniques, hyper-parameter tuning.

UNIT III

End-to end Deep Learning, Convolutional Neural Network, Padding, Strided convolution, Convolution over volumes, Pooling layers, Classic Convolution Networks, Deep Convolution Models, Methodology and Applications of deep learning. Transfer Learning: learning from multiple tasks, Data Augmentation using pre-trained Networks.

UNIT IV

Recurrent Neural Network, Language Model and Sequence Generation, Gated Recurrent Unit, Deep RNN; Deep Generative Models: Boltzmann Machine, RBM, Deep Belief Nets, Deep Boltzmann Machine, Convolutional Boltzmann Machine

Unit V

Deep Learning in Practice: Computer Vision, text, and sequence. Detection Algorithms, Object Detection, Face Recognition, Long Short Term Memory (LSTM); NLP and Word Embedding, Sentiment Classification, Sequence to Sequence Models; Attention Models; Transfer Networks; Generative Adversarial Network (GAN).

References

1. Andrew W. Trask (2019), Grokking Deep Learning, Manning Publication.
2. Francois Chollet (2018), Deep Learning with Python, Manning Publication.
3. Ian Goodfellow, Yoshua Bengio and Aaron Courville (2016), Deep Learning, The MIT Press.
4. Mohamed Elgendy (2020), Deep Learning for Vision Systems, Manning Publication.
5. Nikhil Ketkar and Jojo Moolayil (2021), Deep Learning with Python, Apress Publications.
6. Seth Weidman (2019), Deep Learning from Scratch, O'Reilly Publication.
7. Simon Haykin (2020), Neural Networks and Learning Machines, Pearson Publications.
8. GitHub website: https://github.com/
9. Kaggle website: https://www.kaggle.com/
10. Medium website: https://medium.com/

STAT2EL601C: Qualitative Data Analysis

(4 Credits – 4 hours of teaching per week)

Course Outcome:

This course equips students with the necessary skills to analyse and interpret qualitative data to answer research and policy questions

Course Specific Outcomes:

Upon successful completion, students will have the knowledge and skills to:

1. Understand a range of qualitative analysis approaches that are commonly employed across disciplines;
2. Critically evaluate the advantages and disadvantages of a variety of qualitative analysis methods and select appropriate methods for application;
3. Develop and apply skills in thematic coding techniques;
4. Apply skills in qualitative data analysis using appropriate data management software;
5. Assemble and present the results of qualitative research analyses in written and oral formats.

UNIT I

Categorical response variables: Nominal, ordinal, interval. Probability structure for contingency tables: joint, marginal and conditional probabilities, sensitivity and specificity, independence. Comparing proportions in 2x2 Tables: difference of proportions, relative risk. Odds Ratio: definitions and properties of odds ratio with examples, inference for odds ratio and log odds ratio, relationship between odds ratio and relative risk. Chi-square tests of independence: Pearson statistic, likelihood ratio statistic, tests of independence, partitioning Chi-squared.

UNIT II

Testing independence for ordinal data: linear trend alternative to independence, extra power with ordinal test, choice of score, trend tests for Ix2 and 2xJ tables, nominal-ordinal tables. Exact inference for small samples: Fisher's exact test for 2x2 table, p-values and conservatism for actual P(Type I error), small sample confidence interval for odds ratio. Association in three-way table: partial tables, conditional versus marginal associations, Simpson's paradox, conditional and marginal odds ratios, conditional independence versus marginal independence, homogeneous associations.

UNIT III

Models for binary response variables: logit, log linear, linear probability and logistic regression models. Logit models for categorical data, probit and extreme value models, models with log-log link, model diagnostics. Fitting logit models, conditional logistic regression, exact trend test. Log-linear models for two dimensions - independence model, saturated model and models for cell probabilities.Item Response Theory, Rasch Model.

UNIT IV

Loglinear models for two-way and three-way tables: log-linear model of independence for two-way table, saturated model for two-way tables, log-linear models for three-way tables. Inference for loglinear models: Chi-squared goodness of fit tests, log-linear cell residuals, tests about conditional associations, confidence intervals for conditional odds ratios, three factor interactions, large samples and statistical versus practical significance. Fitting Loglinear models. Strategies in model selection, analysis of residuals, Cochran-Mantel-Haenszel test.

UNIT V

Models for Matched Pairs: Comparing Dependent Proportions, Conditional Logistic Regression for Binary Matched Pairs, Marginal Models for Square Contingency Tables, Symmetry, Quasi-symmetry, and Quasi independence, Analyzing Repeated Categorical

Response Data: Comparing Marginal Distributions: Multiple Responses, Marginal Modeling: Maximum Likelihood Approach, Marginal Modeling: Generalized Estimating Equations Approach, Quasi-likelihood and Its GEE Multivariate Extension, Markov Chains: Transitional Modeling.

REFERENCES:

1. Agresti, A. (2010): Analysis of ordinal categorical data, Wiley.
2. Agresti, A. (2013): Categorical Data Analysis, Third Edition, Wiley.
3. Bilder, C. R. and Loughin, T.M. (2013): Analysis of Categorical Data with R, CRC Press.
4. Bowerman, O. (2000): Linear Statistical models.
5. Congdon, P. (2005): Bayesian Models for Categorical Data, Willey.
6. Kleinbaum, D. G. (1994): Logistic Regression, Springer Verlag.
7. Sutradhar, B. C. (2014): Longitudinal Categorical Data Analysis, Springer.
8. Upton, G.J.G. (2017): Categorical Data Analysis by Example, Wiley.

STAT2EL602A: Practical

(2 Credits)

Practical based upon all theory papers of the semester

STAT2EL602B: Practical using SPSS

(2 Credits)

Practical based upon all theory papers of the semester

STAT2EL602C: Practical using R

(2 Credits)

Practical based upon all theory papers of the semester

STAT2IN601: Internship Field Work

(2 Credits)

Candidates/Students are required to attend an Internship Program during Summer Break.

SEMESTER IV

STAT2CC604: Decision Theory and Bayesian Analysis

(4 Credits – 4 hours of teaching per week)

Course Outcome:

The main objective of this course is to provide in depth knowledge to students about decision theory and Bayesian analysis. The present course provides insight to some important concepts used in decision theoretic approach to Statistics especially from the point of view of Bayesian and subjective notion of Probability.

Course Specific Outcomes:

After successful completion of this course, student will be able to:
1. Appreciate the concepts related to decision theory especially Bayesian and its use in Statistics.
2. To gain insights to different important results related to prior distribution.
3. Appreciate the concept of loss and expected loss.
4. Understand the various types of loss functions and their important results.
5. To gain knowledge about the Bayesian testing of hypotheses and Bayes factor.
6. To understand the Bayesian Interval Estimation and Credible Intervals.

UNIT I

Decision problem, elements of decision theory, loss functions, expected loss, decision rules (non-randomized and randomized), decision principles (conditional Bayes, frequentist), inference problems as decision problems, optimal decision rules. Concepts of admissibility, Bayes rules, admissibility of Bayes rules.

UNIT II

Subjective interpretation of probability. Bayes theorem and computation of the posterior distribution. Natural Conjugate family of priors for a model. Hyper parameters of a prior from conjugate family. Conjugate families for (i) exponential family models, (ii) models admitting sufficient statistics of fixed dimension.

UNIT III

Non informative, improper and invariant priors. Jeffrey's prior. Bayesian point estimation. Bayes estimators for (i) absolute error loss (ii) squared error loss (iii) 0 - 1 loss (iv) Linex loss. Generalization to convex loss functions. Evaluation of the estimate in terms of the posterior risk.

UNIT IV

Bayesian interval estimation via Credible intervals. Highest posterior density regions. Interpretation of the confidence coefficient of an interval and its comparison with the interpretation of the confidence coefficient for a classical confidence interval.

UNIT V

Bayesian testing of Hypotheses: Specification of the appropriate form of the prior distribution for a Bayesian testing of Hypotheses problem. Prior odds, Posterior odds, Bayes factor for various types of testing Hypotheses problems depending upon whether the null hypothesis and the alternative hypothesis are simple or composite. Bayesian prediction problem. Large sample approximations for the posterior distribution.

References

1. Sinha, S.K. (1998). Bayesian Estimation, New Age International.
2. Berger, J. O. (1985). Statistical Decision Theory and Bayesian Analysis, Springer.
3. Bansal, A.K. (2007). Bayesian Parametric Inference, Narosa.
4. Leonard, T. & Hsu, J. S. J. (1999). Bayesian Methods. Cambridge University Press.
5. DeGroot, M. H. (1970). Optimal Statistical Decisions. McGraw Hill.
6. Bernando, J. M. and Smith, A. F. M. (1994). Bayesian Theory, Wiley.
7. Robert, C. P. (2001). The Bayesian Choice: A decision Theoretic Motivation, Springer.
8. Box, G. P. & Tiao, G. C. (1973). Bayesian Inference in Statistical Analysis, Addison – Wesley.
9. Ghosh, J.K., Delampady, M. & Samanta, T. (2006). An Introduction to Bayesian Analysis, Springer.
10. Lee, P. (2012). Bayesian Statistics, Wiley.

STAT2EL603A: Time Series Analysis

(4 Credits – 4 hours of teaching per week)

Course Outcome:

The objective of this course is to study more advanced topics in econometrics and time series viz. MA, AR, ARMA, ARIMA, VAR, ARCH, GARCH Models and Granger Causality Test.

Course Specific Outcomes:

After successful completion of this course, student will be able to:

1. Acquire knowledge of various advanced econometric models, estimation methods and related econometric theories.
2. Conduct econometric analysis of data.
3. Understand Auto-covariance, auto-correlation function and Vector Autoregression.
4. Understand the use of auto regressive models for stochastic volatility.

Unit I

Introduction to time series, its various applications, , Autocorrelation and serial correlation, Effect of autocorrelation on OLS estimators, Detection of presence of autocorrelation in time series: Graphical method, run test, Durbin-Watson test, The Wallis Test, Breusch-Godfrey Test, Box-Pierce-Ljung Statistic, Autocorrelation function (ACF) and Partial Autocorrelation function (PACF), Yule-walker equation.

Unit II

Introduction to Autoregressive processes (AR), AR(1) and AR(2) processes. White Noise, Introduction to Moving Average process (MA), MA(1) and MA(2) processes. Introduction to Auto regressive moving average processes (ARMA), ARMA (1,1) process, Estimation of parameters of AR, MA and ARMA processes

Unit III

Stationarity in Time Series, trend stationary and difference stationary time series, Detection of stationarity in time series: by using graphical inspection method, using integrated series, using unit root test, Dickey-Fuller test for unit root hypothesis, Augmented Dickey-Fuller (ADF) test for difference stationarity against trend stationarity. Introduction to Auto regressive integrated moving average processes (ARIMA), Identification of order for ARIMA models, Introduction to Seasonal Autoregressive Integrated Moving Average (sARIMA) process.

Unit IV

Vector Auto Regression (VAR) model, Testing of order of VAR, the Granger Causality Test, Impulse response function, variance decomposition and forecasting using VAR models, VAR(1) and VAR(2) processes.

Unit V

Introduction of Stochastic Volatility Models, Autoregressive Conditional Heteroscedastic (ARCH) Models, Order determination for ARCH models, Generalized ARCH (GARCH) Models, properties of GARCH models, Forecasting in ARCH and GARCH models.

REFERENCES:

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2. Brooks C., (2012): Introductory Econometrics for Finance, Cambridge University Press.
3. Chatfield C., (2001): Time Series Forecasting, Chapman & Hall/CRC Press.
4. Chatfield C. (2016), The Analysis of Time Series: An Introduction, CRC Press.
5. Chatfield C. (2019), The Analysis of Time Series: An Introduction with R, CRC Press.
6. Cryer JD., Chan KS. (2008): Time Series Analysis with Applications in R, Springer
7. Greene W.H. (2008): Econometrics Analysis, Pearson Education.
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9. Johnston, J., Dinardo J. (2007): Econometric methods, 4th Ed. Mc Graw Hill.
10. Madala GS., Lahiri K. (2001), Introduction to Econometrics, John Wiley & Sons Inc.
11. Makridakis S., Wheelwright S.C., Hyndman R.J. (1998): Forecasting: Methods and Applications, Wiley Publications.
12. Mills TC. (2019): Applied Time Series Analysis: A practical Guide to Modelling and Forecasting, Academic Press.

STAT2EL603B: Artificial Intelligence

(4 Credits – 4 hours of teaching per week)

Course Outcome:

This will introduce the basic principles, techniques, and applications of Artificial Intelligence. This course will facilitate the acquire understanding of knowledge representation and reasoning to understand the various approach of decision making.

Course Specific Outcome:

After successful completion of this course, student will be able to:

1. Identify, apply and solve problems using the AI tools and techniques
2. Get introduced to various sub-fields of artificial intelligence
3. Represent a problem using first order and predicate logic
4. Provide the suitable decision applying the various decision-making mechanism
5. Choose an appropriate learning paradigm that solves the given problem efficiently

UNIT I

AI problems, foundation of AI and history of AI intelligent agents: Agents and Environments, the concept of rationality, the nature of environments, structure of agents, problem solving agents, problem formulation.

UNIT II

Knowledge representation issues, predicate logic: logic programming, semantic nets: frames and inheritance, constraint propagation, representing knowledge using rules, rules-based deduction systems. Reasoning under uncertainty, review of probability, Bayes' probabilistic interferences and Dempster Shafer theory.

UNIT III

Searching: Searching for solutions, uniformed search strategies: Breadth first search, depth first Search. Search with partial information (Heuristic search) Hill climbing, A*, AO* Algorithms, Problem reduction, Game Playing-Adversarial search, Games, mini-max algorithm, optimal decisions in multiplayer games, Problem in Game playing, Alpha-Beta pruning, Evaluation functions.

UNIT IV

First order logic. Inference in first order logic, propositional vs. first order inference, unification & lifts forward chaining, Backward chaining, Resolution, learning from observation Inductive learning, Decision trees, Explanation based learning, Statistical Learning methods, Reinforcement Learning.

UNIT V

Expert systems: Introduction, basic concepts, structure of expert systems, the human element in expert systems, types of expert systems, expert systems and the internet interacts web, knowledge engineering, difficulties in knowledge acquisition, methods of knowledge acquisition, selecting an appropriate knowledge acquisition method, societal impacts reasoning in artificial intelligence, inference with rules, with frames: model based reasoning, case based reasoning, explanation & meta knowledge inference with uncertainty representing uncertainty.

REFERENCES:

1. Elaine Rich, Kevin Knight, & Shivashankar B Nair (2017), Artificial Intelligence, 3rd ed.,McGraw Hill.
2. Patrick Henry Winston (2002) Artificial Intelligence. Third Edition, Pearson Publication.
3. Patterson (2015), “Introduction to Artificial Intelligence & Expert Systems”, Pearson Publication.
4. Richard E. Neapolitan and Xia Jiang (2018), Artificial Intelligence with an Introduction to Machine Learning, 2nd Edition, Chapman and Hall.
5. Stephen Lucci and Danny Kopec (2015), Artificial Intelligence in the 21st Century, 2nd Edition, Mercury Learning & Information.
6. Stuart Russell and Peter Norvig (2024), Artificial Intelligence: A Modern Approach, Fourth Edition, Pearson Publication.
7. Zhongzhi Shi (2011), Advanced Artificial Intelligence, World Scientific Publishing Company.
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STAT2EL603C: Reliability Theory

(4 Credits – 4 hours of teaching per week)

Course Outcome:

The main aim of this course is to provide the knowledge on fundamentals of Reliability theory, concepts and measures along with reliability applications in various domains.

Course Specific Outcomes:

After the completion of this course the students would be able to

1. Understand the concepts of reliability and hazard rate function
2. Know the concept of mean time to failure, redundancy and system reliability
3. Understand important ageing classes and their characterizations
4. Learn different life time distributions with their hazard function, and reliability functions.
5. Obtain the estimates and testing for parameters in respect of some common life time distributions
6. Learn reliability estimation based on failure times and censored life-tests.

UNIT I

Reliability concepts and measures, Hazard rate, Mean time to failure, Mean time between failures. Relations among reliability measures: Reliability, hazard rate and probability density functions. Applications of reliability in various domains. Components and systems, Series and parallel arrangement of components in systems.

UNIT II

Reliability in k out of n systems, Different types of redundancy and use of redundancy, coherent systems, reliability of coherent systems, cuts & paths, Bounds on system reliability. Concept of repair and preventive maintenance. Availability of reparable systems. Reliability growth models; Probability plotting techniques

UNIT III

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

UNIT IV

Truncated distributions. Reliability function and hazard rate for Life distributions: Exponential, Rayleigh, Weibull, Gamma, Normal and Lognormal etc. Estimation of parameters and testing for these models.

UNIT V

Censoring and its types, Reliability estimation and testing for life time distributions in case of censoring.

REFERENCES:

1. Barlow, R.E. and Proschan, F. (1975) Statistical Theory of Reliability and Life Testing, Holt, Reinhart and Winston
2. Bain, L. J. and Engelhardt (1991): Statistical Analysis of Reliability and Life Testing Models; Marcel Dekker.
3. Cox, D. R. and Oakes, D. (1984): Analysis of Survival Data, Chapman and Hall, New York
4. Lawless, J.F. (1982): Statistical Models and Methods of Life Time Data; John Wiley.
5. Lai, C.D and Xie, M. (2006) Stochastic ageing and dependence in reliability, Springer
6. Miller, R. G. (1981): Survival Analysis, John Wiley.
7. Nelson, W. (1982): Applied life Data Analysis; John Wiley.
8. Sinha S K (1986) Reliability and Life Testing, Wiley Eastern.

STAT2EL604A: Factorial Experiments and Response Surface Theory

(4 Credits – 4 hours of teaching per week)

Course Outcome:

This course provides students to understand the design and conduct experiments, as well as to analyze data and interpret the results. Students can also apply experimental design techniques in research and real-world problems.

Course Specific Outcomes:

After successful completion of this course, students will be able to:

1. Introduction to planning valid and economical experiments within available resources.
2. Understand the effects of independence or dependence on different factors under study.
3. Understand how factorial experiments allow the study of main effects and interaction effects between factors.
4. Understand the design and analysis of full factorial experiments for two or more factors with multiple levels.
5. Construct complete and partially confounded factorial designs and perform their analysis.
6. Learn the concepts and advantages of fractional factorial designs for saving resources while maintaining essential information about factors and interactions.
7. Apply techniques such as aliasing to understand how to design fractional factorial experiments with a reduced number of experimental runs.
8. Understand the applications area of designs of experiments such as response surface design, clinical trials, and treatment control design.
9. Understand the concepts of optimality criteria to obtain optimal designs.

UNIT I

General factorial experiments, factorial effects, symmetric factorial experiments, best estimates and testing the significance of factorial effects in $2^n (n \leq 5)$ experiments; analysis of 2^n factorial experiment. Complete and partial confounding in case of $2n$ factorial experiments.

UNIT II

3^n factorial experiments in randomised blocks, analysis of $3^2, 3^3, 3^4$ and 3^n factorial experiments, an extension of the Yates table for 3^n factorial experiments. Complete and partial confounding in case of 3^n factorial experiments.

UNIT III

Fractional Factorial experiments: Construction of one-half and one-quarter fractions of $2^n (n \leq 5)$ factorial experiments, Alias structure, and Resolution of a design. Construction of fraction factorial for $3^n (n \leq 5)$ experiments. Taguchi Methods.

UNIT IV

Response surface experiments: first and second order response surface experiments, Design criterion involving bias and variance, concept of orthogonality, rotatability and blocking designs in response surface designs, and central composite designs.

UNIT V

Clinical trials, treatment-control designs, Crossover designs. Optimal designs: optimality criteria such as A-, D-, C-, and E- optimality for linear and non-linear models.

References

1. Basavarajaiah, D.M. & Murthy, B. N. (2022): Design of Experiments and Advanced Statistical Techniques in Clinical Research, Springer Verlag, Singapore.
2. Das, M.N. & Giri, N. (1979): Design and Analysis of Experiments, Wiley Eastern.
3. Das, M.N. & Giri, N. (2017): Design and Analysis of Experiments, New Age International.
4. David Ratkowsky, D., Alldredge, R. & Evans, M.A. (2020): Cross-Over Experiments: Design, Analysis and Application, CRC Press.
5. Dean, A., Voss, D., &Draguljić, D. (2017): Design and Analysis of Experiments, Springer.
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7. Friedman, L. M., Furburg, C. D. &Demets, L. (1998): Fundamentals of Clinical Trials, Springer Verlag.
8. Goos, P. (2011): Optimal Design of Experiments - A Case Study Approach, John Wiley & Sons Inc.
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13. Montgomery, C.D. (2012): Design and analysis of experiments, Wiley, New York.
14. Panneerselvam, R. (2012). Design and Analysis of Experiments, PHI Learning Private Limited, Delhi.
15. Pearce, S.C. (1984): Design of experiments Wiley, New York.
16. Raghava Rao D. (1971): Construction and Combinatorial problems in Design of Experiment. Wiley
17. Silvey, S.D. (1980): Optimal Design, Chapman and Hall.

STAT2EL604B: Ethics, Integrity and Aptitude
(4 Credits – 4 hours of teaching per week)

Course Outcome:

This paper includes questions to develop the student's attitude and approach to issues relating to integrity, probity in public and social life and his/her approach to various issues and conflicts faced by him/her while dealing with society. Case study approach may be utilized to inculcate these values and appropriate positive aptitude for in depth understanding.

Course specific Outcome:

After completion of the course, a student will be able to:

Understand and have clarity of the human values, ethics and integrity in society and tackle various situations in life with positive attitude for common good.

UNIT I

Ethics and Human Interface- Essence, determinants and consequences of Ethics in human actions; dimensions of ethics; ethics in private and public relationships.

Human Values - lessons from the lives and teachings of great leaders, reformers and administrators; role of family, society and educational institutions in inculcating values.

UNIT II

Attitude- content, structure, function; its influence and relation with thought and behaviour; moral and political attitudes; social influence and persuasion.

Aptitude and foundational values for integrity, impartiality and non-partisanship, objectivity, dedication to social service, empathy, tolerance and compassion towards the weaker-sections.

UNIT III

Emotional intelligence-concepts, and their utilities and application in academic, corporate sector and public services. Contributions of moral thinkers and philosophers from India and world. Values and Ethics in academic and pubic administration- Status and problems; ethical concerns and dilemmas in government and private institutions; laws, rules, regulations and conscience as sources of ethical guidance; strengthening of ethical and moral values in academic life.

UNIT IV

Probity in Education and Research- Concept of Intellectual Property Rights (IPR), Philosophical basis of teaching and probity; Information sharing and transparency in Education and Research, Codes of Ethics, Codes of Conduct, Citizen's Charters, Work culture, Quality of service delivery, challenges of corruption.

UNIT V

Global Issues: Globalization and MNCs –Cross Culture Issues – Business Ethics – Media Ethics – Environmental Ethics – Endangering Lives – Bio Ethics – Computer Ethics – War Ethics – Research Ethics -Intellectual Property Rights.

REFERENCES:

1. P.D.Sharma: Ethics, integrity and Aptitude, Rawat Publications, Jaipur.
2. G. Subba Rao and P.N. Roy Chowdhury: Ethics, Integrity and Aptitude, Access Publishing.
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4. Professional Ethics by R. Subramaniam – Oxford Publications, New Delhi.
5. Ethics in Engineering by Mike W. Martin and Roland Schinzinger – Tata McGraw-Hill – 2003.
6. Professional Ethics and Morals by Prof.A.R.Aryasri, DharanikotaSuyodhana – Maruthi Publications.
7. Engineering Ethics by Harris, Pritchard, and Rabins, Cengage Specific, New Delhi.
8. Human Values & Professional Ethics by S. B. Gogate, Vikas Publishing House Pvt. Ltd., Noida.
9. Engineering Ethics & Human Values by M.Govindarajan, S.Natarajan and V.S.SenthilKumar-PHI Specific Pvt. Ltd – 2009.
10. Professional Ethics and Human Values by A. Alavudeen, R.Kalil Rahman and M. Jayakumaran – University Science Press.
11. Professional Ethics and Human Values by Prof.D.R.Kiran-Tata McGraw-Hill – 2013

STAT2EL604C: Computer Intensive Statistical Methods
(4 Credits – 4 hours of teaching per week)

Course Outcome:

The main objective of this course is to provide in depth knowledge to students about computer intensive statistical methods especially simulation. The present course provides insight to some important concepts that shall provide a solid foundation in simulation and other computer intensive methods used in Statistics.

Course Specific Outcomes:

After successful completion of this course, student will be able to:

1. Appreciate the concepts related to exploratory data analysis.
2. To gain insights to different important results related regression diagnostics.
3. Appreciate the concept of stochastic simulation and its applications.
4. Understand the concept of random number generation and its usage.
5. To gain knowledge about the importance of resampling methods like bootstrap, jack-knife and their use in Statistics.
6. To understand various Monte Carlo methods.

UNIT I

Exploratory data analysis: transforming data, graphical methods of clustering, outliers, influential observations, and diagnostics. EM algorithm: applications to missing and incomplete data problems.

UNIT II

Stochastic simulation: Pseudo random number generation, inverse transform method, generating discrete random variables, generating continuous random variables, generating mixed random variables, generating multivariate normal random vector.

UNIT III

Acceptance -Rejection method for random number generation for both discrete and continuous distributions. Composition method. Monte Carlo method for integration. Statistical analysis of simulated data. Statistical validation techniques, Goodness of fit tests for discrete and continuous data.

UNIT IV

Resampling paradigms: Bootstrap methods, bootstrapping for estimation procedures, bias and standard errors, confidence intervals. Jack-knife and cross-validation: jack-knifing for estimation procedures, cross-validation for tuning Parameters.

UNIT V

Introduction to Markov chain Monte Carlo methods, Hastings–Metropolis algorithm, Gibbs sampler, sampling importance resampling algorithm.

References

1. Gnanadesikan, R.(1997)Methods for Statistical Data Analysis of Multivariate Observations, Wiley.
2. Belsley, D.A. Kuh, E. & Welsch, R.E.(1980). Regression Diagnostics, Wiley.
3. McLachlan, G.J. & Krishnan, T. (2008). The EM Algorithms and Extensions, Wiley.
4. Fishman, G.S.(1996). Monte Carlo: Concepts, Algorithms, and Applications, Springer.
5. Rubinstein, R.Y.(1981). Simulation and the Monte Carlo Method, Wiley.
6. Tanner, M.A.(1996). Tools for Statistical Inference, Springer.
7. Efron, B. & Tibshirani, R.J.(1993). An Introduction to the Bootstrap. Chapman and Hall.
8. Shao, J. & Tu, D.(1995).The Jackknife and the Bootstrap. Springer.
9. Gemerman, D.(2006). Markov Chain Monte Carlo: Stochastic Simulation for Bayesian Inference, Chapman Hall.
10. Robert, C. P. & Casella, G. (2004). Monte Carlo Statistical Methods, Springer.

STAT2D601: Dissertation

(Credits: 08)